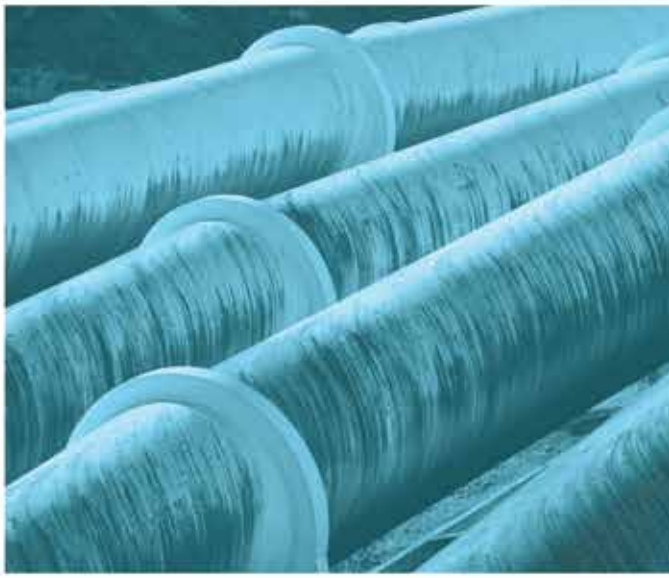



Mandalong Mine

Modification report for modification to development consent SSD-5144

Prepared for Centennial Mandalong Pty Ltd
October 2021



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Mandalong Mine

Modification report for modification to development consent SSD-5144

Report Number

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Client

Centennial Mandalong Pty Ltd

Date

7 October 2021

Version

v1 Final

Prepared by



David Richards
Senior Environmental Scientist
7 October 2021

Approved by



Phil Towler
Associate Director
7 October 2021

This report has been prepared in accordance with the brief provided by the client and has relied upon the information collected at the time and under the conditions specified in the report. All findings, conclusions or recommendations contained in the report are based on the aforementioned circumstances. The report is for the use of the client and no responsibility will be taken for its use by other parties. The client may, at its discretion, use the report to inform regulators and the public.

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Executive summary

Mandalong Mine (Mandalong) is an existing underground coal mining operation producing thermal coal that is supplied to domestic and export markets. Mandalong operates under State significant development (SSD) consent (SSD-5144) which was granted on 12 October 2015 by the NSW Planning Assessment Commission under Part 4, Division 4.1 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). Mandalong is operated by Centennial Mandalong Pty Ltd (Centennial Mandalong).

As identified in Mandalong's *Mining Operations Plan* (MOP) (Centennial Coal 2021), the progression of underground mining is regularly reviewed based on ongoing monitoring of mining and geological conditions. Centennial Mandalong recently encountered poor geological conditions within the Mandalong Southern Extension Area, including a fault zone and igneous sill.

In response to these conditions, amendments to the approved mine plan were sought as part of a modification to SSD-5144 (MOD 9) to maintain coal production, improve mining conditions and improve the financial viability of Mandalong. The MOD 9 application sought to amend the approved mine plan, including reorientating longwalls LW30–LW33.

Since the approval of MOD 9 in April 2021, Centennial Mandalong has continued to review the progression of underground mining within the Mandalong Southern Extension Area. This has identified that further amendments to Mandalong's approved mine plan (primarily, the addition of LW34) are required to maintain coal production and improve the financial viability of Mandalong (following the removal of LW33 and shortening of LW30).

Centennial Mandalong is seeking to modify SSD-5144, pursuant to Section 4.55(2) of the EP&A Act to change Mandalong's approved longwall mine plan. The proposed modification will seek approval for the addition of LW34, which will maximise resource extraction within Mandalong's development consent boundary.

Two updates to Appendix 8 of SSD-5144 are also proposed to:

1. Allow greater flexibility when exploration drilling activities are undertaken on total fire ban days.

2. Change the way Mandalong's annual contributions are distributed to the local community.

The NSW Department of Planning, Industry and Environment (DPIE) and key stakeholders have been consulted regarding the proposed modification to assist in identifying all of the relevant issues to be assessed. This modification report (MR) and supporting technical reports assess the potential impacts of the proposed modification.

The proposed modification has been designed to minimise, as far as practicable, adverse biophysical, social and economic impacts. All residual impacts have been identified and assessed. The proposed amendments to Mandalong's approved longwall mine plan will not significantly change previously assessed and approved impacts. While there will be some residual impacts, the proposed modification and ongoing operation of Mandalong will provide long-term benefits to the local community, region and New South Wales.

All aspects relating to environmental management will continue in accordance with SSD-5144, Environment Protection Licence (EPL) 365 and approved management plans.

The proposed modification of SSD-5144 will have minimal environmental impacts and will remain substantially the same development for which consent was originally granted. As such it is considered the modification can be approved pursuant to Section 4.55(2) of the EP&A Act.

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1 Introduction

1.1 Overview

Mandalong Mine (Mandalong) is an existing underground coal mine near Morisset, approximately 35 kilometres (km) south-west of Newcastle predominantly within the Lake Macquarie local government area (LGA) of New South Wales (NSW) (Figure 1.1). Mandalong is operated by Centennial Mandalong Pty Limited (Centennial Mandalong). Centennial Mandalong has approval to extract run-of-mine (ROM) coal from the West Wallarah and Wallarah-Great Northern seams using a combination of continuous miner, longwall and bord and pillar mining methods.

Mandalong operates under State significant development (SSD) consent SSD-5144 (the consent), which was granted on 12 October 2015 by the NSW Planning Assessment Commission (PAC) under Part 4, Division 4.1 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act).

As identified in Mandalong's *Mining Operations Plan* (MOP) (Centennial Coal 2021), the progression of underground mining is regularly reviewed based on ongoing monitoring of mining and geological conditions. Centennial Mandalong recently encountered poor geological conditions within the Mandalong Southern Extension Area, including a fault zone and igneous sill.

In response to these conditions, amendments to the approved mine plan were sought as part of a modification to SSD-5144 (MOD 9) to maintain coal production, improve mining conditions and improve the financial viability of Mandalong. The MOD 9 application sought to amend the approved mine plan, including reorientating longwalls LW30–LW33.

Since the approval of MOD 9 in April 2021, Centennial Mandalong has continued to review the progression of underground mining within the Mandalong Southern Extension Area. This has identified that further amendments to Mandalong's approved mine plan (primarily, the addition of LW34) are required to maintain coal production and improve the financial viability of Mandalong (following the removal of LW33 and shortening of LW30).

Centennial Mandalong is seeking to modify SSD-5144, pursuant to Section 4.55(2) of the EP&A Act to change Mandalong's approved longwall mine plan. The proposed modification will seek approval for the addition of LW34, which will maximise resource extraction within Mandalong's development consent boundary.

Two updates to Appendix 8 of SSD-5144 are also proposed to:

1. Allow greater flexibility when exploration drilling activities are undertaken on total fire ban days.

2. Change the way Mandalong's annual contributions are distributed to the local community.

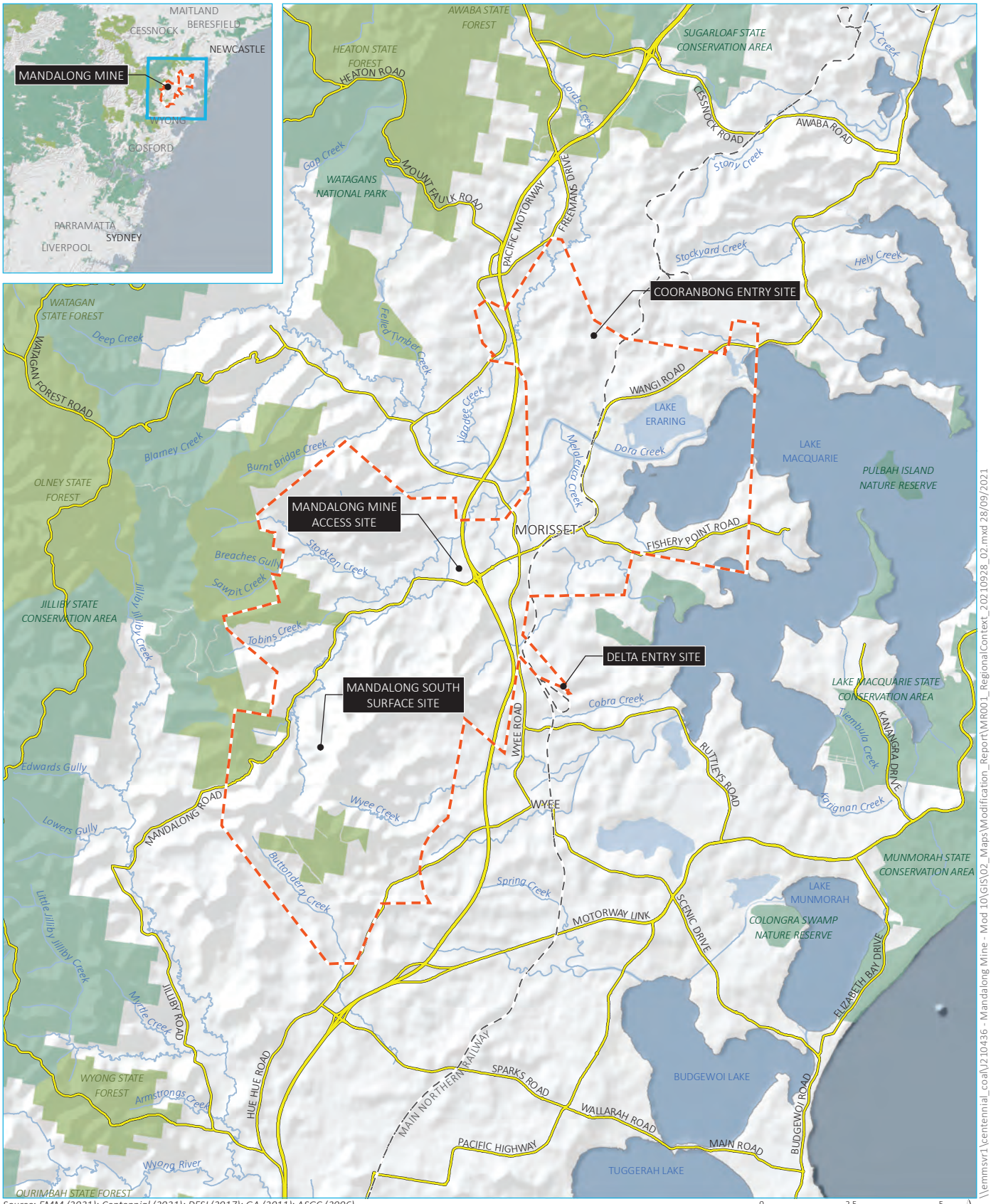
EMM Consulting Pty Limited (EMM) has been engaged by Centennial Mandalong to prepare a modification report (MR) to accompany an application to modify the consent. This MR assesses the impacts of the proposed modification and proposes mitigation measures, where required, to minimise potential impacts.

1.2 Proponent

Centennial Mandalong is a wholly owned subsidiary of Centennial Coal Company Limited (Centennial). Centennial is a wholly owned subsidiary of Banpu Public Company Limited (Banpu).

Centennial Mandalong is the proponent for the modification. The relevant address is:

Centennial Mandalong Pty Limited
Level 18, 1 Market Street
Sydney NSW 2000



Source: EMM (2021); Centennial (2021); DFSI (2017); GA (2011); ASGC (2006)

0 2.5 5 km

GDA 1994 MGA Zone 56

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KEY

- Development consent boundary
- Rail line
- Main road
- Named watercourse
- Named waterbody
- NPWS reserve
- State forest

Regional context

Mandalong Mine Modification 10
Modification report
Figure 1.1

EMM creating opportunities

1.3 Background

Mandalong is an existing underground coal mine approximately 130 km north of Sydney and 35 km south-west of Newcastle, in the lower Hunter Region of NSW. Mandalong has approval to extract up to 6.5 million tonnes per annum (Mtpa) of coal using a combination of continuous miner, longwall and bord and pillar mining methods.

Mandalong comprises of underground mine workings and four surface infrastructure sites (Figure 1.1):

- The Mandalong Mine Access Site (MMAS), encompassing underground workings and associated surface infrastructure (decline tunnel, mine ventilation shafts and fans, gas drainage plant, workshops, administration buildings and mine personnel car parking) near Morisset.
- Delivery of ROM coal from the underground workings to the Cooranbong Entry Site (CES). The coal handling and processing facilities are approved under the Northern Coal Logistics Project (SSD-5145).
- Delivery of ROM coal from underground workings to the Delta Entry Site (DES) near Wyee at the Vales Point Rail Unloader Facility (approved under DA 35-2-2004).
- The Mandalong South Surface Site (MSSS) which is being constructed and, when complete, will consist of ventilation shafts, ventilation fans, underground delivery boreholes and water management infrastructure. The MSSS is located approximately 6 km south-west of the MMAS.

Mandalong operates in accordance with SSD-5144. The primary activities authorised under SSD-5144 are:

- the continued operation of Mandalong, with the exception of the infrastructure and operations at the surface of the CES as described above;
- the extension of Mandalong's underground mining operations into the area covered by Mining Lease (ML) 1722 using a combination of continuous miner and longwall mining methods;
- the extraction of up to 6.5 Mtpa of ROM coal from the West Wallarah and Wallarah-Great Northern Seams within the current mining lease areas;
- the continued use of existing surface infrastructure at the MMAS;
- the installation and operation of surface infrastructure at the MSSS to service the extended underground mining operation;
- employment of up to 815 full-time equivalent (FTE) personnel;
- ongoing exploration drilling activities within the bounds of Centennial Mandalong's ML and Exploration Licence (EL) areas; and
- the continued operation of Mandalong for 24 hours per day, seven days per week.

The mine and operations are described in Chapter 3.

The consent has been modified on nine occasions (see Section 3.2.1).

Mandalong also operates under Environment Protection Licence (EPL) 365.

1.4 Objectives

The objectives of the proposed modification (MOD 10) are to:

- maintain coal production and improve mining conditions at Mandalong;
- improve the financial viability of Mandalong (following the removal of LW33 and shortening of LW30);
- introduce a risk assessment process that can be undertaken prior to the commencement of exploration drilling activities on total fire ban days; and
- improve the distribution of Mandalong's annual contributions to the local community.

Since the approval of MOD 9 in April 2021, Centennial Mandalong has continued to review the progression of underground mining within the Mandalong Southern Extension Area. As a result of these investigations, the decision has been made to shorten LW30 and remove LW33 from the mine plan. These changes have been made via the Extraction Plan process. The shortening of LW30 and removal of LW33 are estimated to result in the sterilisation of approximately 0.4 Mt and 1.6 Mt of coal, respectively.

The proposed modification will allow Centennial Mandalong to access additional coal resource. Secondary extraction of coal as part of the proposed modification will remain within the currently assessed and approved footprint for secondary extraction.

It is not proposed to change the approved life of mining operations or increase the approved extraction rate of 6.5 Mtpa. The proposed modification will allow Centennial Mandalong to efficiently extract additional coal utilising existing Mandalong infrastructure.

Additional details regarding the modification are provided in Chapter 4.

This modification report has been prepared to support the application to modify SSD-5144.

1.5 Justification and alternatives

1.5.1 Mine plan

In 2010, an exploration drilling program in the Mandalong Southern Extension Area identified additional economic coal reserves within the West Wallarah Seam and the Wallarah-Great Northern Seam. These are high in heat energy and low in ash content, making the coal ideal for electricity generation. Centennial Mandalong sought consent for the Mandalong Southern Extension Project to access, develop and extract this additional coal reserve.

Extraction Plans are prepared by Centennial Mandalong for all second workings (in accordance with Condition 6 of Schedule 4 of SSD-5144). The Extraction Plans describe the applicable regulatory framework, mine planning, management and monitoring measures to be implemented to protect all surface/subsurface natural and built features associated with secondary extraction in a given area.

Since the approval of MOD 9 in April 2021, Centennial Mandalong has made the decision to shorten LW30 and remove LW33 from the mine plan (Figure 1.2).

The length of LW30 was reduced through the Extraction Plan process to avoid mining through a high strength igneous dyke. The amendment to LW30 reduces potential subsidence impacts on rock-face features, a tributary to Mannering Creek, Kiar Ridge Road and identified Aboriginal cultural heritage sites.

LW33 will not be extracted due to the extent of an igneous sill intrusion which reduces the minable panel length, making it uneconomic. The removal of LW33 reduces the extent of potential subsidence impacts on surface features, including TransGrid's TL25/26 330-kV electricity transmission line and identified Aboriginal cultural heritage sites.

The proposed modification seeks approval for the addition of LW34 (Figure 1.2), which will maximise resource extraction within the West Wallarah Seam and Mandalong's development consent boundary. The addition of LW34 will improve the continuity of coal extraction and employment at Mandalong. The coal resource targeted by LW34 can be extracted efficiently using existing infrastructure.

Continuation of mining and operations as approved equates to the 'do nothing' or 'business as usual' base case.

Mine planning at Mandalong considers a range of different variables that can influence the viability of mining operations, including safety, resource recovery, environmental impacts, community issues, mining methods and rates, equipment, infrastructure, timing and economics (ie capital and operating costs).

The amended mine plan satisfies Clause 15 of *State Environmental Planning Policy* (Mining, Petroleum Production and Extractive Industries) (Mining SEPP), which encourages consent authorities to consider the efficiency of resource recovery during the assessment process. If the approved mine plan is not amended, the approximately 1.3 Mt of coal within LW34 will not be extracted. This would fail to maximise resource recovery within the development consent boundary and ML 1722.

In NSW, resources are carefully managed to maximise the welfare of society, both now and for future generations. The amended mine plan seeks to maximise coal resource recovery and minimise environmental impacts.

1.5.2 Exploration drilling

Centennial Mandalong is currently not permitted to undertake exploration drilling on total fire ban days. If Appendix 8 of SSD-5144 is not amended, Centennial Mandalong would remain unable to undertake any exploration drilling activities on total fire ban days.

Over 2019 and 2020, Centennial Mandalong undertook surface exploration drilling within EL 6317 during the fire danger period. The commitment within Appendix 8 of SSD-5144 resulted in delays to the surface drilling program and a total of 15 days of drilling production were lost. This impacted the collection of geological information required for mine planning.

A number of exploration activities undertaken by Centennial Mandalong do not involve the act of drilling itself and could continue safely and efficiently on total fire ban days without increasing bushfire risk. This could include pulling out or installing drill casings, completing borehole sealing, packing or unpacking drilling equipment and other site preparation activities.

Greater flexibility around what exploration drilling activities are able to be undertaken on total fire ban days will improve the continuity of these activities during fire danger periods.

1.5.3 Annual contributions

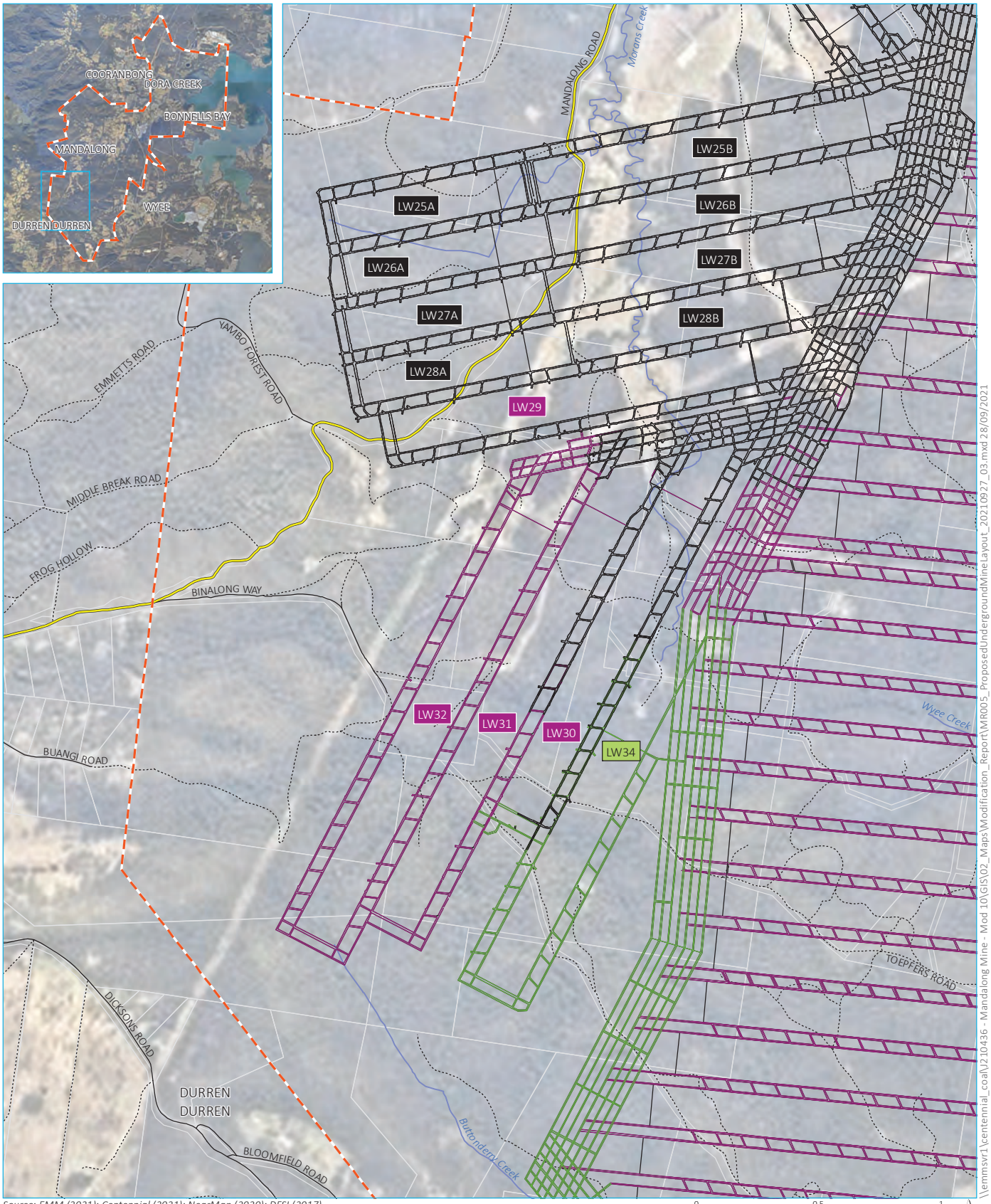
The Lake Macquarie Foundation was established in consultation with LMCC and in accordance with Centennial Mandalong's corporate social responsibility objectives. If Appendix 8 of SSD-5144 is not amended, Mandalong's annual contributions would continue to be distributed via the Lake Macquarie Foundation. The inclusion of the Mandalong Mine Community Consultative Committee (CCC) in this process will ensure local priorities continue to be reflected in the decision making and allocation of community funds.

Centennial Mandalong will also remove the $500,000 limit prescribed by Appendix 8 of SSD-5144 and commit to an ongoing annual contribution of $50,000 for the productive life of Mandalong. If Appendix 8 of SSD-5144 is not amended, Mandalong's annual contributions would be capped at $500,000, resulting in the cessation of funding that positively contributes to projects within the Morisset, Mandalong, Dora Creek and Wyee communities.

1.6 Report contents

This MR describes the site, surrounding area, existing operations at Mandalong, details of the proposed modification, legislative framework, stakeholder consultation and provides an environmental assessment and justification of the proposed modification. This MR is accompanied and supported by the following technical assessments:

- a mine subsidence assessment by Ditton Geotechnical Services Pty Ltd (DGS) (Appendix A);
- a water resources impact assessment (WRIA) by GHD Pty Ltd (GHD) (Appendix B);
- a flooding impact assessment by Umwelt (Australia) Pty Limited (Umwelt) (Appendix C);
- an Aboriginal cultural heritage assessment (ACHA) by Umwelt (Appendix D);
- a biodiversity development assessment report (BDAR) by RPS Australia East Pty Ltd (RPS) (Appendix E);
- a socio-economic assessment by AIGIS (Appendix F); and
- a greenhouse gas (GHG) emissions assessment by EMM (Appendix G).



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Source: EMM (2021); Centennial (2021); NearMap (2020); DFSI (2017)

0 0.5 1 km

GDA 1994 MGA Zone 56

N

KEY

- Development consent boundary
- Mine workings
  - Proposed amendments
  - Approved workings
  - Completed mine workings
- Main road
- Minor road
- Vehicular track
- Named watercourse
- Cadastral boundary

Proposed underground mine layout at Mandalong Mine

Mandalong Mine Modification 10
Modification report
Figure 1.2

EMM creating opportunities

2 Site description

2.1 Site location

Mandalong is an underground coal mine approximately 130 km north of Sydney and 35 km south-west of Newcastle near Morisset predominantly within the Lake Macquarie LGA (Figure 1.1). The southern extent of the development consent boundary is within the Central Coast LGA (Figure 1.1). The development consent boundary encompasses a total area of 11,199 ha (Figure 1.1).

MMAS is the primary access point for Mandalong's underground workings, as well as surface infrastructure. The nearest major population centres to the MMAS are Morisset, 2.5 km to the east; Wyee, 6.5 km to the south-east; and Cooranbong, 4.5 km to the north (Figure 1.1). Access to the MMAS is via Kerry Anderson Drive off Mandalong Road. Both the Sydney to Newcastle M1 Pacific Motorway and Main Northern Railway Line pass through the development consent boundary on a general north-south alignment (Figure 1.1).

2.2 Land use and ownership

Land uses within the development consent boundary include residential and rural-residential, industrial and commercial, utility easements, underground mining and surface operations associated with Mandalong, power generation, agricultural land (predominantly cattle grazing) and production, transport corridors and recreational use.

Parts of the Olney State Forest are within the development consent boundary (Figure 1.1). The Olney State Forest is popular for recreational activities, including hiking, camping and four-wheel driving. Additional notable land uses are the Buttonderry Waste Management Facility, owned and operated by Central Coast Council in the southern extent of the development consent boundary and a number of major service infrastructure lines (including TransGrid's 330-kV power lines).

Surface features above LW34 include:

- tributaries of Morans Creek, Mannering Creek and Buttonderry Creek;
- local roads (including Toepfers Road and Kiar Ridge Road);
- private dwellings, ancillary buildings, fences and driveways; and
- Aboriginal cultural heritage sites.

Land owners within the broader development consent boundary include:

- privately-owned freehold land (including residential and commercial areas);
- Centennial Fassifern Pty Limited (a subsidiary company of Centennial);
- Lake Macquarie City Council (LMCC) (including various public road reserves);
- Central Coast Council (including various public road reserves and Buttonderry Waste Management Facility);
- Origin Energy; and
- NSW Government (including Olney State Forest, M1 Pacific Motorway and Main Northern Railway Line).

Land ownership above the proposed LW34 and immediate surrounds is shown on Figure 2.1.

2.3 Land use zoning

Due to its geographic extent and the diversity of land uses, land use zoning within the development consent boundary is variable. The majority of the approved underground mining area is zoned a mix of E2 Environmental Conservation, E3 Environmental Management, RU2 Rural Landscape and RU3 Forestry pursuant to the Lake Macquarie Local Environmental Plan 2014 (Lake Macquarie LEP).

As noted in Section 2.1, the southern extent of the development consent boundary is within the Central Coast LGA. Land use zoning within the Central Coast LGA is defined under the *Wyong Local Environmental Plan 2013* (Wyong LEP) or *Gosford Local Environmental Plan 2014* (Gosford LEP).

Land use zoning above the proposed LW34 and within the immediate surrounds (Figure 2.2) is:

- E2 – Environmental Conservation;
- E3 – Environmental Management;
- RU3 – Forestry; and
- RE1 – Public Recreation.

2.4 Environmental setting

2.4.1 Geology, topography and soils

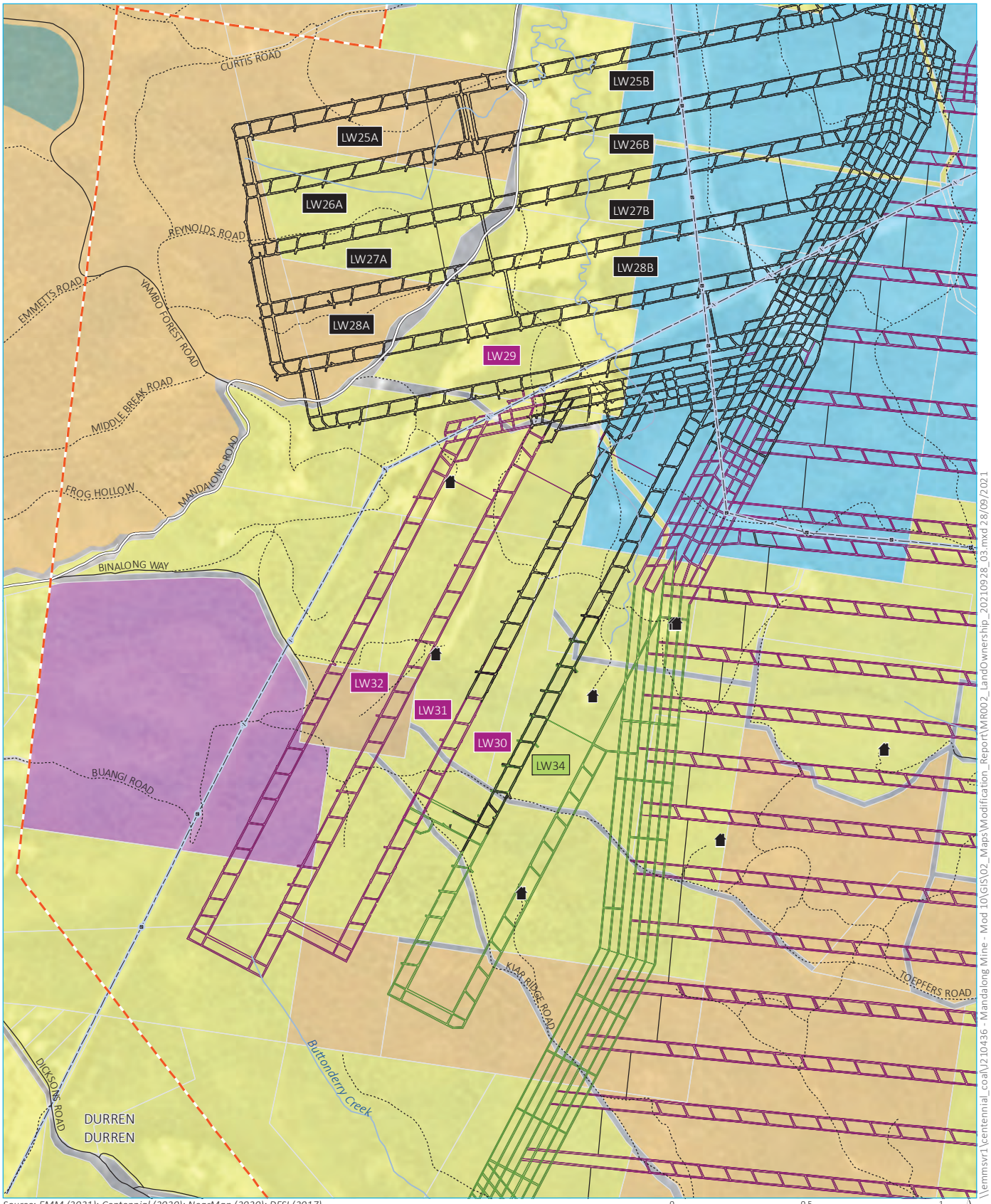
Mandalong is in the south-western part of the Newcastle Coalfield, which occupies the north-eastern portion of the Sydney Basin. The target coal seams are the West Wallarah Seam and the Wallarah-Great Northern Seam. Together, these form the upper part of the Permian Newcastle Coal Measures. The Narrabeen Group lies above the West Wallarah and Wallarah-Great Northern Seams. The Narrabeen Group is comprised of variable sequences of interbedded claystones, siltstones and fine to coarse-grained sandstones.

The mine is in the Mandalong Valley. Diverse landforms are present, including broad flat floodplains of the Stockton Creek and Morans Creek catchment, and undulating hills and rugged ridgelines associated with the surrounding Watagan Mountain range.

The land within the development consent boundary is dominated by two densely timbered ridgelines. Elevations on these ridgelines exceed 200 m Australian Height Datum (AHD). Spurs from these ridgelines descend toward drainages lines in relatively flat areas to the north, east and south of the ridgelines, some of which have been cleared or partially cleared for agricultural production. These valleys are relatively low lying with surface elevations generally less than 50 mAHD.

The ground surface elevation above and surrounding the proposed LW34 ranges from 30 mAHD (along floodplains or drainage lines) to over 100 mAHD (along the ridgelines). The depth of cover above the West Wallarah Seam in this area ranges from approximately 300 m to 450 m.

The Mandalong soil landscape unit is the dominant unit within the development consent boundary.



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Source: EMM (2021); Centennial (2020); NearMap (2020); DFSI (2017)

0 0.5 1 km

GDA 1994 MGA Zone 56

N

KEY

- Private residence
- Development consent boundary

Mine workings
- Proposed amendments
- Approved workings
- Completed mine workings

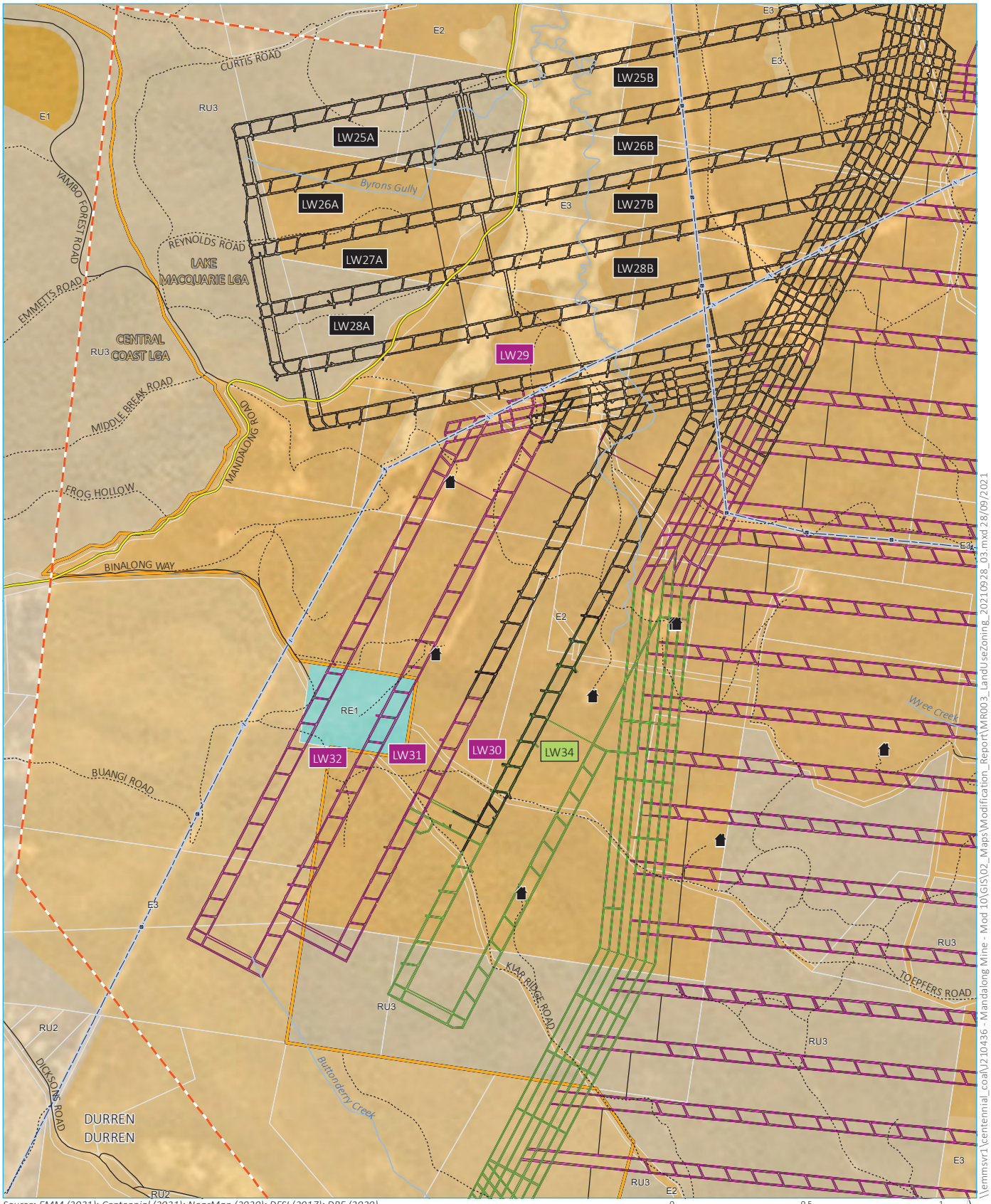
- Electricity transmission line
- Main road
- Minor road
- Vehicular track
- Named watercourse
- Cadastral boundary

Land ownership
- Centennial
- Private
- Central Coast Council
- NSW Government

Land ownership

Mandalong Mine Modification 10
Modification report
Figure 2.1

EMM
creating opportunities



Source: EMM (2021); Centennial (2021); NearMap (2020); DFSI (2017); DPE (2020)

0 0.5 1 km

GDA 1994 MGA Zone 56

N

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KEY

- Private residence
- Development consent boundary

Mine workings
- Proposed amendments
- Approved workings
- Completed mine workings

- Electricity transmission line
- Main road
- Minor road
- Vehicular track
- Named watercourse
- Cadastral boundary
- Local government area

Land use zoning
- E1 National Parks and Nature Reserves
- E2 Environmental Conservation
- E3 Environmental Management
- RE1 Public Recreation
- RU2 Rural Landscape
- RU3 Forestry

Land use zones

Mandalong Mine Modification 10
Modification report
Figure 2.2

EMM creating opportunities

2.4.2 Water resources and hydrology

Groundwater sources in the vicinity of the mine are generally low yielding and predominantly within the Quaternary alluvium, weathered and/or fractured sandstone and coal seams. They are classified as 'less productive' in accordance with the NSW *Aquifer Interference Policy* (AIP) as yields are generally less than 5 litres per second (L/s) and/or the total dissolved solids (TDS) concentration is typically greater than 1,500 milligrams per litre (mg/L).

The majority of the land within the development consent boundary lies within the broader catchment of Lake Macquarie, with the southern portion within the Wyong River catchment. The 'project area' adopted in the flooding assessment (Figure 7.1 and Appendix C) intersects five sub catchment areas:

- Morans Creek, Wyee Creek and Mannering Creek catchments which flow to Lake Macquarie; and
- Buttonderry Creek and Jilliby Creek catchments which flow to the Wyong River.

A small portion of the upstream catchments of Morans Creek, Buttonderry Creek and Mannering Creek are within proximity of the proposed LW34.

Morans Creek is a third order watercourse in the Lake Macquarie catchment. It flows in an approximately north-easterly direction across the project area before flowing into Stockton Creek approximately 4 km north of the project area. Stockton Creek flows into Dora Creek west of Morisset, which flows into Lake Macquarie.

Buttonderry Creek is a second order watercourse in the Wyong River catchment. It flows in a southerly direction to the west of the Buttonderry Waste Management Facility, and then into the Wyong River approximately 6 km south of the project area.

Mannering Creek is a third order watercourse in the Lake Macquarie catchment. It flows in an easterly direction across the project area. Downstream, Mannering Creek is intercepted by Mannering Dam and diverted into Wyee Creek. The diversion is intended to prevent the flow of clean water into Mannering Lake, which is currently used as an ash dam for Vales Point Power Station.

2.4.3 Climate

The Cooranbong (Avondale) Bureau of Meteorology (BoM) weather station is 3 km north of the MMAS. The MMAS experiences warm temperate climates with humid hot summers (classified as 'Cfa' under the Koppen climate classification system). At the Cooranbong (Avondale) station, average rainfall is 1,121 mm per year with an annual minimum of 531 mm (in 1944) and annual maximum of 1,994 mm (in 1950).

3 Existing operations

3.1 Overview of operations

Underground mining operations commenced at Mandalong in January 2005.

As noted in Section 1.3, Mandalong comprises the underground workings and surface infrastructure of MMAS, DES, CES, and MSSS (currently being constructed).

Mandalong's maximum approved extraction rate is 6.5 Mtpa of ROM coal. ROM coal is transferred by conveyor to the Northern Coal Logistics Project, where it is either distributed domestically from CES to Eraring Power Station or hauled to Newstan Colliery's washery by private haul road and washed prior to dispatch by rail for export via the Port of Newcastle. ROM coal can also be distributed to Vales Point Power Station via conveyor from the DES. No coal is transported by road via Mandalong Road or any other road from MMAS.

Mandalong operates under development consent SSD-5144 which was granted on 12 October 2015 by the PAC under Part 4, Division 4.1 of the EP&A Act. The consent will expire on 31 December 2040. The delivery of coal to DES is approved under DA 35-2-2004, while CES is approved under SSD-5145.

3.2 Existing approvals and licences

3.2.1 Development consent

The development consent boundary for SSD-5144 is shown on Figure 1.1. The primary activities currently authorised under the consent are:

- the continued operation of Mandalong, with the exception of the infrastructure and operations at the surface of the CES;
- the extension of Mandalong's underground mining operations into the area covered by ML 1722 using a combination of continuous miner and longwall mining methods;
- the extraction of up to 6.5 Mtpa of ROM coal from the West Wallarah and Wallarah-Great Northern Seams within the current mining lease areas;
- the continued use of existing surface infrastructure at the MMAS;
- the installation and operation of surface infrastructure at the MSSS to service the extended underground mining operation;
- employment of up to 815 FTE personnel;
- ongoing exploration drilling activities within the bounds of Centennial Mandalong's ML and EL areas; and
- the continued operation of Mandalong for 24 hours per day, seven days per week.

As noted in Section 1.3, SSD-5144 has been modified on nine occasions (Table 3.1).

Table 3.1 Summary of modifications

Modification number	Summary of modification	Approval authority	Type	Approval date
1	Relocation of a 2.4 km section of a TransGrid 330 kV transmission line (TL24).	Minister	96(2)	14 June 2016
2	Extension of first workings associated with Longwalls 22 and 23.	Minister	96(1A)	22 September 2016
3	Increased annual production limit from 6 to 6.5 Mtpa of ROM coal.	Minister	96(1A)	16 November 2016
4	Extension of Longwalls 22 and 23 and extraction of an additional 1.4 Mt of ROM coal.	Minister	96(2)	24 March 2017
5	Extension of Longwall 24, addition of Longwall 24A and extraction of an additional 3.7 Mt of ROM coal.	Minister	96(2)	1 August 2017
6	Controlled discharge of mine water from MSSS sediment dam.	Minister	4.55(1A)	15 April 2019
7	Construction of a 33 kV powerline from the MMAS to the MSSS.	Minister	4.55(2)	25 July 2019
8	Increased number of personnel and upgrade to existing substation and car parking facilities at the MMAS.	Minister	4.55(2)	17 January 2020
9	Change to Mandalong's approved mine plan, including reorientating approved longwall panels, removing and renumbering longwalls.	Minister	4.55(2)	1 April 2021

In addition to SSD-5144, Development Consent DA 35-2-2004 was granted in July 2004 by the Minister for Planning, approving the construction and use of the Mandalong Coal Delivery System. This MR only relates to the proposed modification of SSD-5144.

3.2.2 Environment protection licence

Mandalong Mine is a 'premises-based scheduled activity' under Schedule 1 (10) and (28) of the NSW *Protection of the Environment Operations Act 1997* (POEO Act). Mandalong operates under EPL 365 which is administered by the NSW Environment Protection Authority (EPA).

EPL 365 covers coal mining to a scale of greater than 5 Mtpa of product, coal works to a scale greater than 5 Mtpa handled and water discharge to four licenced discharge points (LDPs).

No changes to EPL 365 would be required as a result of the proposed modification.

3.2.3 Mineral authorities

Exploration, mining and mining-related operations at Mandalong occur under the provisions of various mineral authorities (Table 3.2).

Table 3.2 Mineral authorities

Reference	Title	Description	Expiry date
CCL 762	Consolidated Coal Lease	Title of Cooranbong workings, includes some surface land.	13 Oct 2022
Part 746	Consolidated Coal Lease	Title of Cooranbong workings, includes some surface land. Sublease.	31 Dec 2028
ML 1443	Mining Lease	Title for Mandalong Mine workings, includes MMAS.	1 Mar 2020
ML 1543	Mining Lease	Title for Mandalong Mine workings.	25 Nov 2024
ML 1553	Mining Lease	Title for Delta Link Project.	7 Sept 2025
ML 1722	Mining Lease	Title for Mandalong Mine workings, includes surface mining lease for MSSS.	17 Dec 2036
ML 1744	Mining Lease	Title for Mandalong Mine workings.	06 Oct 2037
ML 1793	Mining Lease	Title for some infrastructure at the CES.	16 Jul 2040
MPL 191	Mining Purposes Lease	Title to surface land for water tanks at Cooranbong.	24 Feb 2023
EL 6317	Exploration Licence	Title for exploration activities in the Southern Extension Area.	8 Aug 2019
EL 4443	Exploration Licence	Title for exploration activities over the former Cooranbong Colliery.	23 Oct 2017
EL 4969	Exploration Licence	Title for exploration activities over part of Mandalong Mine.	31 July 2017
EL 5892	Exploration Licence	Title for exploration activities over part of Mandalong Mine.	31 July 2017
A 404	Authorisation 404	Title for exploration activities over part of Mandalong Mine.	31 July 2017

Notes: Renewal applications have been lodged for ML 1443, EL 6317, EL 4443, EL 4969, EL 5892 and A 404.

3.2.4 Mining operations plan

The MOP (Centennial 2021) outlines the proposed operations at Mandalong (as approved by SSD-5144) from 1 December 2016 to 30 November 2023.

3.2.5 Extraction Plan approvals

Underground mining is undertaken in accordance with approved Extraction Plans to satisfy the requirements of relevant mining authorities.

Extraction Plans are prepared by Centennial Mandalong for all second workings (in accordance with Condition 6 of Schedule 4 of SSD-5144). Extraction Plan approval for LW25–31 was granted on 15 January 2019 with modifications required later for LW25–28 to account for a geological fault. An Extraction Plan for LW30 and LW31 (as modified by MOD 9) was approved on 20 July 2021, which included a variation to shorten LW30.

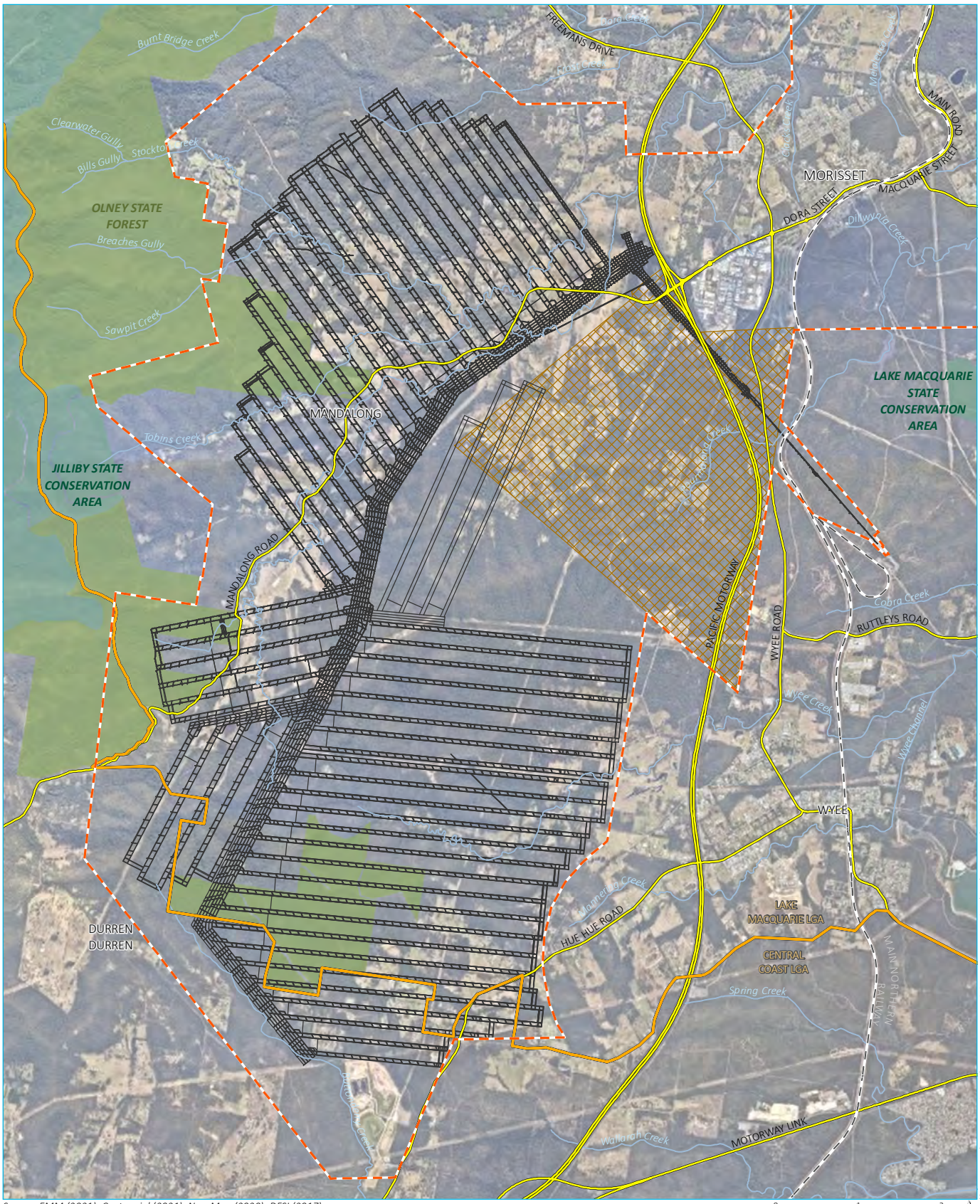
Subsidence impact performance measures are defined in Table 6 and Table 7 of SSD-5144.

3.3 Approved mining operations

First and second workings are undertaken at the mine. ‘First workings’ is defined in SSD-5144 as “development of main headings, longwall gate roads, related cut throughs and the like”. ‘Second workings’ is defined as “extraction of coal from longwall panels, mini-wall panels or pillar extraction”.

The current approved mine plan for the Mandalong Southern Extension Area (Figure 3.1) encompasses a total of 32 longwall panels ranging in length depending on seam conditions and site constraints. They range in width from 160 m to 200 m.

A fleet of modern longwall and development equipment is used at Mandalong, enabling productive and efficient longwall development and extraction.



Source: EMM (2021); Centennial (2021); NearMap (2020); DFSI (2017)

0 1 2 km

GDA 1994 MGA Zone 56

N

KEY

- Development consent boundary
- Area 2: Bord and Pillar Extraction
- Approved mine plan
- Rail line
- Main road
- Named watercourse
- Local government area
- NPWS reserve
- State forest

Approved mine plan for the Mandalong Southern Extension Area

Mandalong Mine Modification 10
Modification report
Figure 3.1

EMM creating opportunities

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3.4 Mine design

The currently approved mining layout (Figure 2 of Appendix 2 of SSD-5144) and subsidence performance measures specified in Table 6 and Table 7 of Schedule 4 of SSD-5144 have been specifically designed to maximise resource recovery while minimising subsidence and associated impacts on the natural and built environment and mitigating impacts on social amenity. The main constraints and issues considered during the mine planning process for the Mandalong Southern Extension Area included:

- geological constraints (including seam thickness and structure including faults and igneous intrusions such as dykes and sills);
- geotechnical constraints (particularly the Munmorah Conglomerate);
- environmental constraints, including:
  - cliff lines;
  - groundwater;
  - creeks;
  - ecology; and
  - Aboriginal cultural and historic heritage;
- social considerations (ie community expectations of acceptable subsidence impacts); and
- surface infrastructure constraints, including:
  - private residences, businesses and associated infrastructure;
  - electricity transmission lines; and
  - telecommunications infrastructure.

The existing approved mine design provides subsidence impacts that are below safe, serviceable and repairable criteria for dwellings. Mandalong's reduced levels of subsidence also minimise potential for impacts to the flood plain and natural and built features (including surface infrastructure).

In accordance with approved Extraction Plans, the progression of underground mining at Mandalong is regularly reviewed in response to the outcomes of ongoing monitoring and geological conditions.

3.5 Water management

Water is used at Mandalong during underground operations, as well as for surface facilities (including machinery operation and wash-down), dust suppression, fire-fighting and staff amenities.

The key functions of Mandalong's water management system are to:

- separate clean and dirty water sources and allow for diversion, collection and treatment as appropriate;
- minimise discharges by maximising, where practicable, available water storages; and
- manage water discharge, in terms of volume and quality, to a level that is acceptable for environmental management.

Surface runoff from areas where there is no coal storage, handling, processing or transportation and no equipment servicing, is considered to be clean water. It is typically from undisturbed catchment areas and impervious areas such as sealed roads and car parks. This runoff is directed around dirty water catchments to avoid potential contamination and minimise the volume of dirty water required to be managed.

Dirty water is runoff from disturbed areas and areas likely to contain coal, oils, greases and hydrocarbons, including workshop and fuel storage areas. Dirty water is managed and treated to remove sediment and residual hydrocarbons prior to discharge in accordance with EPL 365.

During mining operations, water is released from the coal seam and collects in the underground workings. Additional water used in the mining process also collects in the underground workings. Collected water is pumped out of the mining area – referred to as 'mine dewatering'.

Mandalong's underground water management system collects mine water in various low points in the underground workings and pumps it to the Cooranbong underground storage area or goaf. The goaf provides a large storage volume and enables filtration and sediment settlement prior to the water being pumped to the surface via a dewatering bore to the Borehole Dam at the CES.

Centennial Mandalong holds water access licence (WAL) 39767 which allows for the extraction of up to 1,825 megalitres per year (ML/yr) from the Cooranbong underground storage area via the Cooranbong bore (water supply works approval 20WA218789).

3.6 Environmental management

Mandalong has an established environmental management strategy (EMS) that has been developed in accordance with Centennial's EMS Framework and is generally consistent with the elements of ISO 14001. This EMS provides a framework to ensure the effective management of environmental issues and compliance with regulatory requirements for all activities and areas managed by Centennial Mandalong. It also provides a means for continues improvements in environmental performance.

A comprehensive set of environmental management plans are implemented at Mandalong as part of the EMS. These plans are reviewed and updated, as necessary, to reflect operational changes and incorporate additional/amended requirements.

The environmental management plans are backed by an environmental monitoring network. Monitoring results are reported monthly on Centennial's website and in Mandalong's annual review documents.

4 Proposed modification

4.1 Overview of modification

4.1.1 Mine plan

Centennial Mandalong is seeking to modify SSD-5144, pursuant to Section 4.55(2) of the EP&A Act, to include LW34. The approved and proposed mine plans for the western longwalls in the Mandalong Southern Extension Area are shown in Figure 1.2.

LW34 will align with adjacent panels by maintaining the existing panel width of 200 m and all other mining geometry aspects will remain unchanged. Secondary extraction of coal as part of the proposed modification will remain within the currently assessed and approved footprint for secondary extraction.

An Extraction Plan for LW34, that is consistent with the requirements of Condition 6 of Schedule 4 of SSD-5144, will be prepared and implemented prior to the commencement of extraction in LW34.

4.1.2 Exploration drilling

Centennial Mandalong is seeking approval to amend one of the existing commitments in Appendix 8 of SSD-5144. Centennial Mandalong is currently not permitted to undertake exploration drilling on total fire ban days. Total fire ban restrictions are typically based on NSW Rural Fire Service (RFS) regional mapping and local conditions may be of lower risk, particularly during certain hours of the day.

As nominated by RFS, a total fire ban means no fires out in the open. During a total fire ban you cannot:

- light, maintain or use a fire in the open;
- carry out any activity in the open that causes, or is likely to cause, a fire; or
- carry out general purpose hot works (eg welding, grinding or gas cutting or any activity that produces a spark or flame) in the open.

Whilst exploration drilling activities are not specifically nominated in the RFS's total fire ban rules (RFS 2021), it is acknowledged that some activities associated with exploration drilling could cause a fire.

Centennial Mandalong propose to amend the commitment that currently reads "no drilling will be conducted on total fire ban days" to better define the activities that can and cannot be undertaken on a total fire ban day. Centennial Mandalong also propose to introduce a risk assessment process that can be undertaken prior to the commencement of any exploration activities on a total fire ban day.

It is proposed to amend the commitment to read:

> On total fire ban days, a structured assessment of the risk of either igniting or becoming impacted by a fire must be completed by all exploration workers prior to commencing work on that day. The findings of the risk assessment will identify the risk of working along with the required additional controls and mitigation actions.

Centennial Mandalong has engaged with RFS in relation to the proposed modification and the outcomes of this engagement are provided in Section 6.7.1.

4.1.3 Annual contributions

The Lake Macquarie Foundation was established in consultation with LMCC and in accordance with Centennial Mandalong's corporate social responsibility objectives. In accordance with Appendix 8 of SSD-5144, Centennial Mandalong committed to distributing:

a) $50,000 upon the granting of the development consent; and

b) $50,000 on each anniversary of the granting of the development consent until the total amount given by the donor (ie Centennial Mandalong) is $500,000.

Following consultation with LMCC and Mandalong's CCC, an amendment to this commitment is proposed to allow the funds to be distributed via the CCC.

Approval is sought to remove the Lake Macquarie Foundation as the administrator of the fund and include the CCC in the decision-making process for the allocation of Centennial Mandalong's annual contributions.

Centennial Mandalong recognises that the CCC is a key community stakeholder group. A charter and application form will be developed in consultation with CCC members; however, it is anticipated that an annual meeting will be held to assess funding applications that can positively contribute to the Morisset, Mandalong, Dora Creek and Wyee communities.

Centennial Mandalong will also remove the $500,000 limit prescribed by Appendix 8 of SSD-5144 and commit to an ongoing annual contribution of $50,000 for the productive life of Mandalong. The annual contribution will invest in projects that improve community infrastructure and services and create vibrant neighbourhoods and public spaces in the communities of Morisset, Mandalong, Dora Creek and Wyee.

It is proposed to amend the commitment to read:

> Centennial Mandalong will allocate $50,000 annually (from the granting of the consent) until the cessation of mining toward a Mandalong Mine Community Fund. The allocation of these funds to the community will be determined annually by the Mandalong CCC in accordance with a Charter and Application process agreed by the CCC and Company.
>
> The Mandalong Mine Community Fund will invest in projects that improve community infrastructure and services and create vibrant neighbourhoods and public space in the communities of Morisset, Mandalong, Dora Creek and Wyee.
>
> Note: Annual payments are subject to the Mandalong Mine operating and any annual payment otherwise due will be reduced proportionally to reflect any period during which the Mandalong Mine is not operating.

The inclusion of the CCC in this process will ensure local priorities are reflected in the decision-making and allocation of community funds.

4.1.4 Comparison between existing operations and the proposed modification

A comparison between existing approved operations and the proposed modification is provided in Table 4.1.

The proposed modification will not affect the current production rate or delivery limits associated with the CES or the Mandalong Coal Delivery System. No physical changes to Mandalong's approved infrastructure are proposed.

Table 4.1 Comparison of existing operation and proposed modification

Aspect	Existing operation	Proposed modification
Mine life	Under SSD-5144, mining operations are permitted to 31 December 2040.	No change.
Development consent boundary	As shown in Figure 1 of Appendix 2 to SSD-5144.	No change.
Underground mining area	As shown in Figure 2 of Appendix 2 to SSD-5144.	Inclusion of LW34.
Hours of operation	Mandalong operates 24 hours per day, 7 days per week.	No change.
Employment	Mandalong currently has provision to employ up to 815 FTE personnel.	No change.
Mining methods	Underground mining undertaken using continuous miner, longwall and bord and pillar mining methods.	No change.
Longwall mining and production	Mandalong has an approved underground mining area under SSD-5144 (Figure 2 of Appendix 2 to SSD-5144). Approved to extract up to 6.5 Mtpa.	Inclusion of LW34. No change to extraction rate.
Underground mine ventilation	Existing infrastructure at MMAS, CES and MSSS.	No change.
Supporting surface infrastructure	Mine supporting surface infrastructure designed to control and manage water, ventilation, materials delivery and equipment maintenance is situated at the MMAS and the MSSS.	No change.
Coal preparation and handling	No coal preparation or handling is undertaken by Mandalong. All ROM coal is delivered to Northern Coal Services for handling and dispatch.	No change.
Waste coal management	As product coal is not washed at Mandalong, coarse and fine reject material is not generated at Mandalong.	No change
Site access	Access to the MMAS is via Kerry Anderson Drive off Mandalong Road, adjacent to the M1 Pacific Motorway. Access to the MSSS is via the MSSS Access Road.	No change.
Underground water management	Water from Mandalong, Cooranbong and Delta underground workings is transported to the Borehole Dam at the CES.	No change.
Surface water management	Current water management occurs in accordance with the *Mandalong Mine Water Management Plan* (WMP).	No change.
Rehabilitation	Given that Mandalong is an underground coal operation, rehabilitation is currently limited to small areas following exploration or construction, or when surface infrastructure is decommissioned.	No change.

4.2 Environmental management strategy

Mandalong has an established EMS that includes a comprehensive set of environmental management plans that have been developed and implemented at Mandalong. These environmental management plans are backed by an environmental monitoring network. The EMS will continue to be implemented.

4.3 Conditions of consent

The following amendments to SSD-5144 will be required to reflect the proposed modification:

- Figure 2 (approved mine plan) and Figure 3 (indicative extraction schedule) of Appendix 2;
- Figure 1 (built features in the southern extension area), Figure 2 (residences potentially affected by slope instability or rock rollout) and Figure 3 (properties potentially affected by a 1 in 100 year ARI flood event) of Appendix 5;
- Figure 1 (Aboriginal cultural heritage sites) of Appendix 6; and
- Appendix 8 (applicant's statement of commitments).

5 Statutory context

5.1 Introduction

This chapter describes the relevant Commonwealth and State legislation and regulatory framework under which the proposed modification will be assessed and determined.

5.2 Commonwealth legislation

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is administered by the Commonwealth Department of Agriculture, Water and the Environment (DAWE). It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places defined as 'matters of national environmental significance' (MNES). If significant impacts are considered likely, and the action is deemed to be a 'controlled action', the proponent may be asked to provide further information about the proposal.

An assessment of whether the mine may have a significant impact on any MNES was completed as part of the *Mandalong Southern Extension Project Environmental Impact Statement* (EIS) (GSSE 2013a). This assessment determined that no aspect of the project will pose a significant impact on any MNES. Subsequently, a referral to the then Commonwealth Department of Sustainability, Environment, Water, Population and Communities was not made.

Biodiversity impacts are discussed in Section 7.5. The proposed modification will not significantly change previously assessed and approved impacts and secondary extraction will remain within the currently assessed and approved footprint for secondary extraction. No threatened ecological communities (TECs) listed under the EPBC Act have been detected within the project area adopted as part of the BDAR (Section 7.5.3).

The proposed modification has the potential to cause or increase remnant ponding (ie ponding that occurs after prolonged rainfall and/or flooding) within the area affected by subsidence. Due to the minor increase in ponding expected, it is considered unlikely that the proposed modification will result in a significant impact to any EPBC Act listed threatened species.

The proposed modification will not have a significant impact on any MNES listed under the EPBC Act and consequently has not been referred to DAWE.

5.3 NSW State legislation

5.3.1 NSW Environmental Planning and Assessment Act 1979

i Section 4.55(2) modification

The original application for the Mandalong Southern Extension Project (SSD-5144) was approved by the PAC on 12 October 2015. SSD-5144 was most recently modified on 1 April 2021 (Mod 9).

Centennial Mandalong is seeking to modify SSD-5144 pursuant to Section 4.55(2) of the EP&A Act to allow for the proposed amendments to the approved underground mine plan and Appendix 8 of SSD-5144. Compliance of the proposed modification with the requirements of Section 4.55(2) is summarised in Table 5.1.

Table 5.1 Compliance with Section 4.55(2) requirements

Section 4.55 (2) requirements	Comment
(a) it is satisfied that the development to which the consent as modified relates is substantially the same development as the development for which consent was originally granted and before that consent as originally granted was modified (if at all), and	The proposed modification is substantially the same development for which consent was originally granted being an underground coal mine. The proposed modification is seeking to change Mandalong's approved mine plan by adding LW34. The proposed modification will maximise resource extraction within the West Wallarah Seam and Mandalong's development consent boundary. The addition of LW34 will also improve the continuity of coal extraction and employment at Mandalong. The additional coal resource within LW34 can be extracted efficiently using existing infrastructure. The proposed amendments to Appendix 8 of SSD-5144 will not result in any significant changes to the ongoing operation of Mandalong.
(b) it has consulted with the relevant Minister, public authority or approval body (within the meaning of Division 4.8) in respect of a condition imposed as a requirement of a concurrence to the consent or in accordance with the general terms of an approval proposed to be granted by the approval body and that Minister, authority or body has not, within 21 days after being consulted, objected to the modification of that consent, and	Centennial Mandalong has consulted with NSW Department of Planning, Industry and Environment (DPIE) as part of the preparation of this MR. DPIE confirmed the approval pathway for the modification is by way of Section 4.55(2) of the EP&A Act. Further consultation information is provided in Chapter 6.
(c) it has notified the application in accordance with: i) the regulations, if the regulations so require; or ii) a development control plan, if the consent authority is a council that has made a development control plan that requires the notification or advertising of applications for modification of a development consent, and	Clause 118 of the *NSW Environmental Planning and Assessment Regulation 2000* (EP&A Regulation) relates to the notification period associated with 4.55(2) modifications. Notice of the application must be published in a local newspaper by DPIE. DPIE must also cause notice of the proposed modification to be given to each person who made a submission in relation to the original development application. This MR will be placed on public exhibition by DPIE.
(d) it has considered any submissions made concerning the proposed modification within the period prescribed by the regulations or provided by the development control plan, as the case may be.	Any submissions made concerning the proposed modification will be reviewed by DPIE and forwarded to Centennial Mandalong to consider and respond to (via a submissions report).

ii Matters for consideration

Modification applications under Section 4.55(2) of Division 4.9 are required to take into consideration the relevant matters referred to in Section 4.15 of the EP&A Act which include:

(a) the provisions of:

(i) any environmental planning instrument, and

(ii) any proposed instrument that is or has been the subject of public consultation under this Act and that has been notified to the consent authority (unless the Planning Secretary has notified the consent authority that the making of the proposed instrument has been deferred indefinitely or has not been approved), and

(iii) any development control plan, and

(iiia) any planning agreement that has been entered into under section 7.4, or any draft planning agreement that a developer has offered to enter into under section 7.4, and

(iv) the regulations (to the extent that they prescribe matters for the purposes of this paragraph), and

(v) (Repealed)

that apply to the land to which the development application relates,

(b) the likely impacts of that development, including environmental impacts on both the natural and built environment, and social and economic impacts in the locality,

(c) the suitability of the site for the development,

(d) any submissions made in accordance with this Act or the regulations,

(e) the public interest.

Matters a (i), (iii) and (iv) have been addressed in the following sections of this chapter. Matters (b) to (e) are addressed in Chapters 6, 7 and 8.

5.3.2 NSW Environmental Planning and Assessment Regulation 2000

Clause 115 of the EP&A Regulation states the required information an application for development consent under Section 4.55(2) of the EP&A Act must include. Table 5.2 provides an outline of where this information is provided. The proposed modification is not considered designated development under the EP&A Regulation.

Table 5.2 EP&A Regulation Clause 115 information requirements

Clause 115 information requirement	Where addressed
(a) the name and address of application,	Section 1.2 of this MR.
(b) a description of the development to be carried out under the consent (as previously modified),	Chapter 3 of this MR.
(c) the address, and formal particulars of title, of the land on which the development is to be carried out,	Section 2.1 and Appendix 1 of SSD-5144.
(d) a description of the proposed modification to the development consent,	Chapter 4 of this MR.
(e) a statement that indicates either: i. that the modification is merely intended to correct a minor error, misdescription or miscalculation, or ii. that the modification is intended to have some other effect, as specified in the statement,	Section 4.1 of this MR.
(f) a description of the expected impacts of the modification,	Chapter 7 of this MR.
(g) an undertaking to the effect that the development (as to be modified) will remain substantially the same as the development that was originally approved,	Chapter 7 of this MR.

Table 5.2 EP&A Regulation Clause 115 information requirements

Clause 115 information requirement	Where addressed
(g1) in the case of an application that is accompanied by a biodiversity development assessment report, the reasonable steps taken to obtain the like-for-like biodiversity credits required to be retired under the report to offset the residual impacts on biodiversity values if different biodiversity credits are proposed to be used as offsets in accordance with the variation rules under the *Biodiversity Conservation Act 2016*,	The proposed modification will not result in the clearing of native vegetation within the project area. Subsidence predictions indicate that there is potential for impact (via ponding) to approximately 0.00047 ha of native vegetation (Section 7.5.3). If impacts on native vegetation exceed the 0.01 ha threshold nominated by the *Biodiversity Assessment Method* (BAM) (DPIE 2020) calculator, offsets will be required in accordance with the biodiversity offset framework. A total of 3 ecosystem credits and 21 species credits would be required (Section 7.5.3).
(h) if the applicant is not the owner of the land, a statement signed by the owner of the land to the effect that the owner consents to the making of the application (except where the application for the consent the subject of the modification was made, or could have been made, without the consent of the owner),	Landowner's consent is not required for a development application for public notification development if the applicant instead gives notice of the application: • to the owner of the land in writing before the application is made; or • by publishing a notice no later than 14 days after the application is made in a newspaper circulating in the area in which the development is to be carried out.
(i) a statement as to whether the application is being made to the Court (under Section 4.55) or to the consent authority (under Section 4.56)	The proposed modification application is not being made to the NSW Land and Environment Court.
and, if the consent authority so requires, must be in the form approved by that authority.	The form of this application is consistent with DPIE's requirements.

5.3.3 Other relevant NSW State legislation and planning instruments

An outline of other relevant NSW State legislation and planning instruments is provided in Table 5.3.

Table 5.3 Other relevant NSW State legislation

NSW legislation	Comment
POEO Act	Mandalong Mine is a 'premises-based scheduled activity' under Schedule 1 (10) and (28) of the POEO Act. Mandalong Mine operates under EPL 365 which is administered by the NSW EPA under Sections 43(b) and 48 of the POEO Act. No changes to EPL 365 are proposed as part of this modification. The modification, as outlined in Chapter 4, will operate under EPL 365.
NSW *Coal Mine Subsidence Compensation Act 2017*	The land within the development consent boundary is within the Mandalong Mine Subsidence District, West Lake Mine Subsidence District and Wyong Mine Subsidence District. No additional infrastructure is required and therefore no approval from Subsidence Advisory NSW is required.
NSW *Work Health and Safety (Mines and Petroleum Sites) Act 2013*	The NSW *Work Health and Safety (Mines and Petroleum Sites) Act 2013* aims to assist in securing and promoting the health, safety and welfare of people at work at coal operations. Centennial Mandalong hold all necessary approvals under the Act and operations will continue to be regulated under the provisions of the Act.
NSW *Water Act 1912* (Water Act)	The Water Act governs access, trading and allocation of licences associated with surface water and groundwater sources where a water sharing plan is not in place. The Water Act applies to groundwater interference, bore installation and extraction of groundwater. No further licenses or allocation are required for Mandalong as a result of the proposed modification.

Table 5.3 Other relevant NSW State legislation

NSW legislation	Comment
NSW *Water Management Act 2000* (WM Act)	The WM Act is intended to ensure that water resources are conserved and properly managed for sustainable use benefitting both present and future generations. Water sharing plans prepared in accordance with the WM Act include rules for protecting the environment and administrating water licencing and trading. By the operation of Section 89J of the EP&A Act, Mandalong does not require water use approvals under Section 89, water management approvals under Section 90 or a controlled activity approval under Section 91 of the WM Act.
NSW *Mining Act 1992*	Under Part 2 of the Mining SEPP, mining may be carried out with consent on land that is the subject of a ML under the NSW *Mining Act 1992*. No changes to Centennial Mandalong's existing mining tenements are required as part of the proposed modification.
NSW *Rural Fires Act 1997* (RF Act)	The main objectives of the RF Act are to: • prevent, mitigate and suppress bush and other fires in NSW; • co-ordinate bushfire fighting and bushfire prevention throughout the State; • protect people from injury or death and property from damage as a result of bushfires; and • protect the environment. Under Section 63 of the RF Act, owners and occupiers of land have a duty to take practicable steps to prevent the occurrence of bushfires on, and to minimise the danger of the spread of bushfires on or from, that land. Mandalong will continue to be operated in a manner that minimises ignition risks and provides for asset protection consistent with relevant RFS design guidelines.

5.4 Local environmental plans

As stated in Section 2.3, the majority of the approved underground mining area is zoned a mix of E2 Environmental Conservation, E3 Environmental Management, RU2 Rural Landscape and RU3 Forestry pursuant to the Lake Macquarie LEP. Land use zoning above LW34 and within the immediate surrounds pursuant to the Lake Macquarie LEP and Wyong LEP is shown on Figure 2.2 and includes:

- E2 – Environmental Conservation;
- E3 – Environmental Management;
- RU3 – Forestry; and
- RE1 – Public Recreation.

The Mining SEPP aims to provide for the proper management and development of mineral, petroleum and extractive material resources for the social and economic welfare of NSW.

Sub-clause 7(1)(a) of the Mining SEPP states that development for the purpose of underground mining may be carried out on any land with development consent. In relation to any inconsistency between the Mining SEPP and an environmental planning instrument, sub-clause 5(3) provides that the Mining SEPP prevails to the extent of the inconsistency.

On this basis, any provision in the Lake Macquarie LEP or Wyong LEP that would otherwise operate to prohibit the proposed modification has no effect. The proposed modification is therefore permissible with development consent.

5.5 Strategic Regional Land Use Policy

5.5.1 Biophysical strategic agricultural land

The NSW Government's *Strategic Regional Land Use Policy* was introduced in September 2012 and sets out a range of initiatives to better balance growth in the mining industry with the need to protect agricultural land and water resources.

Biophysical strategic agricultural land (BSAL) is defined as land with high quality soil and water resources capable of sustaining high levels of productivity. A total of 2.8 million hectares of BSAL has been identified and mapped at a regional scale across NSW and includes land capable of sustaining high levels of productivity. BSAL within proximity of LW34 is shown on Figure 7.1.

An agricultural impact statement and land and soil capability (LSC) assessment (including consideration of BSAL) were undertaken by GSSE (2013b; 2013c) as part of the *Mandalong Southern Extension Project EIS* (GSSE 2013a). The study area adopted for these assessments included consideration of the land above LW34. The assessments concluded that there were no areas of potential BSAL within the study area.

The proposed modification will not result in any impact to BSAL and no changes to LSC classes are anticipated.

5.5.2 NSW Aquifer Interference Policy

The AIP is a key component of the NSW Government's *Strategic Regional Land Use Policy*. The AIP clarifies the water licensing and approval requirements for aquifer interference activities, including the taking of water from an aquifer in the course of carrying out mining, and defines the considerations for assessing potential impacts to key water-dependent assets.

Centennial Mandalong currently holds several groundwater monitoring licences under the provisions of the *Water Act* for the purposes of monitoring groundwater levels within the development consent boundary.

WAL 39767 is also held by Centennial Mandalong under the WM Act permitting the extraction of up to 1,825 ML/year of groundwater from the coal seam as part of the process of mining (ie dewatering).

Groundwater drawdown impacts are considered to be less than the Level 1 impact considerations under the AIP (Section 7.2.3 and Appendix B). No impacts to registered groundwater users or groundwater dependent ecosystems (GDEs) are predicted.

6 Stakeholder engagement

6.1 NSW Department of Planning, Industry and Environment

Centennial Mandalong wrote to DPIE on 10 June 2021 to introduce the proposed modification and seek advice with regard to the assessment pathway and scope of this MR. DPIE responded on 8 July 2021 to confirm the assessment scope and nominated application under Section 4.55(2) of the EP&A Act as the appropriate approval pathway. A copy of this correspondence is provided in Appendix H. Feedback provided by DPIE and how this has been addressed is summarised in Table 6.1.

Table 6.1 Feedback from DPIE and how it has been addressed

Matter raised	Response
DPIE nominated that the application will be assessed as a Section 4.55(2) application under the EP&A Act.	The approval pathway for the modification is nominated and described in Section 5.3.1 of this MR.
DPIE were satisfied with the preliminary identification of key issues and supported the key areas of focus in the proposed assessment approach, which include: • subsidence; • surface water; • groundwater; • Aboriginal cultural heritage and historic heritage; • biodiversity; • socio-economics; and • GHG.	Chapter 7 addresses the potential impacts of the proposed modification and includes a summary of the findings of the following assessments: • mine subsidence assessment (Appendix A); • WRIA (Appendix B); • flooding impact assessment (Appendix C); • ACHA (Appendix D); • BDAR (Appendix E); • socio-economic impact assessment (Appendix F); and • GHG emissions assessment (Appendix G). Other environmental aspects are also considered in Table 7.6.

6.2 Lake Macquarie City Council

A letter was sent to LMCC on 16 August 2021 to introduce the proposed modification and notify them that a MR will be submitted to DPIE (Appendix H). No feedback on the proposed modification has been received to date.

6.3 Central Coast Council

A letter was sent to Central Coast Council on 16 August 2021 to introduce the proposed modification and notify them that a MR will be submitted to DPIE (Appendix H). No feedback on the proposed modification has been received to date.

6.4 Mandalong Mine Community Consultative Committee

The Mandalong Mine CCC comprises of representatives from the local community and LMCC and is independently chaired. The CCC meets on a quarterly basis and provides a forum for open discussion between Centennial Mandalong, the community, LMCC and other stakeholders on issues directly relating to Mandalong Mine's operation, environmental performance and community relations.

The proposed modification has been discussed at CCC meetings on 23 February and 22 June 2021.

During the February meeting, the chair sought CCC members' views on the proposed changes to the distribution of Centennial Mandalong's annual contributions. As discussed in Section 4.1.3, as part of the proposed modification, approval is sought to remove the Lake Macquarie Foundation as the administrator of the fund and include the CCC in the decision-making process for the allocation of these funds. All CCC members present at the meeting were in favour of the proposed approach.

No feedback regarding the proposed amendments to the mine plan or changes to Mandalong's statement of commitments have been received to date.

6.5 Aboriginal stakeholders

Aboriginal stakeholders were identified and consulted in accordance with *Aboriginal Cultural Heritage Consultation Requirements for Proponents* (DECCW 2010). A detailed description of consultation is presented in Appendix D and a summary is provided in Section 7.4.

6.6 Private landholders

There is one private dwelling ('55' on Figure 7.1) within the angle of draw (AOD) for the proposed LW34. An additional private dwelling ('34' on Figure 7.1) is within the area of influence of LW34 that is described in Appendix A and extends beyond the 20 mm subsidence contour.

Engagement with these landholders commenced in October 2019 in relation to the Extraction Plans and property subsidence management plans for LW30–LW33 and included discussions of mine design options and potential changes. Consultation with these landholders in relation to the proposed modification commenced in July 2021. No feedback regarding the proposed modification has been received to date.

6.7 Other stakeholders

6.7.1 NSW Rural Fire Service

A letter was sent to RFS on 16 August 2021 to introduce the proposed modification and notify RFS that a MR will be submitted to DPIE (Appendix H). No feedback on the proposed modification has been received to date.

6.7.2 Subsidence Advisory NSW

A letter was sent to Subsidence Advisory NSW on 16 August 2021 to introduce the proposed modification and notify them that a MR will be submitted to DPIE (Appendix H). A representative from Subsidence Advisory NSW contacted Centennial Mandalong on 10 September 2021 and confirmed that Subsidence Advisory NSW had no concerns regarding the proposed modification.

6.7.3 Crown Land

A letter was sent to Crown Land on 16 August 2021 to introduce the proposed modification and notify them that a MR will be submitted to DPIE (Appendix H). No feedback on the proposed modification has been received to date.

6.7.4 Forestry Corporation of NSW

A letter was sent to Forestry Corporation of NSW on 16 August 2021 to introduce the proposed modification and notify them that a MR will be submitted to DPIE (Appendix H). No feedback on the proposed modification has been received to date.

6.7.5 Telstra

A letter was sent to Telstra on 16 August 2021 to introduce the proposed modification and notify them that a MR will be submitted to DPIE (Appendix H). No feedback on the proposed modification has been received to date.

7 Assessment of impacts

This section addresses the potential impacts of the proposed modification.

7.1 Subsidence

7.1.1 Overview

DGS has undertaken a mine subsidence assessment of the surface features above the proposed LW34 (Appendix A). The assessment incudes a comparison of predicted maximum subsidence effects between the approved and proposed longwall layouts.

The AOD refers to the area within the line drawn from the limits of extraction of LW34 at the seam level to the 20 mm subsidence contour at the surface (Figure 7.1). The 20 mm subsidence contour is an industry-defined limit and represents the practical measurable limit of subsidence. The 'area of influence' may extend beyond the 20 mm subsidence contour and refers to the area within which far-field subsidence effects could be experienced. The AOD and area of influence have been referenced below as indicators of the extent of potential surface impacts associated with the proposed LW34.

7.1.2 Existing environment

Surface features within the area of influence of the proposed LW34 include:

- first, second and third order tributaries of Morans Creek, Mannering Creek and Buttonderry Creek;
- twelve Aboriginal cultural heritage sites;
- four steep slopes (18° to 30°);
- rocky outcrops and large boulders;
- Toepfers Road and Kiar Ridge Road; and
- two houses with ancillary structures, driveways and fences.

The locations of these features relative to the proposed LW34 are shown in Figure 7.1.

7.1.3 Impact assessment

i Subsidence predictions

Subsidence effect predictions for the proposed LW34 have been assessed using the empirical models presented in the subsidence assessment for the Mandalong Southern Extension Project (DGS 2013). The assessment included consideration of:

- the panel void width (W), average panel cover depth (H) and mining height (T);
- the subsidence reduction potential (SRP) of the overburden and the influence of Mandalong beam thickness (t) and its distance above the mine workings (y);

- the behaviour of the chain pillars and immediate roof and floor system under double abutment loading conditions when longwalls have been extracted along both sides of the pillars; and

- the combined effects of single panel and chain pillar subsidence to estimate final subsidence profiles and subsidence contours for subsequent consideration of environmental impacts.

As noted in Section 1.5, since the approval of MOD 9, Centennial Mandalong has continued to review the progression of underground mining within the Mandalong Southern Extension Area. As a result, LW30 has been shortened, LW33 has been removed from the mine plan and it is proposed LW34 is added. The changes to LW30 and LW33 will be made separately through the Extraction Plan process. The predicted maximum subsidence effects of these changes have been considered.

The mining geometry and subsidence effects for LW30–LW32 and the proposed LW34 are presented in Table 1 of Appendix A. The predicted subsidence effects for the proposed LW34 are compared against the approved LW30–33 predictions (ie MOD 9) in Table 7.1.

Table 7.1 Comparison of predicted maximum subsidence effect for the approved longwall layout and the proposed modification

Parameter	Unit	Approved layout – MOD 9 (ie LW30–33)	Proposed modification – MOD 10 (ie LW34)
Final panel subsidence	m	0.92–1.33	0.49–1.39
Final maximum chain pillar subsidence	m	0.60–1.13	0.69–0.87
Maximum panel tilt*	mm/m	6–22	6–22
Maximum panel convex curvature*^	km^{-1}	0.2–0.7	0.3–0.7
Maximum panel tensile strain*	mm/m	2–7	3–7
Maximum panel concave curvature*^	km^{-1}	0.3–0.9	0.4–0.9
Maximum panel compressive strain*	mm/m	3–9	4–9

Notes: *mean and upper 95% confidence limit (U95%CL) values; ^curvatures = 0.1 x strain (conservative).

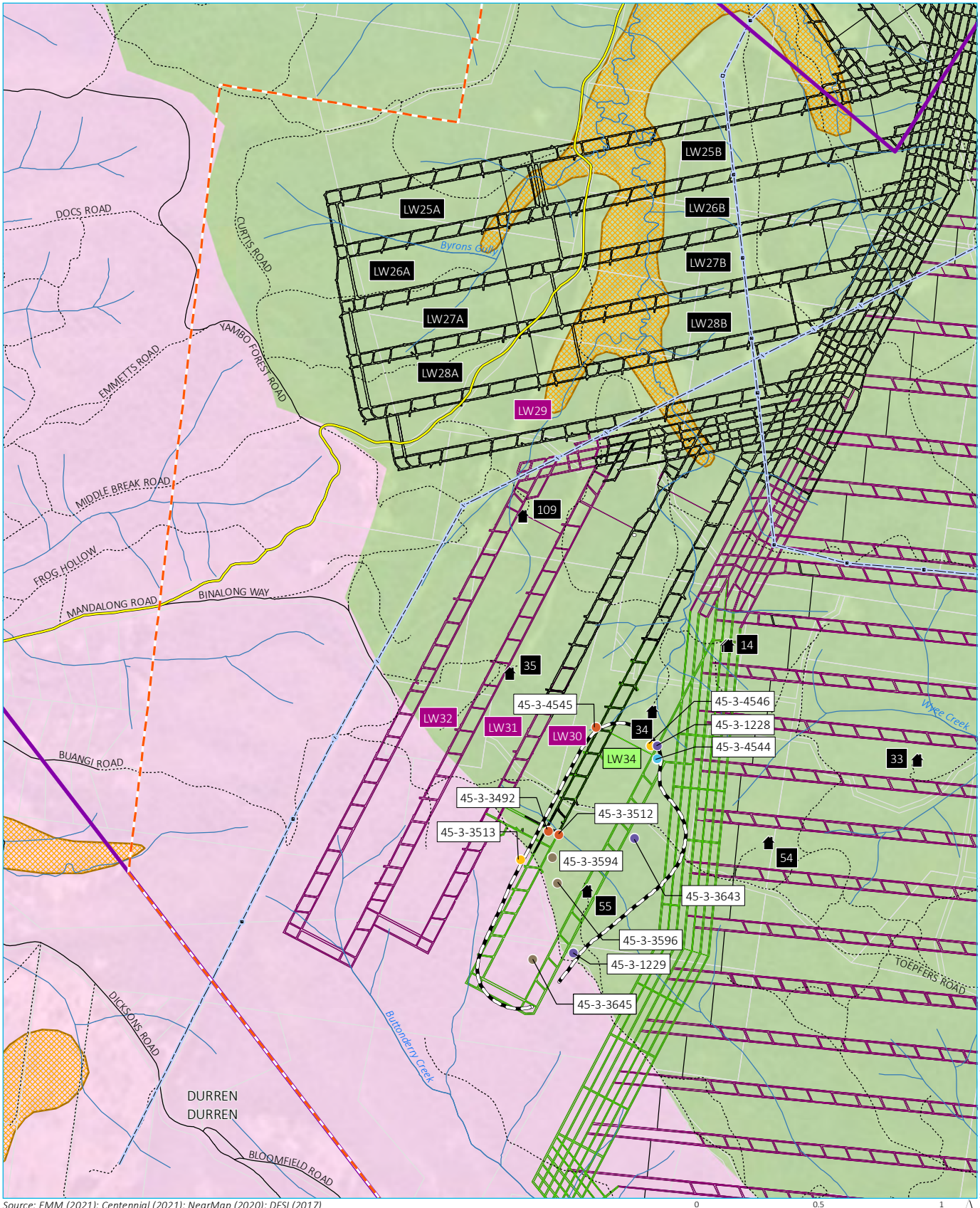
With the exception of an increase to the predicted range of final panel subsidence, predicted subsidence effects for LW34 are within the predicted ranges for the previously assessed and approved underground mine plan.

ii Impacts on surface features

The proposed modification's potential to affect surface features above LW34 has been assessed.

It is noted in DGS (2013) that predicted final maximum panel subsidence magnitudes of 0.9 m–1.3 m may result in the occasional surface crack developing within the limits of the extracted panels in low to moderately undulating terrain (ie slopes <18°). Based on predicted maximum tensile strains of 3 mm/m to 7 mm/m, crack widths were estimated by DGS (2013) to range from 30 mm to 70 mm wide where shallow or exposed rock exists. Cracking is unlikely to occur where there are deep soil or alluvium profiles, as the strain will be more uniformly distributed and absorbed.

Surface cracks ranging from 30-mm to 70-mm wide may occur in relatively flat terrain where there are shallow or exposed rocks (ie along creek beds) or where there are relatively stiff built features (ie roads and culverts). Wider cracks of up to 320 mm may occur on the upper slopes and at or behind slope crests.



Source: EMM (2021); Centennial (2021); NearMap (2020); DFSI (2017)

0 0.5 1 km

GDA 1994 MGA Zone 56

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KEY

- Private residence
- Biophysical strategic agricultural land
- Flooding assessment project area
- Development consent boundary
- Electricity transmission line
- Angle of draw - LW34 (20 mm subsidence contour)
- Main road
- Minor road
- Vehicular track
- Watercourse
- Cadastral boundary

Mine workings

- Proposed amendments
- Approved workings
- Completed mine workings

AHIMS site

- Grinding groove
- Habitation structure
- Rock shelter with artefacts and PAD
- Rock shelter with PAD
- Rock shelter with art

Catchment boundaries

- Lake Macquarie
- Wyong River

Surface features above the proposed LW34

Mandalong Mine Modification 10
Modification report
Figure 7.1

EMM creating opportunities

a Steep slopes

There are four steep slopes above the proposed LW34 that range between 18° and 30°. There are also several rocky sandstone outcrops (3 m–10 m) on the steep slopes which form terraced, continuous profiles of lengths greater than 20 m. Slopes are within the interbedded mudstone and sandstone beds of the Patonga Claystone and Tuggerah Formations. The borehole logs in the area indicate the bedding dips towards the south-west at 1°–2°. There are several concave and convex breaks in slope due to transitioning of sandstone-dominant to claystone-dominant lithologies.

The proposed LW34 may cause subsidence of the steep slopes of up to 1.39 m with tilting of up to 15 mm/m (±1˚) and strain of ±3 mm/m. Based on the subsidence effect predictions and observed subsidence above LW25–LW29, surface cracks ranging from 150 mm to 320 mm width are predicted to occur along the slopes above the proposed LW34. Tensile strains are also expected to migrate up-slope and concentrate along undermined ridges. Compressive strains are expected to migrate downslope or along the low sides of the longwalls.

The approved longwalls were previously assessed as 'unlikely' to cause deep seated or shallow instability on the slopes due to tilting and/or cracking impacts with saturated slope Factor of Safety (FoS) >1.5.

The predicted post-mining surface slope gradient changes (based on U95%CL values) for the proposed LW34 are presented in Figure 8 of Appendix A and are consistent with the findings presented in DGS (2020a; 2020b).

The changes to the previously assessed FoS are only 'slightly' decreased (<1%) and the likelihood of instability is unlikely to change as a result of the proposed modification.

b Rock falls

The predicted subsidence and associated tilt and strains could result in minor cracking along existing rock faces or rock outcrops on steep slopes and along watercourses. It is possible that sandstone boulders will be released downslope due to the presence of cliff lines greater than 5 m within the AOD for the proposed LW34; however, it is noted that this risk is already present due to natural weathering processes. The risk of property damage due to rock falls is considered very low.

c Watercourses

There is a first order tributary of Buttonderry Creek within the potential area of influence for the proposed LW34; however, it is outside of the AOD and won't be directly subsided or impacted by the proposed modification. First, second and third order tributaries of Morans Creek and Mannering Creek are within the AOD for the proposed LW34 (Figure 7.1). Cover depth along the creek bed ranges from approximately 330 m and 335 m.

As a result of the proposed modification, potential changes to the creek beds have been identified as:

- Mannering Creek gradients above the proposed LW34 are expected to increase by 0.6% (0.4˚) and decrease by 0.9% (0.4˚); and
- Morans Creek gradients above the proposed LW34 are expected to decrease by 0.2% (0.1˚).

Changes to surface gradients along creek beds will result in 'minor' to 'negligible' erosional impacts along the creeks. The predicted gradient changes for the creeks are unlikely to result in significant impact differences between the proposed and approved mining layouts.

Minor cracking in creek beds may cause some shallow, sub-surface re-routing of surface flows. Valley closure movements of up to 100 mm may occur across creeks where sandstone beds exist at the surface.

The pre-mining and predicted post-mining ponding depths for the proposed LW34 have been estimated. No significant pre- or post-mining ponding or erosion impacts are expected.

d Power infrastructure

There are no TransGrid towers or Ausgrid power poles within the area of influence of LW34.

There is a domestic power line on one of the private dwellings within the area of influence of LW34; however, the power line itself is outside the 20 mm AOD for the proposed LW34.

e Private dwellings

There are two private dwellings ('34' and '55' on Figure 7.1) within the area of influence of the proposed LW34. The predicted final subsidence effect results for each dwelling are presented in Table 7.2.

Table 7.2 Predicted subsidence effects at private dwellings

Private dwelling ID	Cover depth (m)	Final subsidence (m)	Final maximum tilt (mm/m)	Final maximum curvature (km^{-1})	Final maximum strain (mm/m)
34	312	0.09	0.5	0.01	0.1
55	387	0.18	6	0.15	1.5

The predicted subsidence effects for the two dwellings remain within 'safe, serviceable and repairable' (SSR) limits and unlikely to exceed 'negligible' or 'Category 0' Damage in accordance with AS2870-2011 Residential Slabs and Footings.

f Roads

There are two unsealed, public roads (Toepfers Road and Kiar Ridge Road) within the area of influence of the proposed LW34 (Figure 7.1). Impacts on these roads due to predicted subsidence effects associated with the proposed modification include:

- tensile crack widths of between 10 mm and 20 mm;
- compressive shearing or heaving between 10 mm and 30 mm;
- increase of super-elevation in the road of 0.2%–1.3%; and
- cracking of culverts and fill embankments.

The predicted subsidence effects and impacts due to the proposed modification are consistent with the approved mining layout.

g Aboriginal cultural heritage sites

As discussed in Section 7.4.2, there are 12 Aboriginal cultural heritage sites within the AOD for the proposed LW34 (Figure 7.1). Potential subsidence impacts to these sites for both the previously approved and proposed mine plans (ie addition of LW34) are shown in Table 6B (proposed) and Table 6C (previously approved) of Appendix A.

The likelihood of cracking damage occurring at each of the sites is:

- Morans Creek Corrected (45-3-1228 – rock shelter with art) – unlikely (changed from 'very unlikely' for the previously approved layout);
- Olney Corrected (45-3-1229 – rock shelter with art) – unlikely (changed from 'very unlikely' for the previously approved layout);

- RPS PS07 (45-3-3643 – rock shelter with art) – unlikely (changed from 'very unlikely' for the previously approved layout);
- RPS CYL05 (45-3-3492 – grinding groove) – unlikely (changed from 'likely' for the previously approved layout);
- RPS PS26 (45-3-3512 – grinding groove) – unlikely (changed from 'possible' for the previously approved layout);
- MS9-GG-3 (45-3-4545 – grinding groove) – possible (changed from 'likely' for the previously approved layout);
- RPS PS27 (45-3-3594 – habitation structure – no potential archaeological deposit (PAD) or objects) – very unlikely (changed from 'unlikely' for the previously approved layout);
- RPS PS30 (45-3-3596 – habitation structure – no PAD or objects) – possible (changed from 'very unlikely' for the previously approved layout);
- RPS PS31 (45-3-3645 – habitation structure – no PAD or objects) – possible (changed from 'very unlikely' for the previously approved layout);
- RPS PS28 (45-3-3513 – rock shelter with PAD) – unlikely (changed from 'possible' for the previously approved layout);
- MS9-RS-2 (45-3-4546 – rock shelter with PAD) – unlikely (changed from 'very unlikely' for the previously approved layout); and
- MS9-RS-3 (45-3-4544 – rock shelter with artefacts and PAD) – unlikely (changed from 'very unlikely' for the previously approved layout).

Potential subsidence impacts on Aboriginal cultural heritage sites are discussed further in Section 7.4.

h Historical heritage sites

There are no historical heritage sites within the area of influence of the proposed LW34.

7.1.4 Management and mitigation

Impact management strategies for steep slopes will be detailed in the Extraction Plan and will include consideration of surface monitoring and visual inspections. Subsidence that results in cracking greater than 50 mm wide on steep slopes will likely require repair to limit further deterioration of slope stability, increased erosion or adverse safety impacts. Surface crack repair works may also be required during or at the completion of mining the proposed LW34. Crack repairs may involve ripping, backfilling and top dressing works or the pouring of cement-modified sand, fly-ash grout or unbound crushed rock into wider, deeper cracks.

Mandalong currently manages the undermining of residences via property subsidence management plans. This process will continue as part of the proposed modification.

Aboriginal cultural heritage will continue to be managed in accordance with the *Northern Region Aboriginal Cultural Heritage Management Plan* (ACHMP) and any subsequent Aboriginal Cultural Heritage Management Plan prepared to support the Extraction Plan.

7.1.5 Conclusion

Subsidence effects for the proposed modification and potential increases in subsidence due to geological disturbance of the overburden above the proposed LW34 are predicted to be similar to the predicted subsidence effects assessed and approved as part of MOD 9 and the Mandalong Southern Extension Project. The proposed modification will not increase previously assessed impacts for any identified natural or built features by greater than 10%.

7.2 Water resources

7.2.1 Overview

A water resources impact assessment (WRIA) assessing the groundwater and surface water impacts of the proposed modification was prepared by GHD (Appendix B). The assessment:

- reviewed the existing condition of groundwater and surface water systems;
- identified components of the proposed modification with the potential to impact groundwater and surface water environments;
- assessed the potential impacts of the proposed modification on:
  - groundwater levels and quality;
  - water and salt balance;
  - waterway geomorphology;
  - surface water quality; and
  - downstream water users (including licensed water users and basic landholder rights); and
- recommended measures to avoid, minimise and mitigate potential impacts.

GHD has updated the groundwater model for Mandalong to reflect the proposed changes to the underground mine plan and compare potential groundwater impacts to those assessed and approved under SSD-5144 (Appendix B).

The modification area adopted for the WRIA is the land within the AOD for the 20 mm subsidence contour for the proposed LW34 (ie the area within which subsidence may occur) (Figure 7.1).

7.2.2 Existing environment

i Groundwater

a Local hydrogeology

As noted in Section 2.4.2, the groundwater sources in the vicinity of the mine are generally low yielding and predominantly within the clayey Quaternary alluvium, weathered and/or fractured sandstone and coal seams. They generally are classified as 'less productive' in accordance with the AIP as yields are generally less than 5 L/s and/or the TDS concentration is typically greater than 1,500 mg/L.

b Groundwater users

There are approximately 167 bores within a 5 km radius of the approved mining area with:

- 84 registered as monitoring/test bores;
- 1 registered for monitoring/town water supply; and
- 82 registered for domestic, irrigation, farming and/or stock use.

The registered domestic and stock bores that were identified primarily extract groundwater from the Triassic sandstone and conglomerate formations with yields generally less than 1 L/s.

There are three bores within 2 km of the proposed LW34 (GW201651, GW201652 and GW201653), all of which are monitoring bores owned by Centennial Mandalong.

c Groundwater dependent ecosystems

A number of potential GDEs have been identified within the development consent boundary:

- Coastal Wet Gully Forest;
- Freshwater Wetland Complex; and
- Alluvial Tall Moist Forest.

These potential GDEs generally coincide with creeks and drainage lines. GDEs with potential to occur within the modification area are likely to be moist sheltered gully forest along creeks and are not considered to be completely reliant on groundwater. No high priority GDEs listed in the relevant Water Sharing Plans (ie North Coast Fractured and Porous Rock Groundwater Sources and Hunter Unregulated and Alluvial Water Sources) have been identified within or adjacent to the modification area.

d Groundwater monitoring

Mandalong's groundwater monitoring network includes monitoring bores in alluvial and fractured and porous rock groundwater sources. Bores are monitored quarterly for groundwater levels and quality (electrical conductivity (EC) and pH) while some bores contain water level loggers for continuous monitoring of groundwater levels.

No monitoring bores have been installed within the area immediately surrounding the proposed LW34 due to the high depth of cover above the West Wallarah Seam and low risk of impact to alluvial groundwater sources. The closest monitoring bores are north of this area above LW26 (MSGW03A, MSGW03B and MSGW03C).

ii Surface water

a Overview

The majority of land within the development consent boundary lies within the broader catchment of Lake Macquarie, with the southern portion within the Wyong River catchment. The local surface water environment is described in detail in Section 2.4.2 and Chapter 3 of Appendix C.

b Surface water management

Surface water runoff from areas where there is no coal storage, transportation, handling or processing, or any disturbance is considered to be clean water, as it is unlikely to be contaminated with coal fines or sediment.

Mandalong's existing surface water management system is described in detail in the WMP and has progressively developed over the life of Mandalong. No changes to the WMP will be required as part of the proposed modification.

c Surface water users

There are licenced surface water users on the Wyong River; however, the area above the proposed LW34 comprises less than 1% of the total catchment area of the Wyong River and therefore potential impacts on downstream water users on the Wyong River are considered negligible and have not been assessed.

No downstream surface water users were identified on Buttonderry Creek. Licenced surface water users on Morans Creek and Mannering Creek were previously identified and assessed by GHD (2017). Adverse impacts to downstream surface water users on Morans Creek and Mannering Creek were considered unlikely due to the low risk of potential impact and the ephemeral nature of the waterways (GHD 2017).

d Surface water monitoring

Surface water quality monitoring is undertaken on Morans Creek (SWMP06 and SWMP07) and Buttonderry Creek, (SWMP08) (Figure 5.3 of Appendix B). Central Coast Council also undertake monitoring upstream of the Buttonderry Waste Management Facility (Figure 5.3 of Appendix B). There is also a flow and level gauge on Morans Creek approximately 8 km downstream of the proposed LW34.

No surface water quality monitoring is currently undertaken on Mannering Creek.

7.2.3 Impact assessment

i Groundwater inflows

Modelled groundwater inflows for the approved and proposed mining layout are presented in Figure 7.2.

Total groundwater inflows into the connected Cooranbong Colliery, Mandalong and Mandalong South workings under proposed conditions are predicted to peak at approximately 2 ML/day (735 ML/year) in 2035.

The peak predicted groundwater inflow for the proposed modification is slightly lower than the peak groundwater inflow assessed as part of MOD 9. The minor differences in results are predominantly attributed to the changes in the size and number of longwalls (including shortening of LW30, removal of LW33 and addition of LW34).

All groundwater take is from the fractured and porous rock groundwater source (not alluvium). As noted in Section 3.5, Centennial Mandalong holds WAL 39767 which allows for the extraction of up to 1,825 ML/year from the Cooranbong underground storage area via the Cooranbong bore. The predicted peak groundwater inflow under proposed conditions remains well below the entitlement of 1,825 ML/year.

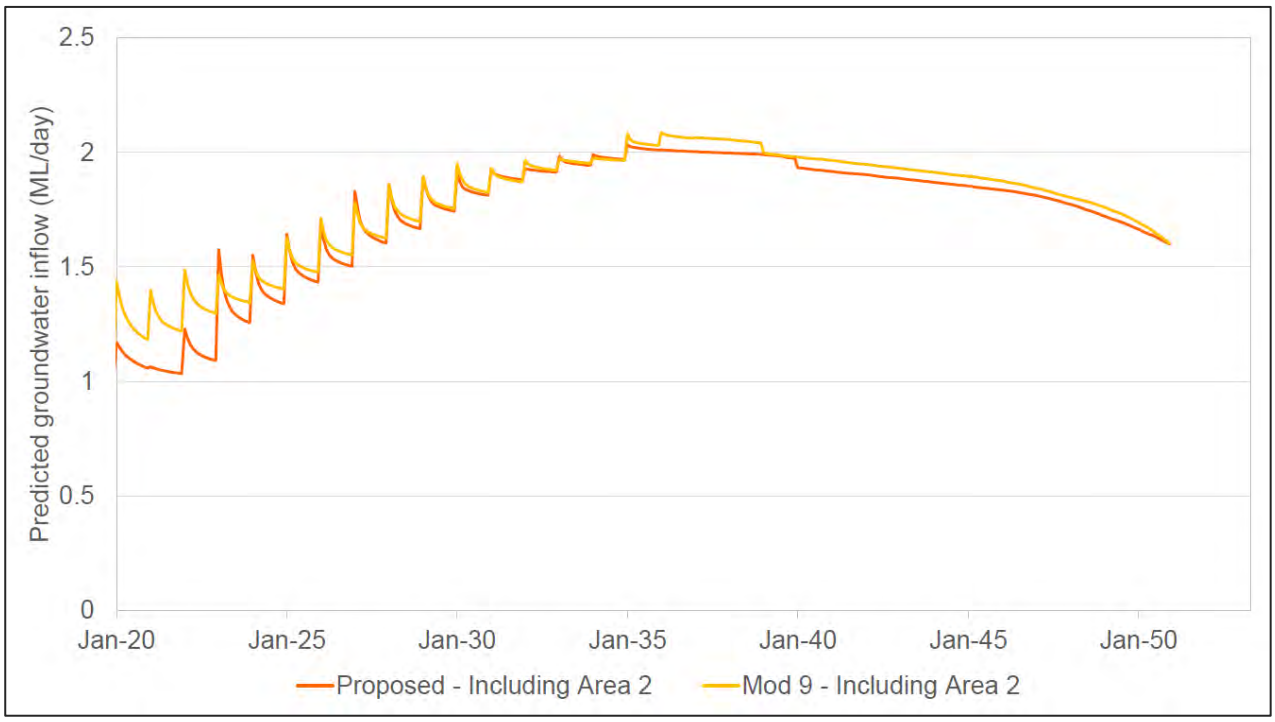


Figure 7.2 Comparison of modelled groundwater inflows (approved (MOD 9) and proposed conditions)

Note: Area 2 is approved for bord and pillar first workings. No changes to Area 2 are proposed as part of MOD 10. The reference to Area 2 has been included in Figure 7.2 as this area was specifically considered as part of a recent groundwater model update.

ii Groundwater drawdown

Based on the results of the groundwater model, underground mining is unlikely to result in a water table drop greater than 0.1 m within the alluvial groundwater throughout the period of mining. Any reductions in alluvial groundwater levels are expected to be temporary and localised and may occur during undermining as a result of the development of shallow tensile and compressive cracks and resulting localised increases in hydraulic conductivity and porosity. It is expected that these cracks will fill over time and the hydraulic conductivity and porosity should return to pre-mining values.

As shown in Figure 7.3, the proposed modification is predicted to result in a reduction to the extent of the 2 m drawdown contour, which is expected to contract by approximately 700 m to the south and west (when compared with the previously approved mine plan).

The predicted impacts on alluvial groundwater and fractured and porous rock groundwater attributable to the proposed modification are expected to be less than the Level 1 minimal impact considerations from the AIP and are therefore considered acceptable.

Groundwater drawdown at registered bores and GDEs will remain within Level 1 impact considerations of the AIP.

iii Groundwater quality

Alluvial groundwater is consistently between pH 5 and 8 and groundwater EC varies considerably within the alluvium across the development consent boundary, ranging from less than 1,000 µS/cm to over 10,000 µS/cm. Fractured and porous rock groundwater is consistently between pH 6 and 8, with EC typically ranging from about 6,000 µS/cm to over 10,000 µS/cm.

Since longwall mining commenced at Mandalong in 2005, no changes in groundwater pH or EC resulting in a lowering of the beneficial use category have been identified. The proposed modification is not expected to reduce the beneficial use category of alluvial groundwater or fractured and porous rock groundwater.

iv Water and salt balance

Water balance modelling results predicted that rainfall, runoff, evaporation, transfers from CES and potable water supply to the underground workings will be similar for approved and proposed conditions. It is predicted that groundwater inflows will be slightly decreased and therefore discharges via LDP001 will be slightly lower than for the approved conditions.

The water and salt balance modelling predicts a decrease in groundwater flows into the underground mining areas. The maximum groundwater inflow (predicted to occur in 2035) is predicted to decrease from 746 ML/year to 736 ML/year.

The average salinity of groundwater inflows was estimated to be 6,610 µS/cm. Salt associated with groundwater inflows was modelled to decrease from approximately 3,302 t/year for approved conditions to approximately 3,260 t/year for proposed conditions in 2035.

The proposed modification is predicted to result in a slight decrease in the volume of mine water discharged through LDP001 at CES (ie from 1,179 ML/yr to 1,171 ML/yr in 2035).

v Surface water quality

Baseline surface water quality monitoring has identified some metal species are elevated relative to default guideline values and nearby Morans Creek.

Subsidence fracturing may expose previously unweathered near-surface rock, which when weathered can release substances such as aluminium, cobalt, iron, manganese, nickel and zinc into surface water or shallow groundwater. Elevated salinity and potentially ecotoxic metal concentrations could be observed downstream of areas with such subsidence fracturing.

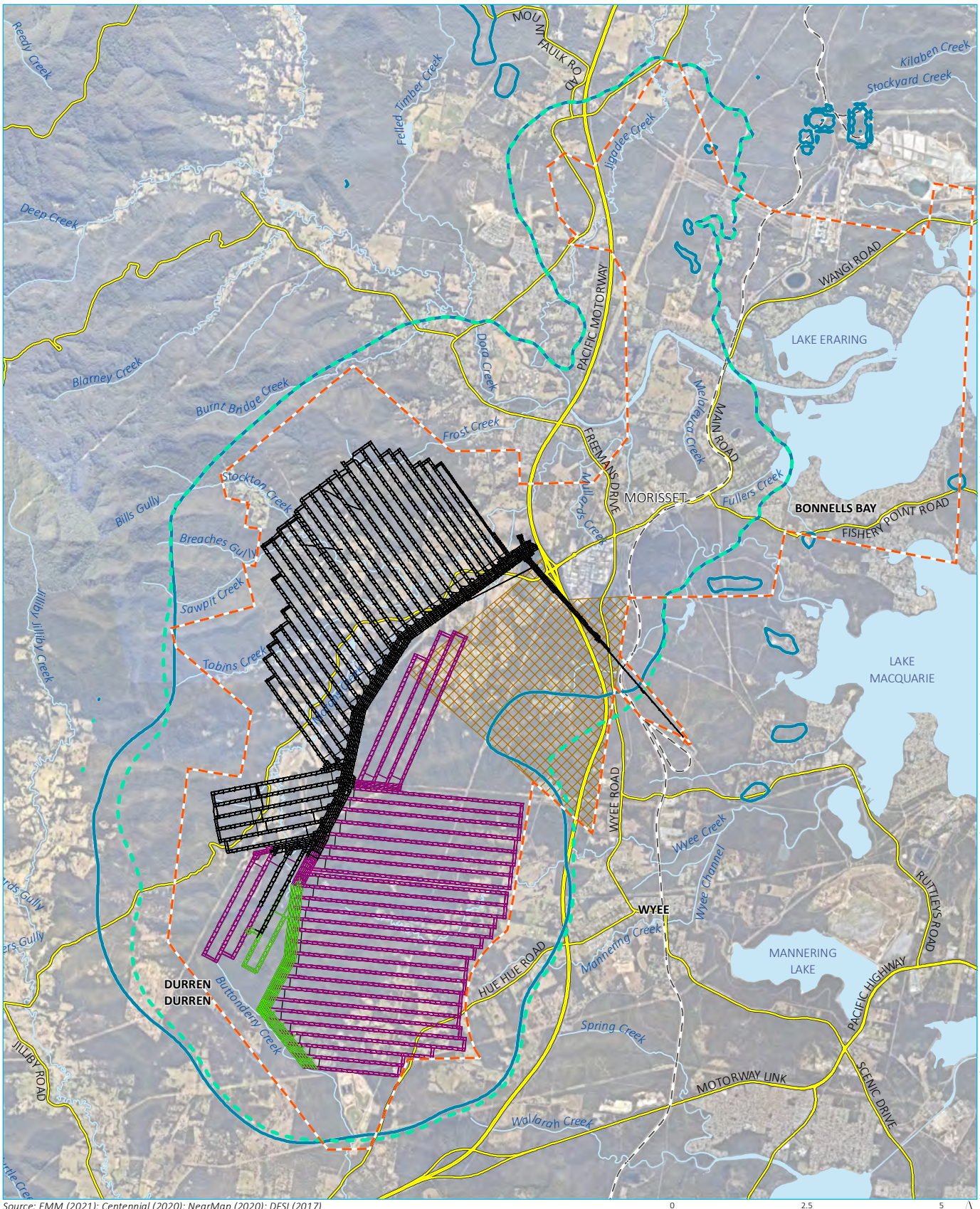
As noted in Section 7.1.5, subsidence effects for the proposed modification and potential increases in subsidence due to geological disturbance of the overburden above the proposed LW34 are predicted to be similar to the predicted subsidence effects assessed and approved as part of MOD 9 and the Mandalong Southern Extension Project. Potential impacts on surface water quality are therefore likely to be consistent with those previously assessed and approved.

Changes to localised subsurface flow diversions and decreased surface water connectivity, which can lead to reduced dissolved oxygen concentrations (due to decreased re-aeration from turbulent flow) and iron precipitation as a result of the proposed modification are considered unlikely.

vi Watercourse geomorphology

Subsidence can impact watercourse integrity by changing channel morphology and behaviour due to changes in valley floor tilt and bed cracking. The proposed modification has potential to impact the geomorphic behaviour and character of watercourses within the modification area.

The watercourses considered as part of the WRIA are bedrock-confined and therefore have low susceptibility to geomorphic impacts. Potential impacts on watercourse geomorphology are therefore likely to be consistent with those previously assessed and approved.



Source: EMM (2021); Centennial (2020); NearMap (2020); DFSI (2017)

0 2.5 5 km

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KEY

- Development consent boundary
- Area 2: Bord and Pillar Extraction
- Rail line
- Main road
- Named watercourse
- Named waterbody
- Approved groundwater drawdown contour (2 m)
- Proposed groundwater drawdown contour (2 m)

Mine workings

- Proposed amendments
- Approved workings
- Completed mine workings

Groundwater drawdown

Mandalong Mine Modification 10
Modification report
Figure 7.3

EMM
creating opportunities

vii Downstream water users

No potentially impacted downstream surface water users were identified and therefore no impacts are expected.

7.2.4 Management and mitigation

Groundwater and surface water will continue to be managed in accordance with the WMP.

Following approval of the proposed modification, the WMP and *Northern Operations Discharge Management Plan* (Centennial 2016) will be reviewed and, if necessary, updated to include any changes to water management required by the proposed modification.

7.2.5 Conclusion

No significant changes to the groundwater and surface water impacts previously assessed and approved under SSD-5144 have been identified. Groundwater drawdown impacts are considered to be less than the Level 1 impact considerations under the AIP. No impacts to registered groundwater users or GDEs are predicted. Groundwater and surface water monitoring and management will continue at Mandalong in accordance with the WMP.

7.3 Flooding

7.3.1 Overview

Umwelt completed an assessment of flood impacts associated with the proposed changes to the underground mine plan (Appendix C).

The project area adopted as part of this assessment is defined on Figure 7.1 and encompasses an area of 4,464 ha in the southern portion of the development consent boundary.

A two-dimensional hydrodynamic flood model was employed to model flood behaviour for several design storm events within the project area. Consistent with previous flooding assessments (including those prepared for the *Mandalong Southern Extension Project EIS* (GSSE 2013a), Mod 4, Mod 5 and Mod 9), only watercourses of third order and higher have been modelled (ie Morans Creek only). As the tributaries of Buttonderry Creek and Mannering Creek are first and second order watercourses within the vicinity of LW34, they have not been included in the hydraulic modelling.

7.3.2 Existing environment

As noted in Section 2.4.2, the majority of the land within the development consent boundary lies within the broader catchment of Lake Macquarie, with the southern portion within the Wyong River catchment (Figure 7.1). The project area intersects five sub catchment areas:

- Morans Creek, Wyee Creek and Mannering Creek catchments which flow to Lake Macquarie; and
- Buttonderry Creek and Jilliby Creek catchments which flow to the Wyong River.

A small portion of the upstream catchments of Morans Creek, Buttonderry Creek and Mannering Creek are within proximity of the proposed LW34.

7.3.3 Impact assessment

The flooding assessment considered if subsidence from underground mining has the potential to impact flood behaviour within the project area, including on:

- catchment area boundaries;
- watercourse stability and associated water quality;
- remnant ponding; and
- flood regimes.

The flooding assessment considered if changes in flood behaviour have potential to impact environmental flows and/or downstream users.

i Catchment area boundaries

Catchment boundaries of the creek systems to be undermined will not change significantly as a result of the proposed modification (relative to approved mining activities under SSD-5144).

ii Watercourse stability and associated water quality

Longwall subsidence within the project area has the potential to impact the physical characteristics and hydraulic response of flows within a watercourse. Subsidence can cause changes to the longitudinal grades which can impact flow velocities and tractive stresses at various locations. An increase in tractive stress can result in increased erosion and sediment transport. Changes to flow velocity and tractive stress during flood events can impact the stability of a watercourse, causing scouring, changes to channel geometry and/or rerouting of the watercourse.

Analyses of the Mannering Creek, Morans Creek and Buttonderry Creek long sections indicate the proposed LW34 will not change watercourse stability impacts for Mannering Creek, Morans Creek or Buttonderry Creek when compared to approved mining activities under SSD-5144.

iii Remnant ponding

The proposed modification has the potential to cause or increase remnant ponding (ie ponding that occurs after prolonged rainfall and/or flooding) within the area affected by subsidence. Analysis of remnant ponding for the proposed modification compared with remnant ponding for approved mining activities under SSD-5144 indicates:

- remnant ponding is typically confined to existing flow paths (Figure 4.2 of Appendix C);
- minor increases in remnant ponding may occur along Buttonderry Creek; and
- there will be negligible change in remnant ponding along Mannering Creek and Morans Creek.

Compared to the approved mining scenario, a slight increase in total remnant ponding area of 0.01 ha is predicted (ie an increase of less than 1%).

The majority of the change in the area of remnant ponding is a result of the different LiDAR dataset and extent used for the approved and proposed mining landforms (relative to the pre-mining landform).

The analysis indicates that potential impacts on remnant ponding are confined to existing flow paths with no predicted impact on access routes to, or within, properties (and residences) within the project area.

iv Flood regimes

The predicted subsidence from the proposed modification may change the flood regime (flood behaviour and flood extent) within the project area and surrounds. However, it will not materially change the flood regime impacts (ie depth, extent, velocity, duration or hazard) for Mannering Creek, Morans Creek or Buttonderry Creek compared to approved mining activities under SSD-5144.

There are four dwellings within the 100 year average recurrence interval (ARI) flood extent. There will be no change in the 100 year ARI flood level compared with existing approved mining activities under SSD-5144. There will be no change to the number of dwellings within the 100 year ARI flood extent.

No impacts to the functionality of roads during flooding are expected as a result of the proposed modification.

v Environmental flows and downstream users

Long-term predicted losses to baseflows are expected to have negligible impacts on streamflow conditions within potentially affected watercourses.

As there is low potential for changes to water quantities (including annual flow volumes, baseflows and environmental flows), downstream users are unlikely to experience significant changes to water availability as a result of the proposed modification.

The proposed modification will not result in adverse cumulative impacts on water use or flows in the areas within and surrounding the project area.

7.3.4 Management and mitigation

Watercourses will continue to be monitored and mitigation measures will continue to be implemented (where required), through the Extraction Plan process, to reduce the potential for additional scouring.

If increases in remnant ponding are identified during monitoring of subsidence watercourse stability, drainage mitigation works will be implemented.

If subsidence remediation works are required, erosion and sediment control measures will be implemented to assist with remediation and reduce impacts on downstream water quality.

7.3.5 Conclusion

The proposed modification will not significantly change previously assessed and approved flooding impacts.

7.4 Aboriginal cultural heritage

7.4.1 Overview

An ACHA was completed by Umwelt (Appendix D) in accordance with the relevant guidelines.

Consultation with the registered Aboriginal parties (RAPs) regarding activities at Mandalong have been ongoing since 2011. The following RAPs were consulted regarding the proposed modification in accordance with the *Aboriginal Cultural Heritage Consultation Requirements for Proponents* (DECCW 2010):

- Awabakal Descendants Traditional Owners Aboriginal Corporation;
- Awabakal Traditional Owners Aboriginal Corporation;

- Bahtahbah Local Aboriginal Land Council;
- Biraban Local Aboriginal Land Council;
- Cacatua Cultural Consultants;
- Darkinjung Local Aboriginal Land Council;
- Guringai Tribal Link Aboriginal Corporation;
- Wonn1 Contracting; and
- Yula-Punaal Education and Healing Aboriginal Corporation.

The project area adopted for the ACHA is the land within the AOD for the 20 mm subsidence contour for the proposed LW34 (ie the area within which subsidence may occur) and encompasses approximately 52 ha (Figure 7.4).

7.4.2 Existing environment

The project area is made up of ridges, crests, drain lines/watercourses, disturbed terrain and slopes (ranging from gently inclined to steep). Past Aboriginal people would have had access to a range of plant resources utilised for food, medicine, shelter and the manufacture of artefacts. Extensive vegetation clearing would have initially occurred during non-Aboriginal settlement from the mid to late 1800s, resulting in substantial increases to the erosion regime. Contemporary disturbance has occurred from vegetation clearance associated with the establishment and ongoing maintenance of electricity transmission infrastructure, roads and access tracks and private residences.

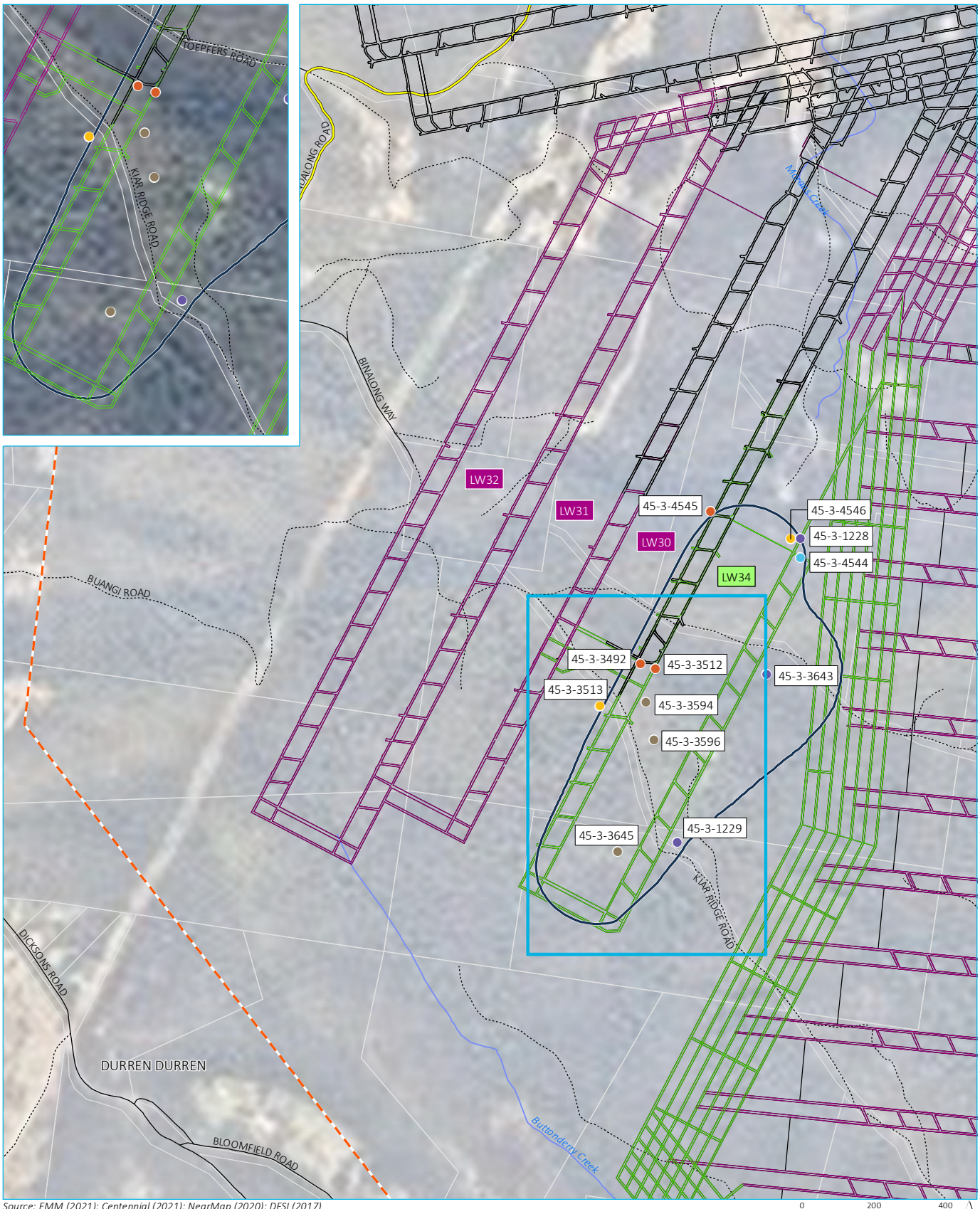
There are 101 sites registered in the Aboriginal Heritage Information Management System (AHIMS) within an approximately 4 km by 4 km area surrounding the project area (Table 7.3). Of these sites, the majority (78%) are on or within sandstone outcrop locations (eg sandstone benches or rock shelters).

Table 7.3 AHIMS sites by site feature

Site feature	Number of sites
Aboriginal resource and gathering	8
Art (pigment or engraved)	8
Artefact	11
Artefact/art (pigment or engraved)	1
Grinding groove	33
Habitation structure	21
Modified tree (carved or scarred)	5
PAD	13
Water hole	1
Total	**101**

There are 12 AHIMS registered sites within, or immediately adjacent to (ie within 15 m of), the project area (Figure 7.4):

- three rock shelters with art:
  - 45-3-1228 – Morans Creek Corrected;
  - 45-3-1229 – Olney Corrected; and
  - 45-3-3643 – RPS PS07;
- three grinding grooves:
  - 45-3-3492 – RPS CYL05;
  - 45-3-3512 – RPS PS26; and
  - 45-3-4545 – MS9-GG-3;
- three habitation structures (no PAD or objects):
  - 45-3-3594 – RPS PS27;
  - 45-3-3596 – RPS PS30; and
  - 45-3-3645 – RPS PS31;
- two rock shelters with PAD:
  - 45-3-3513 –RPS PS28; and
  - 45-3-4546 –MS9-RS-2; and
- one rock shelter with artefacts and PAD:
  - 45-3-4544 – MS9-RS-3.



Source: EMM (2021); Centennial (2021); NearMap (2020); DFSI (2017)

0 200 400 m

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KEY

- Development consent boundary
- ACHA project area
- Main road
- Minor road
- Vehicular track
- Named watercourse
- Cadastral boundary

Mine workings
- Proposed amendments
- Approved workings
- Completed mine workings

AHIMS site
- Grinding groove
- Habitation structure
- Rock shelter with artefacts and PAD
- Rock shelter with PAD
- Rock shelter with art

Aboriginal cultural heritage field survey results and AHIMS sites

Mandalong Mine Modification 10
Modification report
Figure 7.4

EMM creating opportunities

7.4.3 Assessment criteria

i Predictive model

A predictive model was used to consider the archaeological pattern of the local and regional area and the environmental context of the project area. This predicted:

- low potential for the presence of scarred trees in the project area;
- low potential for artefact scatters or isolated finds due to the absence of perennial watercourses and the elevated/inclined nature of the majority of the project area;
- low potential for stone arrangements due to the landforms within the project area and proximity to contemporary disturbance associated with electricity transmission infrastructure, roadways and private residences;
- moderate to high potential for grinding groove sites due to the presence of drainage lines within the project area; and
- moderate potential for rock shelters and rock overhangs due to the known presence of this site type within and surrounding the project area.

ii Survey strategy

Surveys of the project area were undertaken from 14—17 September 2020 and on 21 July 2021 and were attended by two archaeologists, members of the RAPs and representatives from Centennial Mandalong. The project area was surveyed on foot and broken up into four survey units, which were largely based upon cadastral boundaries.

7.4.4 Impact assessment

No new Aboriginal sites were identified during the course of the surveys.

As listed in Section 7.4.2, there are 12 AHIMS registered Aboriginal sites within, or immediately adjacent to, the project area (Figure 7.4). Subsidence from mining activities within the proposed LW34 have potential to impact Aboriginal sites identified within the project area. For example, substantial subsidence can lead to major surface cracking and even the collapse of rock shelters. Minor levels of subsidence can also cause cracking. Predicted subsidence levels for the 12 Aboriginal sites within, or immediately adjacent to, the project area are listed in Table 7.4.

Table 7.4 Subsidence predictions for Aboriginal sites within the project area

Site name (AHIMS number)	Site type	Subsidence (m)	Horizontal strain (mm/m)[1]	Cracking damage potential	Tilt (mm/m)	Erosion damage potential
Morans Creek Corrected (45-3-1228)	Rock shelter with art	0.09	1.6	Unlikely	4.0	Unlikely
Olney Corrected (45-3-1229)	Rock shelter with art	0.03	0.5	Unlikely	1.4	Very unlikely
RPS PS07 (45-3-3643)	Rock shelter with art	0.10	0.6	Unlikely	1.1	Very unlikely
RPS CYL05 (45-3-3492)	Grinding groove	0.29	1.3	Unlikely	7.4	Unlikely
RPS PS26 (45-3-3512)	Grinding groove	0.52	1.1	Unlikely	12.4	Possible
MS9-GG-3 (45-3-4545)	Grinding groove	0.84	1.5	Possible	15.4	Possible
RPS PS27 (45-3-3594)	Habitation structure (no PAD or objects)	0.39	0.4	Very unlikely	9.0	Unlikely
RPS PS30 (45-3-3596)	Habitation structure (no PAD or objects)	0.62	-2.5 (1.5)*	Possible	2.2	Very unlikely
RPS PS31 (45-3-3645)	Habitation structure (no PAD or objects)	0.46	-0.7 (1.5)*	Possible	7.7	Unlikely
RPS PS28 (45-3-3513)	Rock shelter with PAD	0.02	0.6	Unlikely	1.3	Very unlikely
MS9-RS-2 (45-3-4546)	Rock shelter with PAD	0.19	2.5	Unlikely	7.9	Unlikely
MS9-RS-3 (45-3-4544)	Rock shelter with artefacts and PAD	0.09	1.9	Unlikely	4.6	Unlikely

1. Tensile strain is positive; transient or dynamic strain in brackets.

As shown in Table 7.4, subsidence impacts are considered 'possible' at two habitation structures (no PAD or objects) and one grinding groove site. Of these, impacts are already approved at one of the habitation structures and the grinding groove site.

7.4.5 Management and mitigation

Management and mitigation strategies and methodologies to protect Aboriginal sites are detailed in the ACHMP. The ACHMP will be updated to include reference to the revised subsidence predictions for the 12 sites identified as within, or adjacent to, the project area. The monitoring requirements in Section 6.5 of the ACHMP will be applied to these sites and reports will be prepared detailing the outcomes of the monitoring.

If subsidence impacts increase from those described in Table 7.4, Centennial Mandalong will consult with the RAPs and qualified archaeologists to reassess the suitability of the management and mitigation strategies and methodologies.

An Aboriginal Cultural Heritage Management Plan will also be prepared to support the Extraction Plan for LW34.

7.4.6 Conclusion

There are 12 Aboriginal sites within, or adjacent to, the project area. During the survey, no new Aboriginal sites were identified. Subsidence from mining activities within the proposed LW34 have potential to impact Aboriginal sites identified within the project area. Management and mitigation strategies and methodologies to protect Aboriginal sites from subsidence-related impacts will be implemented in accordance with the ACHMP.

7.5 Biodiversity

7.5.1 Overview

A biodiversity development assessment report (BDAR) (Appendix E) has been prepared by RPS to assess any potential biodiversity impacts resulting from the proposed modification.

The BDAR has been prepared in accordance with the following legislation and guidance:

- EPBC Act;
- NSW *Biodiversity Conservation Act 2016* (BC Act);
- NSW *Biosecurity Act 2015*; and
- *Biodiversity Assessment Method* (BAM) (DPIE 2020).

The project area adopted for the BDAR is the land within the AOD for the 20 mm subsidence contour for the proposed LW34 (ie the area within which subsidence may occur) and encompasses approximately 52 ha (Figure 7.5).

7.5.2 Existing environment

i Landscape features

a Bioregions

The project area is within the Sydney Interim Biogeographic Regionalisation for Australia (IBRA) region and Wyong subregion.

b Watercourses

The project area is within the upper reaches of Morans Creek, Mannering Creek and Buttonderry Creek and includes several unnamed tributaries. There is no key fish habitat mapped within the project area and there are no wetlands within the project area.

c Areas of geological significance

There are several sandstone crevices and cliffs within the project area associated with the Watagan Rise Mitchell Landscape. Locations of these geological features are shown in Figure 2–1 of Appendix E.

ii Native vegetation

a Overview

Approximately 1,137 ha of vegetation occurs within a 1,500 m buffer of the project area. The percentage of native vegetation cover within this area is approximately 93.5%. Vegetation mapping and inspection of recent aerial photography indicates a limited amount of vegetation clearing (6.5%).

The condition of native vegetation for most of the project area was moderate to good quality, generally impacted by edge effects associated with adjacent power easements and nearby rural properties.

b Plant community types

Five plant community types (PCTs) and six vegetation zones were identified within the project area. These are presented in Table 7.5 and shown in Figure 7.5.

Table 7.5 Vegetation zones mapped within the project area

Vegetation zone	Plant community type (PCT)	Condition	Total area (ha)	Vegetation integrity score	Area of potential impact (ha)
1	1528 - Jackwood - Lilly Pilly - Sassafras riparian warm temperate rainforest of the Central Coast	Moderate	0.04	65.4	-
2	1556 - Tallowwood - Smooth-barked Apple - Blackbutt grass tall open forest of the Central and lower North Coast	Moderate	25.1	97.4	0.000083
3	1568 - Blackbutt - Turpentine - Sydney Blue Gum mesic tall open forest on ranges of the Central Coast	Moderate	7.2	65.5	0.00031
4	1573 - Sydney Blue Gum - Lilly Pilly mesic tall open forest of coastal ranges and tablelands escarpment	Moderate	2.48	74.7	0.000078
5	1588 - Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast	Moderate	15.44	65.1	-
6	Disturbed/cleared	Non-native	1.92	12.4	0.00022

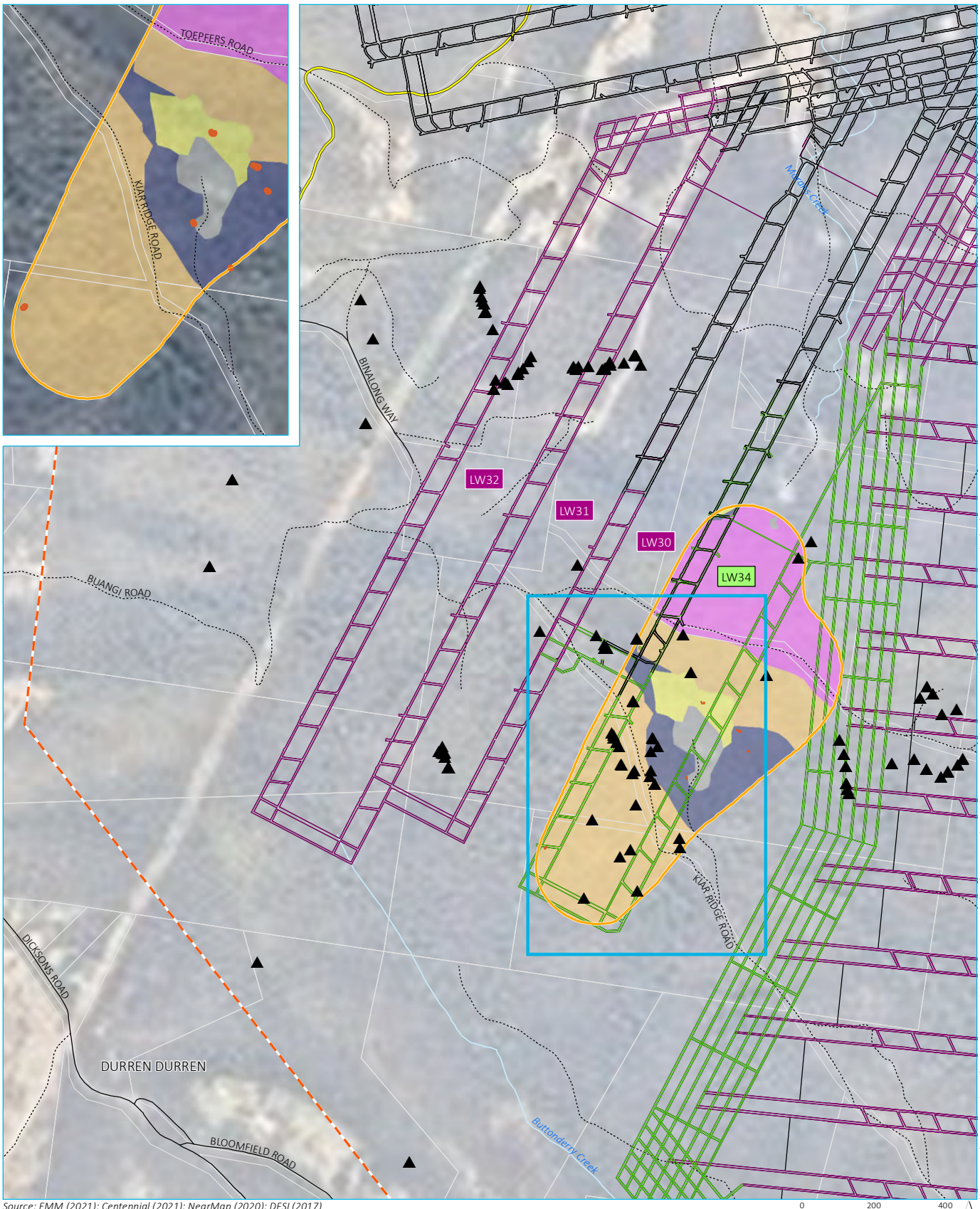
Notes: The area of impact to native vegetation is approximately 0.0005 ha; however, this value is too small for the BAM calculator to recognise and has been rounded up to the nearest accepted number (ie 0.01 ha per PCT) to calculate offset liability should impacts occur. Misalignment of the project area (52.17 ha) and the sum of the total area for the zones listed in this table is due to rounding.

iii Habitat assessment

A habitat assessment was undertaken at the same time as the vegetation mapping to identify potential fauna habitat within the project area, including:

- habitat trees (including large hollow-bearing trees);
- flowering shrubs and feed tree species;
- sandstone rocky outcrops (including rock crevices, caves and cliffs); and
- tributaries of Morans Creek, Mannering Creek and Buttonderry Creek.

Habitat features within the project area are shown in Figure 7.5.



Source: EMM (2021); Centennial (2021); NearMap (2020); DFSI (2017)

0 200 400 m

GDA 1994 MGA Zone 56

N

KEY

- BDAR project area
- Development consent boundary
- Impacts to native vegetation (ponding)
- Main road
- Minor road
- Vehicular track
- Named watercourse
- Cadastral boundary

Mine workings

- Proposed amendments
- Approved workings
- Completed mine workings
- Potential cave or rock overhang habitat

Plant community type

- 1528 - Jackwood - Lilly Pilly - Sassafras riparian warm temperate rainforest of the Central Coast
- 1556 - Tallowwood - Smooth-barked Apple - Blackbutt grass tall open forest of the Central and lower North Coast
- 1568 - Blackbutt - Turpentine - Sydney Blue Gum mesic tall open forest on ranges of the Central Coast
- 1573 - Sydney Blue Gum - Lilly Pilly mesic tall open forest of coastal ranges and tablelands escarpment
- 1588 - Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast
- Cleared/disturbed

Vegetation zones and key habitat features

Mandalong Mine Modification 10
Modification report
Figure 7.5

EMM
creating opportunities

iv Threatened species

A search of DAWE's Protected Matters Search Tool (PMST) for MNES, including threatened species likely to occur within the project area was performed as part of the BDAR.

An assessment of habitat constraints for threatened species was undertaken to indicate the likelihood of threatened species being present. Three threatened species were excluded from further assessment due to the absence of suitable habitat components within the project area.

The following key species were identified as having the potential to be present in the project area:

- Gang-gang Cockatoo (*Callocephalon fimbriatum*);
- Glossy Black-Cockatoo (*Calyptorhynchus lathami*);
- Eastern Pygmy-possum (*Cercartetus nanus*);
- Large-eared Pied Bat (*Chalinolobus dwyeri*);
- Red Helmet Orchid (*Corybas dowlingii*);
- Leafless Tongue Orchid (*Cryptostylis hunteriana*);
- White-flowered Wax Plant (*Cynanchum elegans*);
- White-bellied Sea Eagle (*Haliaeetus leucogaster*);
- Pale-headed Snake (*Hoplocephalus bitorquatus*);
- Stephens' Banded Snake (*Hoplocephalus stephensii*);
- Green and Gold Bell Frog (*Litoria aurea*);
- Green-thighed Frog (*Litoria brevipalmata*);
- Littlejohn's Tree Frog (*Litoria littlejohni*);
- Square-tailed Kite (*Lophoictinia isura*);
- Parma Wallaby (*Macropus parma*);
- Biconvex Paperbark (*Melaleuca biconvexa*);
- Grove's Paperbark (*Melaleuca groveana*);
- Little Bent-winged Bat (*Miniopterus australis*);
- Large Bent-winged Bat (*Miniopterus orianae oceanen*);
- Stuttering Frog (*Mixophyes balbus*);
- Giant Barred Frog (*Mixophyes iteratus*);

- Southern Myotis (*Myotis macropus*);
- Barking Owl (*Ninox connivens*);
- Powerful Owl (*Ninox strenua*);
- Greater Glider (*Petauroides volans*);
- Squirrel Glider (*Petaurus norfolcensis*);
- Brush-tailed Rock-wallaby (*Petrogale penicillata*);
- Brush-tailed Phascogale (*Phascogale tapoatafa*);
- Koala *(Phascolarctos cinereus)*;
- Common Planigale (*Planigale maculata*);
- Long-nosed Potoroo (*Potorous tridactylus*);
- Grey-headed Flying-fox (*Pteropus poliocephalus*);
- Eastern Australian Underground Orchid (*Rhizanthella slateri*);
- Scrub Turpentine (*Rhodamnia rubescens*);
- Native Guava (*Rhodomyrtus psidioides*);
- Black-eyed Susan (*Tetratheca juncea*);
- Red-backed Button-quail (*Turnix maculosus*);
- Masked Owl (*Tyto novaehollandiae*); and
- Sooty Owl (*Tyto tenebricosa*).

Targeted flora and fauna surveys were undertaken to identify the presence or absence of these key species in the project area. The only threatened flora species detected within the project area during survey was Scrub Turpentine, which is listed as 'critically endangered' under the BC Act. Threatened fauna detected within the project area during surveys included:

- Masked Owl – listed as 'vulnerable' under the BC Act (foraging only, not breeding); and
- Glossy Black Cockatoo – listed as 'vulnerable' under the BC Act.

As surveys could not be conducted during prescribed survey periods, presence was assumed for 25 threatened species considered as having potential to be present in the project area (Table 4–3 of Appendix E).

7.5.3 Impact assessment

i Potential direct and indirect impacts

The proposed modification will not result in the clearing of native vegetation within the project area. Subsidence predictions indicate that there is potential for the incremental increase in ponding to lead to a partial loss of vegetation integrity to approximately 0.00047 ha of native vegetation (namely 0.000083 ha (0.83 m^2) of PCT 1556, 0.00031 ha (3.1 m^2) of PCT 1568 and 0.000078 ha (0.78 m^2) of PCT 1573) (Table 7.5).

Given the limited and minor extent of cracking and the low chance for dislodgement of rock structures by predicted subsidence, the proposed modification is considered unlikely to have a greater than negligible impact on habitat of threatened species associated with caves, crevices, rocks or cliff habitat.

Hydrological changes to Morans Creek, Mannering Creek and Buttonderry Creek (and associated tributaries) due to subsidence have potential to influence riparian-associated vegetation and habitat downstream. The proposed modification is not expected to materially change the watercourse stability impacts for these watercourses from those identified and approved under SSD-5144 (Section 7.3.3). Therefore, downstream ecological impacts due to the proposed modification are expected to be negligible.

The proposed modification will lead to a minor increase in traffic related to surface monitoring activities (eg environmental monitoring and geotechnical surveys). The risk of vehicle strike of fauna when travelling off public roads will be reduced by restricting vehicles to a 40 km/hr speed limit.

Structural changes to rock-habitat features as a result of subsidence have the potential to disturb microbats, microbat roosts and other species that may be present within the sandstone formations in the project area. Cave-associated species with potential to be impacted by the proposed modification include:

- Large-eared Pied Bat;
- Little Bent-winged Bat;
- Large Bent-winged Bat; and
- Sooty Owl.

ii Serious and irreversible impacts

Eastern Australian Underground Orchid is considered a potential entity to meet the serious and irreversible impacts (SAII) principle. This species could not be surveyed within the recommended survey period. The assessment for SAII is provided in Chapter 7 of Appendix E.

Records of Eastern Australian Underground Orchid are only known from fewer than 10 locations. The closest known record of this species is approximately 40 km from the project area. Therefore, it is considered that the minor extent of predicted ponding (ie less than 0.001 ha or 10 m^2) is unlikely to exceed a threshold of impact for this species.

iii Impacts requiring offsets

The minimum value for an area of impact within the BAM calculator is 0.01 ha. The area of impact associated with the proposed modification is significantly less than 0.01 ha (ie 0.00047 ha or 4.7 m^2). Therefore, a threshold of 0.01 ha is proposed, prior to which the credit requirements identified below and in Appendix E will not be necessary.

An adaptive management approach will be implemented through the Extraction Plan for LW34. If impacts of greater than 0.01 ha are detected as a result of the proposed modification, ecosystem and species credits will be satisfied in accordance with the NSW Biodiversity Offset Scheme.

a Ecosystem credits

Should the impact threshold of 0.01 ha be exceeded, ecosystem credits required to offset impacts associated with the proposed modification will include:

- 1 credit for impacts to an area of up to 0.01 ha of PCT 1556;
- 1 credit for impacts to an area of up to 0.01 ha of PCT 1568; and
- 1 credit for impacts to an area of up to 0.01 ha of PCT 1573.

If required, these credit requirements will be satisfied in accordance with the NSW Biodiversity Offset Scheme through retiring credits, based on like-for-like rules where possible. Payments into the Biodiversity Conservation Fund may be made where suitable credits are not available within Centennial-owned stewardship sites.

b Species credits

Should the impact threshold of 0.01 ha be exceeded, species credits required to offset impacts associated with the proposed modification will include:

- 1 credit for potential impacts to Gang-gang Cockatoo;
- 1 credit for potential impacts to Eastern Pygmy Possum;
- 1 credit for potential impacts to Leafless Tongue Orchid;
- 1 credit for potential impacts to White-bellied Sea Eagle;
- 1 credit for potential impacts to Pale-headed Snake;
- 1 credit for potential impacts to Stephens' Banded Snake;
- 1 credit for potential impacts to Green-thighed Frog;
- 1 credit for potential impacts to Littlejohn's Tree Frog;
- 1 credit for potential impacts to Square-tailed Kite;
- 1 credit for potential impacts to Stuttering Frog;
- 1 credit for potential impacts to Giant Barred Frog;
- 1 credit for potential impacts to Southern Myotis;
- 1 credit for potential impacts to Barking Owl;
- 1 credit for potential impacts to Powerful Owl;
- 1 credit for potential impacts to Squirrel Glider;
- 1 credit for potential impacts to Brush-tailed Phascogale;
- 1 credit for potential impacts to Grey-headed Flying Fox;

- 1 credit for potential impacts to Eastern Australian Underground Orchid;
- 1 credit for potential impacts to Black-eyed Susan;
- 1 credit for potential impacts to Masked Owl; and
- 1 credit for potential impacts to Sooty Owl.

If required, these credit requirements will be satisfied in accordance with the NSW Biodiversity Offset Scheme through retiring credits, based on like-for-like rules where possible. Payments into the Biodiversity Conservation Fund may be made where suitable credits are not available within Centennial-owned stewardship sites.

iv Matters of national environmental significance

No TECs listed under the EPBC Act were detected within the project area. Due to the minor increase in ponding expected to occur as a result of the proposed modification, significant impacts on EPBC Act listed threatened species are unlikely to occur.

7.5.4 Management and mitigation

Ecology monitoring, assessment and reporting are currently managed through Mandalong's EMS, the *Northern Region Biodiversity Management Plan* (Northern Region BMP) and *Mandalong Mine Biodiversity Management Plan* (Mandalong BMP). The EMS and BMPs will continue to operate under the proposed modification.

Consistent with the Mandalong BMP, a monitoring program will be implemented to evaluate the impacts of subsidence on cave structures for microbat roosting if threatened microbat species (namely Little Bent-winged Bat and Large-eared Pied Bat) are found to be roosting within the project area. Further surveys for Sooty Owl will also be performed to determine whether breeding activity for this species is occurring within the caves within the project area. If threatened microbat species or breeding activity for Sooty Owl are detected, monitoring will need to:

- incorporate an appropriate baseline period; and
- be undertaken until the full effects of subsidence are realised.

Consistent with the Mandalong BMP, a flora monitoring program will also be undertaken to determine if plant communities and or threatened flora are impacted by the proposed modification.

As noted above, the BAM calculator has a minimum area of impact of 0.01 ha. Monitoring undertaken as part of the Mandalong BMP and Extraction Plan will be used to detect whether impacts on native vegetation of greater than 0.01 ha occur. If this threshold is met, ecosystem and species credits will be required.

7.5.5 Conclusion

The proposed modification will not result in the clearing of native vegetation within the project area. Subsidence predictions indicate that there is potential for impact (via ponding) to approximately 0.00047 ha (<5 m^2) of native vegetation (namely 0.000083 ha of PCT 1556, 0.00031 ha of PCT 1568 and 0.000078 ha of PCT 1573).

Monitoring undertaken as part of the Mandalong BMP and Extraction Plan will be used to detect whether impacts on native vegetation of greater than 0.01 ha occur. If this threshold is met, a total of 3 ecosystem credits and 21 species credits may be required to offset the impacts of the proposed modification on native vegetation and threatened species.

Residual impacts on biodiversity will be managed through the implementation of the Mandalong BMP, which will include monitoring programs for threatened species and an adaptive management strategy for potential impacts on threatened bats and Sooty Owl.

7.6 Socio-economic

7.6.1 Overview

A socio-economic assessment was prepared by AIGIS (Appendix A) to assess the potential social and economic impacts of the proposed modification. The assessment was undertaken with reference to the *Guidelines for the Economic Assessment of Mining and Coal Seam Gas Proposals* (DPE 2015) and supporting technical notes. Given the scale of the proposed modification, a standalone social impact assessment and economic impact assessment were not required (Table 6.1).

7.6.2 Impact assessment

i Potential social impacts

The proposed modification will not affect Mandalong's current production rate and the number of workers (FTE) will not increase; however, Centennial Mandalong has identified that should LW34 not be included in the mine plan, up to 78 FTE positions could be suspended at Mandalong for a period of approximately 10 months.

Mandalong's workforce is regionally based, with approximately 99% residing in the LGAs of Lake Macquarie (61%), Newcastle (14%), Central Coast (10%), Maitland (7%) and Cessnock (7%) (Annexure 4 of Appendix F). Consequently, the majority of the workforce's social and economic activity is expected to take place in the local and regional areas surrounding Mandalong, contributing to the socio-economic functioning of these areas. The proposed modification will ensure continuity of employments for Mandalong's workforce, allowing them to continue to engage in the community and contribute to the social fabric, functioning and cohesion of their communities.

The inclusion of the CCC in decisions regarding the distribution of Centennial Mandalong's annual contributions will ensure local priorities are reflected in the allocation of community funds. The annual contribution will continue to invest in projects that improve community infrastructure and services and create vibrant neighbourhoods and public spaces in the communities of Morisset, Mandalong, Dora Creek and Wyee.

Centennial Mandalong support numerous community organisations and events (including the LMCC School Environment Awards and the Annual Morisset Show). The removal of the $500,000 limit on Mandalong's annual contributions will ensure annual contributions of $50,000 are ongoing for the productive life of Mandalong.

ii Potential economic impacts

Centennial Mandalong has identified that should LW34 not be included in the mine plan, up to 78 FTE positions could be suspended for a period of approximately 10 months. The proposed modification will ensure continuity of operations at Mandalong and will result in positive economic outcomes for the otherwise potentially affected part of the workforce.

A modified cost benefit analysis was completed for the proposed modification (Chapter 2 of Appendix F). The aggregate effect of the proposed modification is the retention of up to $164 million of economic benefit accruing to the NSW economy or the equivalent loss of this activity should the mine plan remain as per the existing approval.

The combined loss of royalties incurred through the shortening of LW30 and removal of LW33 is estimated to be $16.4 million. Extraction of LW34 is anticipated to generate approximately $10 million in royalties, thereby reducing the net cost of foregone royalties from the amendments to Mandalong's mine plan to approximately $6.4 million.

The continued operation of Mandalong will help to maintain Centennial Mandalong's commercial engagements with locally and regionally based suppliers, thus indirectly supporting employment and further activity for the relevant businesses.

7.6.3 Management and mitigation

Due to the negligible socio-economic impacts associated with the proposed modification, no additional management or mitigation measures are proposed.

7.6.4 Conclusion

Centennial Mandalong has identified that should LW34 not be included in the mine plan, up to 78 FTE positions could be suspended for a period of approximately 10 months. The proposed modification will ensure continuity of operations and employment at Mandalong and will result in positive socio-economic outcomes for the otherwise potentially affected part of the workforce.

7.7 Other environmental aspects

An assessment of other environmental aspects as a result of the proposed modification is provided in Table 7.6.

Table 7.6 Potential impacts of the proposed modification

Environmental consideration	Impact assessment
Land and agricultural resources	The proposed modification does not require any additional surface infrastructure. No areas of BSAL will be impacted by the proposed modification (Figure 7.1). An agricultural impact statement (GSSE 2013b) and LSC assessment (GSSE 2013c) were undertaken as part of the *Mandalong Southern Extension Project EIS* (GSSE 2013a). The assessments concluded that Mandalong will not have an impact on the pre-disturbance land and soil capability or agricultural suitability classes of land within the development consent boundary if appropriate disturbance management strategies are implemented. The EMS, *Mandalong Mine Land Management Plan* and erosion and sediment control plans will continue to operate under the proposed modification. No additional mitigation measures for potential impacts to land and agricultural resources are considered warranted.
Historical heritage	The proposed modification does not require any additional surface infrastructure. As described in Section 7.1.3, there are no historical heritage sites within the area of influence of the proposed LW34. Historical heritage will continue to be managed in accordance with the *Northern Region Historic Heritage Management Plan*.
Visual amenity	The proposed modification does not require any additional surface infrastructure. The proposed modification will not result in additional visual amenity impacts.
Waste	The proposed modification does not require any additional construction activities. No wastes are predicted to increase as a result of the proposed modification. Waste will continue to be managed in accordance with the EMS with all waste disposed of at a licenced waste management facility.
Traffic and transport	The proposed modification will not affect the current production rate or delivery limits associated with CES or the Mandalong Coal Delivery System and no physical changes to Mandalong's approved infrastructure are proposed. The number of workers (FTE) at Mandalong will not increase as a result of the proposed modification. Therefore, no additional traffic management or mitigation measures for the local and regional road network are required.

Table 7.6 Potential impacts of the proposed modification

Environmental consideration	Impact assessment
Air quality	The proposed modification will not affect the current production rate or delivery limits associated with CES or the Mandalong Coal Delivery System and no physical changes to Mandalong's approved infrastructure are proposed. Consequently, the proposed modification will not significantly change air quality impacts from those currently generated by approved operations. Air quality will continue to be managed in accordance with the *Northern Region Air Quality and Greenhouse Gas Management Plan*.
Greenhouse gases	The annual production rate at Mandalong will not increase as a result of the proposed modification. The only greenhouse gas (GHG) emission sources anticipated to change as a result of the proposed modification is downstream energy production from product coal (ie Scope 3 end-user combustion of the coal). As noted in Section 1.4, the shortening of LW30 and removal of LW33 has resulted in a loss of approximately 0.4 Mt and 1.6 Mt of ROM coal from each longwall, respectively. The addition of LW34 will result in the extraction of approximately 1.3 Mt. Therefore, total ROM coal extracted at Mandalong will decrease by 645,186 t when compared to the amount of ROM coal approved for extraction under MOD 9 (ie 60,515,116 t). This represents a decrease in ROM coal of 1.1%. By accounting for the loss of coal resources from the removal of LW33 and shortening of LW30, as well as the addition of LW34, life of mine (LOM) Scope 3 GHG emissions for the proposed modification will decrease from 147,443,870 t CO_2-e (MOD 8) to 145,871,887 t CO_2-e (MOD 10) (Table 4.2 of Appendix G). This represents an approximately 1.1% decrease in LOM Scope 3 emissions relative to the MOD 8 GHG emissions inventory (EMM 2019). GHG emissions will continue to be managed in accordance with the *Northern Region Air Quality and Greenhouse Gas Management Plan*.
Noise and vibration	The proposed modification will not affect the current production rate or delivery limits associated with the CES or the Mandalong Coal Delivery System and no physical changes to Mandalong's approved infrastructure are proposed. Consequently, the proposed modification will not significantly change noise and vibration impacts from those currently generated by the approved operation of the mine. Noise will continue to be managed in accordance with the *Northern Region Noise Management Plan*.

Table 7.6 Potential impacts of the proposed modification

Environmental consideration	Impact assessment
Hazards and risks	Bushfire risk at Mandalong will continue to be managed through a number of preventative management actions including: • managing potential sources of ignition via a hot works permit; • maintaining firebreaks; • providing firefighting equipment; • having trained and competent personnel on-site who can conduct fire-fighting if required; and • regular dialogue with RFS in relation to bushfire management practices. Exploration drilling has the potential to expose workers to bushfires in isolated or rough terrain, with limited access provisions and potentially hindering a safe evacuation. Specific risk management actions which will continue to be implemented for exploration drilling activities include: • firefighting equipment will be kept on all active sites at all times; • the hot work management system will be followed to prevent any fires resulting from hot works outside of designated areas; • fire trails and access tracks will be maintained to a suitable standard to allow water tanker access; • Centennial Mandalong will not burn off any grass, foliage or herbage; • operational procedures and evacuation planning will be prepared prior to the commencement of site preparation works to identify site specific emergency access/egress; and • evacuation plans and emergency contacts will be provided on-site and will be included in the staff inductions, as will the significance of working on bushfire prone land. As discussed in Section 4.1.2, Centennial Mandalong will implement a structured assessment of the risk of either igniting or becoming impacted by a fire prior to commencing exploration drilling activities on a given day. The findings of the risk assessment will identify the risk of working along with the required additional controls and mitigation actions. Bushfire risks at Mandalong will continue to be managed in accordance with the *Bushfire Management Plan*. The *Exploration Activities Management Plan* will be updated to reflect the proposed changes to the limitations on exploration drilling activities on total fire ban days.

8 Justification of the modified project

A description of the need and justification for the proposed modification is provided below with regard to biophysical, social and economic factors; the principles of ecologically sustainable development (ESD); and the consistency of the proposed modification with the objects of the EP&A Act.

8.1 Modification impacts

This MR examines the potential impacts that may result from the proposed modification. The assessment of environmental issues has been multi-disciplinary and involved consultation with DPIE and key stakeholders, including LMCC, Central Coast Council, Mandalong Mine CCC, RAPs, RFS and private landholders.

The proposed modification will not result in significant environmental, social or economic impacts and the MR has identified that any residual impacts can be appropriately managed through proposed management measures and Mandalong's existing EMS.

8.2 Modification benefits

The proposed amendments to the approved mine plan take into account all available information and will enable safe and efficient operations to continue at Mandalong. The proposed modification will help to maintain coal production and improve the financial viability of Mandalong.

The proposed modification is a minor alteration to an approved coal mine operation which represents an orderly and economic use of a resource approved for extraction for use in domestic power generation with some coal also exported. The modification will allow the efficient extraction of coal, while minimising potential environmental and social impacts.

Continuation of mining and operations as approved equates to the 'do nothing' or 'business as usual' base case. If the approved mine plan is not amended, the approximately 1.3 Mt of coal within LW34 will not be extracted. This would fail to maximise resource recovery within the development consent boundary and ML 1722. Centennial Mandalong has identified that should LW34 not be included in the mine plan, up to 78 FTE positions could be suspended at Mandalong for a period of approximately 10 months with ensuing adverse socio-economic impacts.

The proposed modification will provide greater flexibility around what exploration drilling activities are able to be undertaken on total fire ban days and will improve the continuity of these activities during fire danger periods.

The inclusion of the CCC in the distribution of Mandalong's annual contributions will ensure that local priorities are reflected in the allocation of community funds. The removal of the $500,000 limit on Mandalong's annual contributions will ensure annual contributions of $50,000 are ongoing for the productive life of Mandalong.

All aspects relating to environmental management will continue in accordance with SSD-5144, the relevant EPL and the approved management plans.

8.3 Ecologically sustainable development

The principles of ESD, for the purposes of the EP&A Act, are provided in Clause 7(4) of Schedule 2 of the EP&A Regulation. The four principles of ESD are:

- precautionary principle – the precautionary principle states that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;
- inter-generational equity – the principle of inter-generational equity is that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations;

- conservation of biological diversity and maintenance of ecological integrity – the conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making; and
- improved valuation and pricing of environmental resources – improved valuation, pricing and incentive mechanisms should be promoted.

The overall objectives of ESD are to use, conserve and enhance natural resources. This ensures that ecological processes are maintained facilitating improved quality of life, now and into the future. Centennial Mandalong is committed to the principles of ESD and understands that biophysical, social and economic objectives are interdependent. Centennial Mandalong acknowledges that a well-designed and effectively managed operation will avoid significant and/or costly environmental impacts or degradation.

The proposed amendments to the underground mine plan have been designed to avoid impacts where possible. Where impacts are unavoidable, the proposed works have been designed to reduce the impacts to a level which is as low as is reasonably practicable. Appropriate management measures have been identified to mitigate any residual impacts from the proposed modification.

Consideration has been given to appropriately identifying, avoiding, mitigating and managing environmental risks. This demonstrates environmental due diligence and will provide for ongoing and adaptive monitoring and management of Mandalong in line with the principles of ESD outlined in the following sections.

8.3.1 Precautionary principle

This MR, including the appended technical assessments, has assessed the potential impacts of the proposed modification on biophysical, social and economic factors. As described in Chapter 7, the proposed amendments to the underground mine plan will not significantly change previously assessed and approved impacts. Where existing management controls and mitigation strategies are not already in place to monitor, mitigate and/or manage the potential impacts of the proposed modification, additional safeguards have been proposed.

8.3.2 Inter-generational equity

Centennial Mandalong undertakes ongoing environmental monitoring with mitigation measures to provide effective environmental management across its existing operations. This management is provided through planning, communication, documentation, review and feedback. These environmental management measures ensure that the health, diversity and productivity of the environment is maintained or enhanced for future generations.

8.3.3 Conservation of biological diversity and maintenance of ecological integrity

The potential environmental impacts of the proposed modification and the existing and/or additional measures to ameliorate these potential impacts are detailed in this MR. The proposed modification will not result in the clearing of native vegetation within the project area. Subsidence predictions indicate that there is potential for impact (via ponding) to approximately 0.00047 ha (<5 m^2) of native vegetation.

If impacts on native vegetation exceed the 0.01 ha threshold nominated by the BAM calculator, offsets will be provided in accordance with the biodiversity offset framework. Residual impacts will be managed through the implementation of the Mandalong BMP, which includes monitoring programs for threatened species and an adaptive management strategy for potential impacts on threatened bats and Sooty Owl.

8.3.4 Improved valuation and pricing of environmental resources

Centennial Mandalong will optimise the valuation and pricing of the coal resource within the development consent boundary at Mandalong by continuing to efficiently extract coal resources utilising existing approved infrastructure.

8.4 Conclusion

The proposed amendments to the underground mine plan have been designed to reduce the impacts to a level which is as low as is reasonably practicable. The proposed amendments to the underground mine plan will not significantly change previously assessed and approved impacts and all residual impacts have been identified and assessed.

The proposed modification is considered to be consistent with the relevant objects of the EP&A Act, including the principles of ESD, and will not change the nature of the development originally approved. There will be ongoing economic investment and employment benefits both locally and regionally, while minimising potential environmental and social impacts.

The proposed modification will provide greater flexibility around what exploration drilling activities are able to be undertaken on total fire ban days and will improve the continuity of these activities during fire danger periods.

The inclusion of the CCC deciding the distribution of Mandalong's annual contributions will ensure that local priorities are reflected in the allocation of community funds.

All aspects relating to environmental management will continue in accordance with SSD-5144, EPL 365, the various approved plans and other elements of the consent.

The proposed modification is anticipated to result in minimal environmental impacts beyond those previously assessed and approved under SSD-5144.

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Abbreviations

ACHA	Aboriginal cultural heritage assessment
ACHMP	Northern Region Aboriginal Cultural Heritage Management Plan
AHD	Australian height datum
AHIMS	Aboriginal Heritage Information Management System
AIP	NSW *Aquifer Interference Policy*
ARI	average recurrence interval
BAM	*Biodiversity Assessment Method*
Banpu	Banpu Public Company Limited
BC Act	NSW *Biodiversity Conservation Act 2016*
BDAR	biodiversity development assessment report
BoM	Bureau of Meteorology
BSAL	biophysical strategic agricultural land
CCC	community consultative committee
Centennial	Centennial Coal Company Limited
Centennial Mandalong	Centennial Mandalong Pty Limited
CES	Cooranbong entry site
DAWE	Commonwealth Department of Agriculture, Water and the Environment
DES	Delta entry site
DPIE	NSW Department of Planning, Industry and Environment
EC	electrical conductivity
EIS	environmental impact statement
EL	exploration licence
EMM	EMM Consulting Pty Limited
EMS	environmental management strategy
EPA	NSW Environment Protection Authority
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
EPL	environment protection licence
EP&A Act	NSW *Environmental Planning and Assessment Act 1979*
EP&A Regulation	NSW Environmental Planning and Assessment Regulation 2000

ESD	ecologically sustainable development
FOS	factor of safety
FTE	full-time equivalent
GDE	groundwater dependent ecosystem
GHG	greenhouse gas
Gosford LEP	Gosford Local Environmental Plan 2014
ha	hectares
km	kilometres
IBRA	Interim Biogeographic Regionalisation of Australia
Lake Macquarie LEP	Lake Macquarie Local Environmental Plan 2014
LDP	licenced discharge point
LGA	local government area
LMCC	Lake Macquarie City Council
LOM	life of mine
l/s	litres per second
LSC	land and soil capability
Mandalong	Mandalong Mine
Mandalong BMP	Mandalong Biodiversity Management Plan
MMAS	Mandalong Mine access site
Mining SEPP	State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007
mg/l	milligrams per litre
ML	mining lease
mm	millimetres
MNES	matters of national environmental significance
MOP	mining operations plan
MR	modification report
MSSS	Mandalong South surface site
Mt	million tonnes
Mtpa	million tonnes per annum
Northern Region BMP	Northern Region Biodiversity Management Plan
NSW	New South Wales

PAC	Planning Assessment Commission
PAD	potential archaeological deposit
PCT	plant community type
PMST	Protected Matters Search Tool
POEO Act	NSW *Protection of the Environment Operations Act 1997*
RAP	registered Aboriginal party
RF Act	NSW *Rural Fires Act 1997*
RFS	NSW Rural Fire Service
ROM	run-of-mine
RTS	response to submissions
SAII	serious and irreversible impact
SEPP	State Environment Planning Policy
SRP	subsidence reduction potential
SSD	State significant development
t	tonnes
TDS	total dissolved solids
TEC	threatened ecological community
WAL	water access licence
Water Act	NSW *Water Act 1912*
WM Act	NSW *Water Management Act 2000*
WMP	Mandalong Mine Water Management Plan
Wyong LEP	Wyong Local Environmental Plan 2013

Appendix A

Subsidence assessment









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DgS
Ditton Geotechnical Services

Centennial Mandalong Pty Ltd

Subsidence Assessment for the Proposed LW34 at the Mandalong Mine: SSD-5144 Approval Modification (Mod 10)

DGS Report No. MAN-001/14

Date: 22 September 2021

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22 September 2028

Mr James Wearne
Group Manager Approvals/Environment
Centennial Mandalong
12 Kerry Anderson Drive
Mandalong NSW 2264

DGS Report No. MAN-001/14

Dear James,

Subject: Subsidence Assessment for the Proposed LW34 at the Mandalong Mine: SSD-5144 Approval Modification (Mod 10)

This report has been prepared in accordance with the brief provided on the above project.

Please contact the undersigned if you have any questions regarding this matter.

For and on behalf of
Ditton Geotechnical Services Pty Ltd



Steven Ditton
Principal Engineer

Executive Summary

This subsidence assessment has been completed to support the SSD-5144 Modification 10 (Mod 10) regarding the proposed Longwall (LW) 34 in the West Wallarah Seam (WW) at the Mandalong Mine (Mandalong).

Mandalong operates under State significant development (SSD) consent SSD-5144, which was granted on 12 October 2015 by the NSW Planning Assessment Commission under Part 4, Division 4.1 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act).

As identified in Mandalong's Mining Operations Plan (MOP) (**Centennial Coal 2018**), the progression of underground mining is regularly reviewed dependent on ongoing monitoring and geological conditions. Centennial Mandalong has encountered poor geological conditions within the Mandalong Southern Extension Area (LW25 to 33), including a fault zone and igneous sill. In response to these conditions and in order to maintain coal production, improve mining conditions and the financial viability of Mandalong, amendments to the approved mine plan were sought as part of a modification to SSD-5144 (herein referred to as MOD 9). As part of MOD 9, Centennial Mandalong sought approval to amend the approved mine plan, including the reorientation of LW30 to LW33.

Since the approval of MOD 9 in April 2021 for LW30 to 33, Centennial Mandalong has continued to review the progression of underground mining at Mandalong. As a result of these investigations, the decision has been made to shorten LW30 and remove LW33 from the mine plan. The shortening of LW30 and removal of LW33 are estimated to result in the sterilisation of approximately 0.4 million tonnes (Mt) and 1.6 Mt of coal, respectively. Consequently, Centennial Mandalong has explored options to access additional coal resources.

Centennial Mandalong is now seeking to modify SSD-5144, pursuant to Section 4.55(2) of the EP&A Act, and change Mandalong's approved mine plan to include LW34 to the east of LW30 (herein referred to as MOD 10 or the proposed modification). The addition of LW34 will maximise resource extraction within the West Wallarah Seam and Mandalong's development consent boundary and improve the continuity of coal extraction and employment at Mandalong.

This subsidence assessment has been completed to support a Modification Report (MR) for MOD 10 and includes the approved LW30 to 32 and the proposed LW34 in the Mandalong Southern Extension Area. Only the surface features that have not been previously assessed in MOD 9 have been assessed in this study (i.e. those features within the angle of draw from LW34).

Subsidence predictions and impacts due to the Approved LW30 to 32 are presented in the MOD 9 Submissions Report (**DgS, 2020a**). The effects of the shortening of LW30 are assessed in the Variation to LW30 and 31 Extraction Plan report (**DgS, 2021**).

This report has assessed the likely and credible worst-case subsidence effects and impacts due to the proposed mining layout of LW30 to 34, as shown in **Figure 1a**. A comparison between the previous subsidence predictions and impacts assessed in the Mod 9 Report has also been made and commented upon.

The proposed LW34 will have a void width of 200 m and cover depths ranging from 320 m and 440 m (with an average of 380 m) to give *sub-critical* panel width/cover depth ratios (W/H) of 0.45 to 0.63.

Longwall extraction heights will vary between 3.6 m and 3.8 m, depending on seam thickness (+/- 0.1 m). Solid chain pillar widths between LW30 will be 46 m and 99 m long with a development height of 3.5 m and roadway or tunnel width of 5.2 m.

The main access headings to the future eastern mining area will be re-orientated toward the south-east.

The following surface features exist within the assessment area:

- First, second and third order tributaries of Morans and Mannering Creeks.
- First order tributary of Buttonderry Creek is outside the angle of draw to LW34 and won't be directly subsided or impacted by the proposed longwall.
- Twelve Aboriginal cultural heritage sites (3 grinding grooves, 2 rock shelters with PAD, 1 rock shelter with Artefacts, 2 rock shelters with Art and 4 habitation structures (rock shelters with no PAD, artefacts or art).
- four steep slopes (1a, 1b, 1d, 1e) ranging between 18^{o} and 30^{o} and heights ranging from 50 m to 80 m.
- rocky outcrops and large boulders associated with the Triassic Terrigal Sandstone Formation. The exposures range in height from 3 m to 10 m (RF12-19 & 29)
- two unsealed roads/tracks on Crown Land (Toepfers & Kiar Ridge Roads)
- two houses with ancillary structures, driveways and fences (No. 34 and 55)

Subsidence Assessment

Subsidence effect and impact predictions for the features above the proposed longwalls have been adapted from **ACARP, 2003** and subsidence effect data from the Mandalong Mine to-date (LWs 1 to 29). At the time of report preparation, Mandalong had extracted (and reported on) four 125 m wide longwalls, twenty-one 160 m wide longwalls and five 180 m wide longwalls in the West Wallarah Seam.

Based on experience from the Mandalong Mine and other longwall mines in the Lake Macquarie Area, it is likely that the development of subsidence will be reduced by the massive conglomerate and sandstone units that exist within the overburden. Borehole data indicates that the assessment area is situated within the Triassic Narrabeen Group and upper sequences of the Newcastle Coal Measures.

In the assessment area, the Mandalong Beam is typically 22 m to 36 m thick and located approximately 100 m above the longwalls +/- 5m. The high strength and stiffness of the conglomerate unit has meant the overburden in the past has been able to span between chain pillars and limit subsidence to between 0.5 m and 1.0 m. The presence of geological structure

(N-NW striking normal faults/dykes and seam rolls) has allowed the Mandalong beam to break down into thinner units and cause subsidence to increase up to 1.3 m. The overall impacts to the surface features have not increased significantly as result of this behaviour.

The proposed increase in panel width to 200 m for LW34 is also commensurate with the increase in depth of cover and will allow the previous sub-critical panel geometry to be maintained. As the proposed panels are sub-critical (i.e. W/H < 0.7), it is likely that panel sag subsidence will be similar to the chain pillar subsidence (due to natural compressive arching between the pillars).

The vertical stress acting on the tailgate chain pillars after mining LW30 to 32 and 34 is estimated to range from 29 to 41 MPa due to the deeper cover depths, with Factor of Safety (FoS) values of 1.33 to 2.07 estimated.

Chain pillar stresses for extracted longwalls to-date have ranged from 17 MPa to 32 MPa with subsidence ranging between 0.2 m and 0.76 m for pillar heights of 3.5 m. The longwall extraction height (T) will also decrease from 4.5 m (average) to a range between 3.6 m and 3.8 m as the WW Seam thins towards the seam split to the east of the mining area.

The maximum subsidence effect predictions for the proposed LW34 are as follows:

- **Final maximum panel subsidence** ranges from 0.49 m to 1.39 m (13.2% to 37.6%T).
- **Final maximum tailgate chain pillar subsidence** ranges from 0.69 m to 0.87 m (18.6% to 23.5%T) for a pillar stress of 39.3 MPa and an FoS of 1.22.
- **Maximum panel tilt** ranges from 4 to 15 mm/m (mean values) and from 6 mm/m to 22 mm/m (U95%CL values).
- **Maximum panel compressive strains** range from 2 to 6 mm/m (mean values) and from 4 to 9 mm/m (U95%CL values).
- **Maximum panel tensile strains** range from 2 to 5 mm/m (mean values) and from 3 to 7 mm/m (U95%CL values).

Predicted Impacts to Natural Features

Based on the predicted maximum panel subsidence, tilt and strain values for LW34, the potential for the following subsidence related impacts and their likely effect on natural and built features have been assessed:

- **Surface cracking:**

  Based on the predictions, surface cracks ranging from 30 mm to 70 mm width may occur in relatively flat terrain where shallow or exposed rock exists (i.e. along creek beds) or where relatively stiffer built features (i.e. roads and culverts) exist. Wider cracks of up to 320 mm may occur on the upper slopes and at or behind slope crests.

  It was also noted in **DgS, 2020a** that surface cracking has been rare above the Mandalong LW1 to 24a, and it was likely to be due to the presence of thinly bedded, near surface

strata of the Tuggerah and Patonga Claystone Formations that tend to 'shear' into thinner beams during subsidence development instead of generating fresh, vertical cracks.

However, since the extraction of LW25 to 29 surface cracks and surface heave movements of up to 100 mm were observed on Mandalong Road and the southern mine extension mine site access road above LW25b. The cracks were remediated in accordance with the management plans. The impacted slopes above the extracted LW25b ranged from 15^o to 18^o and were in the 'moderate' range.

An inspection of an ephemeral creek bed above LW28b in April 2021 identified an apparent 1 mm wide crack in the exposed sandstone rock bar adjacent to a grinding Groove Site (TBM34). The crack was actually an existing NE/SW striking joint and was tapered vertically, indicating tensile strain had opened it after mining (pre-mining photo indicates a closed joint or 'hairline' crack existed before mining). The nearest survey lines (CS-22 and CS-23) indicated tensile strains may have ranged between 1.8 mm/m and 4.3 mm/m between the rib-side and the groove site, which was 22 m from the rib over the goaf. Compressive strain of 2.9 mm/m was also recorded across the creek bed, suggesting valley closure effects may have affected the joint through buckling-type deformation. The predicted strain of 2 mm/m at the groove site was assessed in the 'possible' cracking impact category in **DgS, 2020b**.

Several other heritage sites, including a grinding groove site (TBM31) on the creek bed and a stone arrangement (TBM32) were not impacted by measured strains ranging between -3.5 mm/m (compressive) and 1.5 mm/m (tensile). 'Possible' cracking impacts were indicated before undermining occurred.

- **Height of sub-surface fracturing above the panels:**

  Heights of continuous cracking are very unlikely to interact with the surface cracking zone within 15 m from the surface. It is assessed that the Constrained Zone of at least 176 m thick is likely to develop above the Fractured Zone in the overburden and is likely to provide adequate protection to watercourses and near surface ground waters.

- **Surface gradient changes along Creeks:**

  Mannering Creek gradients above LW34 are expected to increase by 0.6% (0.4^o) and decrease by 0.9% (0.4^o). It is predicted that changes to surface gradients will result in 'minor' to 'negligible' erosional impacts.

- **Ponding:**

  There are no pre or post mining ponding impacts expected along the Mannering Creek due to LW34.

- **General slope stability:**

  LW34 is predicted to cause subsidence of the steep slopes of up to 1.39 m with tilting up to 15 mm/m (+/- 1^o) and strain of +/- 3 mm/m. Surface cracking with widths of 150 mm to 320 mm are estimated near the crests or high sides of longwalls below the slopes. Cracks are likely to taper down to depths between 5 m and 20 m.

The steep slopes in their current, pre-mining condition are assessed to have a 'low' sliding potential over bedding partings for an extreme range of climatic conditions (i.e. dry to saturated).

The subsided slopes for the same climatic conditions and range of expected tilts and strains are also assessed to have 'low' sliding potential during worst-case conditions, which may include unrepaired, water filled cracks. Rock exposures along ridge crests are unlikely to detach and move down slope (i.e. rock fall roll out) due to mine subsidence.

- **Valley uplift and closure:**

  Valley closure and uplift movements up to 100 mm may occur across creeks where sandstone beds exist at the surface.

- **Far-field horizontal displacements and strains:**

  It has been assessed from Mandalong Monitoring data that far-field strains are likely to be less than 1 mm/m at 0.5 x cover depth and less than 0.3 mm/m beyond an angle of draw of 45^{o} or a distance equal to 1 x cover depth outside longwall extraction limits. Measurable horizontal displacements are likely to be < 20 mm beyond a distance of 1 x the cover depth.

  No impacts to surface features are predicted due to far-field movements caused by LW34.

- **Practical Angle of Draw:**

  Surface displacements and strains are unlikely to cause damage to sensitive features located beyond an angle of draw of 26.5^{o} (0.5 x H) at the Mandalong mine. The presence of steep topography will also modify the locations of tensile and compressive strains and should be considered on a case-by-case basis.

Natural Feature Management Strategies

Each of the key features of the Modification Area have been assessed and provided with impact management strategies as follows:

- **Surface cracking:**

  Surface crack repair works may need to be implemented around the affected areas of the site, and, if public roads, watercourses and steep slopes are impacted. Crack repairs in the flatter areas may involve ripping, backfilling and top dressing works or the pouring of cement-modified sand or fly-ash grout or unbound crushed rock into wider, deeper cracks. Temporary crack repairs may be required before active mine subsidence has finished.

- **Steep Slopes and Rocky Outcrops:**

  Subsidence that results in cracking > 50 mm wide on steep slopes, will probably require repair to limit further deterioration of slope stability, increased erosion or safety impacts. The cracks will probably require the use of tracked equipment to back fill or re-grade affected areas with erosion resistant materials, such as imported crushed rock or low strength, cement-modified sand or flyash grout. Impact management strategies for steep

slopes should include surface monitoring and visual inspections, with placement of signs along public access ways that warn of mine subsidence impacts.

The predicted subsidence and associated tilt and strains could result in minor cracking along the existing rock faces or rock outcrops and talus boulders on steep slopes. It is considered that the release of sandstone boulders down slope is 'possible' due to the presence of several minor cliff lines in the modification area. The likelihood of a boulder impacting the shed or house below the densely timbered slopes and causing damage to the property or loss of life is assessed to be 'very unlikely' ($<10^{-5}$) to 'barely credible' ($<10^{-6}$).

The risk of property damage due to rock rollouts is assessed to be 'Very Low' or no worse than for the 'no mining case'.

- **Watercourses:**

  Extraction Plans will need to include Trigger Action Response Plans and remediation strategies for the unlikely occasions when cracking does occur along creeks and streams. Surface piezometers will be necessary to monitor ground water level adjustment and recovery for several years after each panel undermines a creek.

  Based on Mandalong Mines impact experience to-date, it is assessed that the proposed subsidence beneath the watercourses and Groundwater Dependent Ecosystems (GDEs) areas above the proposed mining layout is unlikely to cause significant, long-term impacts due to the presence of strain-absorbing alluvium and low levels of surface cracking experienced to-date.

  Local experience to-date suggests that if increased in-channel ponding occurs it can either remain as an 'additional' pond along the creek or be remediated in consultation with the relevant government agency.

Predicted Impacts to Built Features & Archaeology Site and Management Strategies

- **Residences**:

  There are two private dwellings within the potential zone of influence from the proposed LW34. The maximum subsidence at the residences is predicted to range from 0.09 m to 0.18 m, with tilts ranging from 0.5 to 6 mm/m, hogging and sagging curvatures from 0.01 to 0.15 km^{-1} (radii of 100 km to 6.7 km), and tensile and compressive strains of 0.1 to 1.5 mm/m.

  Predicted subsidence effects for the houses are expected to be within 'Safe, Serviceable and Repairable' (SSR) limits and unlikely to exceed 'very slight' or 'Category 0' Damage in accordance with **AS2870 - 2011**.

  The houses will not have their floor levels subsided below the minimum free board of 0.5 m above the 1 in 100-year flood level after mining is completed.

  Mandalong Mine currently manages the undermining of residences via a Property Subsidence Management Plan (PSMP) process. This process has been successful and will be continued into the proposed modification area.

- **Archaeology:**

  There are twelve Aboriginal Heritage Sites (AHS) located within the zone of influence of the proposed LW34. The assessment indicates that one Grinding Groove and two Habitation Structures (rock shelters with no PAD or objects) may 'possibly' be impacted by the proposed LW34.

  Two Grinding Grooves, two Habitation Structures, three Rock Shelters with PAD / Artefacts and two Rock Shelters with Art are 'unlikely' or 'very unlikely' to be impacted by subsidence cracking.

  It is assessed that the proposed mining layout is 'unlikely' to have a greater impact on the Aboriginal Heritage Sites than the Previous Mod 9 and Approved EIS layouts.

- **Power lines:**

  TransGrid Towers - There are no Transgrid Towers within the zone of potential influence of LW34.

  Ausgrid Domestic Powerlines - There are no timber power poles within the zone of potential influence of LW34.

  Power lines should continue to be managed in accordance with the Mine's Built Features Management Plan in consultation with TransGrid, Ausgrid and Subsidence Advisory NSW.

- **Communications:**

  Telstra have infrastructure throughout the Project Area and are likely to tolerate the predicted subsidence effects without remediation works. Mandalong Mine currently has an effective Communications Management Plan, which is revised for each Extraction Plan. This plan outlines the expected impacts, inspection regimes and potential or proposed mitigation measures.

- **Roads:**

  There are two public unsealed Crown roads (Toepfers Road and Kiar Ridge Road) present above the proposed LW34. The roads are unsealed with reinforced concrete pipe culverts at watercourse crossings. There are also several unsealed, gravel fire trails and private access roads.

  The roads and tracks may be subsided by up to 1.07 m with tilts up to 13 mm/m and strains of +/- 2 to 3 mm/m. It is assessed that they may be impacted by surface cracking of widths ranging between 10 mm and 20 mm and/or uplift of up to 30 mm.

  Public Roads should continue to be managed by the Mine's Public Roads Management Plan to provide signage and traffic control measures to affect repairs and maintain safety for road users during active subsidence periods.

Summary

It is concluded that the assessed range of potential subsidence and far-field displacement impacts after the mining of the proposed longwall panels will be manageable for the site features, based on the analysis outcomes and discussions with the stakeholders to-date. The outcomes are consistent with the EIS and Mod 9 Reports.

Furthermore, it is concluded that the proposed MOD 10 mining layout will not change the previous assessments of impact for any of the natural or built features by more than 10%.

Impact management plans and strategies will be developed to allow appropriate Trigger Action Responses and mine planning adjustments or mitigation measures necessary to deliver satisfactory outcomes.

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Glossary of Terms

Angle of Draw (AoD)	The angle to the vertical from the sides or ends of an extracted panel and the line drawn from the limits of extraction at seam level to the 20 mm subsidence contour at the surface. The 20 mm subsidence contour is an industry defined limit and represents the practical measurable limit of subsidence.
Barrier Pillar	The pillar of coal left beneath sensitive surface features (e.g. TransGrid Tension Towers) and adjacent longwall panels.
Chain Pillars	The pillar of coal left between adjacent longwall panels. The pillars form a barrier that allows the goaf to be sealed off and facilitates tailgate roof stability during longwall panel extraction. The height of the chain pillars is usually the same as the *development height*.
Compressive Strain	A decrease in the distance between two points on the surface. Compressive strains may cause shear cracking or steps at the surface if > 3 mm/m and are usually associated with concave curvatures near the middle of the panels.
Confidence Limits	A term used to define the level of confidence in a predicted *Subsidence Effect* (see definition below) subsidence impact parameter and based on a database of previously measured values above geometrically similar mining layouts.
Cover Depth (H)	The depth (H) from the surface to the mine workings roof horizon.
Critical Panels	Longwall panels that are almost as deep as they are wide (W) (i.e. 0.7 <W/H < 1.4) and is the point where 'bending' of the overburden starts to occur. If there are no massive strata present, significantly higher magnitudes of subsidence start to occur (i.e. panel geometries are transitional between sub and super critical panels, where the overburden does not span).
Curvature	The rate of change of tilt between three points (A, B and C), measured at set distances apart (usually 10 m). The curvature is plotted at the middle point or point B and is usually concave in the middle of the panel and convex near the panel edges. i.e. curvature = (tilt between points A and B - tilt between points B and C)/(average distance between points A to B and B to C) and usually expressed in 1/km. Radius of curvature is the reciprocal of the curvature and is usually measured in km (i.e. radius = 1/curvature). The curvature is a measure of surface 'bending' and is generally associated with cracking.
Credible Worst-	The Credible Worst-Case (CWC) prediction for a given

Case	*Subsidence Effect* and is normally the Upper 95% Confidence Limit determined from measured data and the line of 'best fit' or mean used to calculate the mean value. The CWC values are typically 1.5 to 2 times the mean values.
Design Angle of Draw (Design AoD)	The 'practical' angle of draw (AoD) used to define minimum or allowable distances from the sides and ends of an extracted pillar panel to sensitive surface features. It is considered to be an effective impact management tool in which to minimise impact from differential subsidence effects parameters such as tilt, curvature and strain, which may cause cracking or instability. A Design AoD of 26.5^o has been used with negligible impact to surface features at the Mandalong Mine to-date.
Development Height (h)	The height at which the first workings (i.e. the main headings & gateroads) are driven.
Dry-sclerophyll Forest	Multi-aged stands of eucalypts with a forest floor dominated by hard leafed shrubs such as banksias, wattle and tea trees.
Extraction Height (T)	The height at which the seam is mined or extracted across a longwall face.
Assessment Area	The area that will be affected by mine subsidence and far-field effects from the extraction of the proposed longwall panels associated with the Mandalong Southern Extension Area. Centennial Mandalong have adopted an area defined by the predicted 20 mm subsidence contour outside the limits of proposed longwall extraction.
Factor of Safety (FoS)	The ratio between the strength of a pillar divided by the load applied to the pillar.
Far-Field Displacement	Horizontal displacement outside of the 26.5^o AoD, which is due to horizontal stress relief in the strata above an extracted panel of coal. The strains outside a 26.5^o AoD due to these movements are usually < 0.5 mm/m and unlikely to cause impact to surface features.
First Workings	The tunnels or roadways driven by a continuous mining machine to provide access to the production panels in a mine (i.e. main headings and gate roads). The roof of the roadways is generally supported by high strength steel rock bolts encapsulated in chemical resin. Subsidence above first workings pillars and roadways is generally < 20 mm.
Full Tributary Area Load	Refers to the full weight of the prism of rock directly above the pillar of coal supporting it. The prism area is defined by the line drawn half-way between the pillar and the adjacent pillars surrounding it. The volume

	of rock above the pillar is then determined by multiplying the Tributary Area by the depth of cover. The load is then determined by multiplying the volume by the density of rock (normally assumed to be 2.5 t/m^3).
Goaf	The extracted void behind a retreating longwall that the immediate roof of the overburden collapses into soon after the coal has been extracted. The overburden above the 'goaf' then sags down and compresses it, resulting in a subsidence 'trough' developing at the surface.
Heaving	The shortening and distorting effect of compressive strains and shear strains due to mine subsidence on surface terrain, which results in localised shear failures or movements and uplift of soils and rock.
Horizontal Displacement	Horizontal displacement of a point after subsidence has occurred above an underground mining area within the AoD. It can be predicted by multiplying the tilt by a factor derived for the near surface lithology at a site (e.g. factors of around 7 to 15 are normally applied in the Newcastle Coalfield by DgS).
Inbye	An underground coal mining term used to describe the relative position of some feature or location in the mine that is closer to the working coal face than the reference location.
Inflexion Point (d)	The point above a subsided area where tensile strain changes to compressive strain along the deflected surface. It is also the point where maximum tilt occurs above an extracted longwall panel. It is typically located between 0.25 and 0.4 x cover depth from the panel sides, depending on panel W/H ratio.
Longitudinal Subsidence Profile	Subsidence measured (or predicted) along a longwall panel centre line.
Mean Values	The average value of a given *Subsidence Effect* (i.e. of subsidence, tilt, curvature or strain) predicted using a line of 'best fit' through a set of measured data points against key independent variables (e.g. panel width, cover depth, extraction height).
Outbye	An underground coal mining term used to describe the relative position of some feature or location in the mine that is closer to the point of mine entry than the reference location.
Outlier	A data point well outside the rest of the observations, representing a presumed anomaly (e.g. a measurement related to a structural discontinuity or fault in the overburden that causes a compressive strain concentration at the surface, in an otherwise tensile strain field).
Panel Width (W)	The void width of an extracted longwall between chain pillars.
Primary	Subsidence that is caused directly by second workings or

Subsidence	longwall mining due to the sagging of overburden after coal is extracted and the immediate roof collapses into the void left behind by the retreating longwall. Primary subsidence usually occurs soon after the undermining of a given surface location and continues for several weeks as the longwall retreats further along the panel.
Residual Subsidence	The last 5% to 10% of subsidence that occurs after primary subsidence is complete and is due to the re-consolidation or re-compaction of goaf and overburden. It is a time dependent component of the subsidence and is unlikely to cause further impact to surface features.
Secondary Subsidence	Indirect subsidence that is likely to occur above an extracted longwall panel if another longwall is extracted adjacent to it. The additional subsidence is caused by chain pillar compression and load transfer mechanisms to the goaf. These events can occur several times (at an exponentially decreasing rate) after the passing of at least three or four longwall panels.
Second Workings	Refers to the removal of coal between first workings pillars and usually results in goaf formation as spans between pillars are significantly increased. Second workings are therefore performed on retreat in a longwall panel that will no longer be required to provide access or ventilation to a given section of mine.
Strain	The change in horizontal distance between two points at the surface after mining, divided by the pre-mining distance between the points. i.e. Strain = ((post-mining distance between A and B) - (pre-mining distance between A and B))/(pre-mining distance between A and B) and is usually expressed in mm/m. Strain can be estimated by multiplying the curvature by a factor derived for the near surface lithology at a site (e.g. a factor of around 10 is normally applied in the Newcastle Coalfield). Discontinuous overburden behaviour however, can result in local strain and curvature concentrations at cracks, making accurate predictions difficult. A rule of thumb is normally applied to allow for these effects, which is to increase smooth profile strains (and curvatures) by 2 to 4 times occasionally at a given location. The increase in strain also usually develops at locations with exposed rock profiles, as opposed to areas with deep soil profiles.
Sub-critical Panels	Longwall panels that are much deeper than they are wide (i.e. W/H < 0.7) and cause lower magnitudes of subsidence than shallower panels, due to natural arching or catenary action within the overburden across the extracted coal seam.

Subsidence	The difference between the pre-mining surface level and the post-mining surface level at a point, after it settles above an underground mining area.
Subsidence Effect	The term used to define the subsidence and differential subsidence parameters (i.e. subsidence, tilt, strain and horizontal displacement) that may or may not have an impact on natural or built surface and sub-surface features above a mining area.
Subsidence Impact	The impact that a subsidence effect has on natural or built surface and sub-surface features above a mining area.
Subsidence Mitigation/ Amelioration	Modifying or reducing the impact of subsidence on a feature, so that the impact is within safe, serviceable, and repairable limits (normally applied to moderately sensitive built features that can tolerate a certain amount of subsidence).
Subsidence Reduction Potential (SRP)	Refers to the potential reduction in subsidence due to massive strata in the overburden being able to either 'bridge' across an extracted panel with sub-critical or critical geometry, or have a greater bulking volume when it fails above super-critical panel geometry. The term was defined in an **ACARP, 2003** study into this phenomenon and is common in NSW Coalfields where massive sandstone / conglomerate units exist.
Super-Critical Panels	Longwall panels that are not as deep (H) as they are wide (W) (i.e. W/H > 1.4) and will cause failure of the overburden and maximum subsidence that is proportional to the mining height (i.e. 0.5 to 0.6 T).
TARP	Trigger Action Response Plan.
Tilt	The rate of change of subsidence between two points (A and B), measured at set distances apart (usually 10 m). Tilt is plotted at the mid-point between the points and is a measure of the amount of differential subsidence. i.e. Tilt = (subsidence at point A - subsidence at point B)/(distance between the points) and is usually expressed in mm/m.
Tensile Strain	An increase in the distance between two points on the surface. Tensile strains > 2 mm/m are likely to cause cracking at the surface with shallow soil profiles over rock and are usually associated with convex curvatures near the sides (or ends) of the panels. Tensile strain also usually develops above chain pillars.
Transverse Subsidence Profile	Subsidence measured (or predicted) across a longwall panel or cross line.

Valley Closure The inward (or outward) movement of valley ridge crests due to subsidence trough deformations or changes to horizontal stress fields associated with longwall mining. Measured movements have ranged between 10 mm and 400 mm in the NSW Coalfields and are usually visually imperceptible.

Valley Uplift The phenomenon of upward movements along the valley floors due to **Valley Closure** and buckling of sedimentary rock units. Measured movements have ranged between 10 mm and 400 mm in the NSW Coalfields and may cause surface cracking in exposed bedrock on the floor of the valley (or gorge). The uplift due to valley closure is usually 0.5 to 1 times the closure magnitude.

1.0 Introduction

This letter provides a mine subsidence assessment of the surface features above the proposed addition of LW34 to the approved mine plan in the West Wallarah Seam at the Centennial Mandalong Mine, Mandalong.

Mandalong operates under State significant development (SSD) consent SSD-5144, which was granted on 12 October 2015 by the NSW Planning Assessment Commission under Part 4, Division 4.1 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act).

As identified in Mandalong's Mining Operations Plan (MOP) (**Centennial Coal 2018**), the progression of underground mining is regularly reviewed dependent on ongoing monitoring and geological conditions. Centennial Mandalong has encountered poor geological conditions within the Mandalong Southern Extension Area, including a fault zone and igneous sill. In response to these conditions and in order to maintain coal production, improve mining conditions and the financial viability of Mandalong, amendments to the approved mine plan were sought as part of a modification to SSD-5144 (herein referred to as MOD 9). As part of MOD 9, Centennial Mandalong sought approval to amend the approved mine plan, including the reorientation of LW30 to LW33.

Since the approval of MOD 9 in April 2021, Centennial Mandalong has continued to review the progression of underground mining within the Mandalong Southern Extension Area. As a result of these investigations, the decision has been made to shorten LW30 and remove LW33 from the mine plan. The shortening of LW30 and removal of LW33 are estimated to result in the sterilisation of approximately 0.4 million tonnes (Mt) and 1.6 Mt of coal, respectively. Consequently, Centennial Mandalong has explored options to access additional coal resources.

Centennial Mandalong is now seeking to modify SSD-5144, pursuant to Section 4.55(2) of the EP&A Act, and change Mandalong's approved mine plan to include LW34 to the east of LW30 (herein referred to as MOD 10 or the proposed modification). The addition of LW34 will maximise resource extraction within the West Wallarah Seam and Mandalong's development consent boundary and improve the continuity of coal extraction and employment at Mandalong.

This subsidence assessment has been completed to support a Modification Report (MR) for MOD 10 and includes the approved LW30 to 32 and the proposed LW34 in the Mandalong Southern Extension Area. Only the surface features within the angle of draw of LW34 have been assessed in this study. Subsidence predictions and impacts due to the Approved LW30 to 32 are presented in the MOD 9 Submissions Report (**DgS, 2020a)**. The effects of the shortening of LW30 are assessed in the Variation to LW30 and 31 Extraction Plan report (**DgS, 2021b**).

2.0 Scope

This report has included the following assessment items:

(i) the predicted mean and credible worst-case subsidence effects due to LW34 and their potential impact to natural, man-made and heritage features. The subsidence effects of the proposed LW30 to 32 are included in the assessment.

(ii) a review of the prediction model performance against measured values for previous longwalls at Mandalong (LW25 to 29). The geophysical and lithological logs have also been reviewed with updates made to the Mandalong Beam thickness and location contours to ensure the Subsidence Reduction Potential (SRP) assessment is consistent with the measured subsidence.

(iii) Based on the outcomes of the review, the prediction model has been modified to improve its performance against the measured subsidence profiles and hence the proposed longwalls LW30 to 32 and 34.

(iv) a comparison between the previous predictions and impacts provided in the Mod 9 Report (**DgS, 2020a**) for the surface features within the zone of influence of LW34.

3.0 Proposed Addition of LW 34

The following changes to the approved mining layout are as follows:

- LW34 will be 200 m wide (void width) and added to the east of LW30.
- The chain pillars between LW34 and LW30 will be 46 m wide and 99 m long (solid dimensions).
- The main access headings to the future eastern mining area will be re-orientated toward the south-east.

The cover depths for LW34 will range between 320 m and 440 m (average of 380 m) to give *sub-critical* panel width/cover depth ratios (W/H) of 0.45 to 0.63. Longwall extraction heights will vary between 3.6 m and 3.8 m, depending on seam thickness (+/- 0.1 m).

The mining development height will be 3.5 m and the roadways will be nominally 5.2 m wide.

As discussed in the Mod 9 Submissions Report (**DgS, 2020a**), the panel geometry has been designed to control mine subsidence effects to tolerable or appropriate levels in accordance with stakeholder and government agency requirements.

4.0 Surface Features above the Proposed LW34

Surface features within the potential area of influence of the proposed LW34 include:

- First, second and third order tributaries of Morans Creek and Mannering Creek.
- First order tributary of Buttonderry Creek is outside the angle of draw to LW34 and won't be directly subsided or impacted by the proposed longwall.
- Twelve Aboriginal cultural heritage sites (3 grinding grooves, 2 rock shelters with PAD, 1 rock shelter with Artefacts, 2 rock shelters with Art and 4 habitation structures (rock shelters with no PAD, artefacts or art).
- four steep slopes (1a, 1b, 1d, 1e) ranging between 18^o and 30^o and heights ranging from 50 m to 80 m.
- rocky outcrops and large boulders associated with the Triassic Terrigal Sandstone Formation. The exposures range in height from 3 m to 10 m (RF12, 13, 15-19, 29)
- two unsealed roads/tracks on Crown Land (Toepfers & Kiar Ridge Roads)
- two houses with ancillary structures, driveways and fences (No. 34 and 55)

The location of the surface features and depths of cover contours to the mine workings are shown in **Figures 1a** and **1b**. Survey monitoring lines referred to in this and previous studies are shown in **Figure 1c**.

The surface features and reduced level contours are shown in **Figures 2a** to **2c**. The steep slope sections are shown in **Figure 2d**.

5.0 Mining Geometry and Maximum Subsidence Effect Predictions

5.1 General

Subsidence effect predictions for proposed longwalls LW30 to 32 & 34 have been assessed using the empirical models presented in **DgS, 2013** after:

(i) each longwall block has been extracted (i.e. First S_{max}), and

(ii) after mining of all of the proposed longwall panels are complete (i.e. Final S_{max}).

The assessment methodology requires the consideration of the following:

- The panel void width (W), average panel cover depth (H) and mining height (T).

- The subsidence reduction potential (SRP) of the overburden (High, Moderate or Low) and the influence of Mandalong Beam thickness (t) and its distance above the mine workings (y).

- The behaviour of the chain pillars and immediate roof and floor system under double abutment loading conditions when longwalls have been extracted along both sides of the pillars.

- The combined effects of single panel, chain pillar and goaf edge subsidence to estimate Final subsidence profiles and subsidence contours for subsequent environmental impact assessment.

The input parameters described above have been derived from **Figures 3a** to **3d**. The site geology (lithology and structure) has also been considered and shown in **Figure 3e**.

5.2 Predicted Maximum Subsidence Effects for LW30 to 32 and LW34.

The borehole data in the study area indicates 'Low' to 'Moderate' Subsidence Reduction Potential (SRP) overburden exists above the proposed longwalls with some 'natural arching' expected to occur for the sub-critical longwall geometries; see **Figures 4a** and **4b**.

The empirical model curves used to predict the single panel subsidence, chain pillar subsidence, goaf edge subsidence and angle of draw to the 20 mm subsidence contour are presented in **Figures 4c** to **4f**.

The maximum first and final subsidence, tilt, curvature and strain magnitudes were estimated for the multiple longwall panels with the empirical curves presented in **DgS, 2020a** for the Mod 9 report.

A review of the model performance above LW25b to 29 is presented in **Section 5.3**. The outcome of the review was to modify the Mandalong Beam thickness model, estimated chain pillar subsidence prediction model and the proportion of the chain pillar, goaf edge and sag subsidence used to predict the multi-panel subsidence. The adjustments have affected the previous subsidence values presented by +/- 200 mm (or +/- 15%).

The mining geometry and predicted subsidence effects for the proposed LW30 to 32 & 34 are presented in **Table 1** and based on the updated/modified prediction models.

Table 1 - Predicted Maximum Subsidence Effects for LWs 30 to 32 & 34 (Panel Void Width W = 200 m)

LW #	Panel Width W (m)	Cover Depth H (m)	W/H Ratio	Mining Height^ (T)	Chain Pillar Width w (m)	Massive Strata Unit Thickness t (m)	Unit y (m)	SRP	First S_{max} (m)		Final S_{max} (m)		Final Chain Pillar Stress (MPa) & FoS		Final Chain Pillar S_p (m)		Maximum First (Final) Tilt T_{max} (mm/m)		Maximum Horizontal Tensile Strain* (mm/m)		Maximum Horizontal Compressive Strain* (mm/m)	
									m	*U95*	*m*	*U95*	*Stress*	*FoS*	*m*	*U95*	*m*	*U95*	*m*	*U95*	*m*	*U95*
Crossline XL 3																						
34	200	440	0.45	3.8	*246*	30	104	Low	0.48	0.62	0.49	0.62	15.1	77	-	-	4 (4)	6 (6)	2	3	2	4
31	200	420	0.48	3.7	53	34	103	Low	0.52	0.72	1.07	1.28	41.0	1.50	0.72	0.90	4 (13)	7 (19)	4	6	5	8
32	200	430	0.47	3.6	52	30	102	Low	0.75	0.88	0.98	1.11	27.4	2.17	-	-	8 (11)	12 (17)	3	4	4	6
Crossline XL 4																						
34	200	380	0.53	3.7	46	*30*	100	*Low*	0.64	0.87	1.16	1.39	39.3	1.22	0.69	0.87	6 (15)	9 (22)	5	7	6	9
30	200	380	0.53	3.6	51	*34*	100	*Mod*	0.62	0.84	1.14	1.34	40.0	1.43	0.69	0.86	6 (14)	9 (21)	2	4	3	5
31	200	450	0.44	3.6	53	*36*	100	*Mod*	0.52	0.71	1.11	1.31	46.2	1.33	0.76	0.93	4 (14)	7 (20)	2	3	3	4
32	200	490	0.41	3.6	52	*30*	100	*Low*	0.66	0.77	1.02	1.00	<u>32.1</u>	1.85	-	-	6 (12)	10 (18)	2	4	3	5
Crossline XL 4a																						
30	200	300	0.65	3.8	51	22	99	Low	1.03	1.26	1.30	1.53	28.7	2.00	0.54	0.63	12 (17)	18 (26)	5	8	6	10
31	200	335	0.60	3.6	53	30	97	Low	0.99	1.18	1.26	1.46	29.6	2.07	0.54	0.63	11 (16)	17 (25)	4	6	6	9
32	200	330	0.61	3.7	52	25	97	Low	1.04	1.24	1.08	1.29	<u>19.6</u>	<u>3.03</u>	-	-	12 (13)	19 (20)	4	6	5	8

^ - Roadway height = 3.5 m & pillar length (solid) l = 98.4 m; Unit y = distance to base of massive strata unit above the mine workings; SRP = Subsidence Reduction Potential of the overburden strata unit for the proposed panel geometry (i.e. Low, Moderate, High); y = distance strata unit above mine roof; * - Near surface rock may cause strain concentrations which are 2 x 'smooth' profile strains; m = mean; U*95* = Upper 95% Confidence Limit; <u>underlined</u> - single side abutment load effects only; shaded - LW34 predictions.

The predicted U95%CL and mean subsidence profiles for XL4 above the proposed LW30 to 32 & 34 are shown in **Figures 5a** and **5b**.

The predicted mean and U95%CL subsidence effect results for the proposed LW34 are summarised below:

- **First maximum panel subsidence** ranges from 0.48 m to 0.87 m (12.6% to 23.5% of the mining height, T).
- **Final maximum panel subsidence** ranges from 0.49 m to 1.39 m (13.2% to 37.6%T).
- **Final maximum chain pillar subsidence** ranges from 0.69 m to 0.87 m (18.6% to 23.5% of the mining height, T).
- **Maximum first and final panel tilt** values range from 4 to 15 mm/m (mean values) and 6 mm/m to 22 mm/m (U95%CL values).
- **Maximum panel compressive strains** range from 2 to 6 mm/m (mean values) and from 4 to 9 mm/m (U95%CL values).
- **Maximum panel tensile strains** range from 2 to 5 mm/m (mean values) and from 3 to 7 mm/m (U95%CL values).
- **Maximum panel concave (sagging) curvatures** range from 0.2 km^{-1} to 0.6 km^{-1} (mean values) or radii of curvature of 5 km to 1.7 km. U95%CL values range between 0.4 km^{-1} and 0.9 km^{-1} or radii of curvature of 2.5 km to 1.1 km.
- **Maximum panel convex (hogging) curvatures** range from 0.2 km^{-1} to 0.5 km^{-1} (mean values) or radii of curvature 5 km to 2 km. U95%CL values range between 0.3 km^{-1} and 0.7 km^{-1} or radii of curvature of 3.3 km to 1.4 km.

Based on the calibrated SDPS® model, predictions of U95%CL final subsidence effect contours (subsidence, tilt and horizontal strain) for the proposed longwalls LW30 to 32 and 34 are presented in **Figures 6a** to **6c**.

Pre-mining and post-mining surface levels above the approved and proposed longwalls are shown in **Figures 7a** and **7b**. The level contours are based on the U95%CL (Credible Worst-Case) subsidence predictions.

Post-mining surface gradient change contours are shown in **Figure 8**.

The predicted impacts in the proposed modification area are discussed in **Section 6**.

For completeness, the performance of the prediction model has been reviewed for LW25 to 29 and presented in **Section 5.3**.

5.3 Review of Subsidence Effect Predictions for LW25 to 29

A review of the predicted and measured subsidence effects has been completed for the survey cross line CS-22 above LW25b to LW28b and LW29. The purpose of the review was to provide an updated assessment of the prediction model reliability and previously assessed subsidence effects for LW1 to 33 in the Mod 9 report (**DgS, 2020a**).

A summary of the mining geometry and massive strata units for LW25 to 29 are presented in **Table 2A**.

Table 2A - Mine Workings Geometry Mandalong Mine's LW25 to 29

LW #	Survey Line (CS)	Panel Width W (m)	Cover Depth H (m)	Panel W/H	Face Height T (m)	Chain Pillar Width w_{cp} (m)	Pillar w/h*	Massive Unit Thickness t (m)	Massive Unit Location Above Workings y (m)	SRP
25b	22	180	295	0.61	4.3	46.0	13.1	30	100	M
26b	22	180	320	0.56	4.3	43.4	12.4	30	101	M
26b	22	180	330	0.55	4.2	43.4	12.4	30	101	M
27b	22	180	286	0.63	4.0	43.4	12.4	30	102	M
28b	22-23	180	280	0.64	4.0	43.4	12.4	30	103	M
29	23	180	295	0.61	4.3	43.4	12.4	30	104	M

* - h = development height of 3.5 m adopted for LW25a,b - 29.

The previous and adjusted model outcomes are compared to measured values in the following results tables. The measured single panel subsidence, chain pillar subsidence and goaf edge subsidence parameters were also plotted with the databases in **Figures 4c** to **4e**.

A summary of measured v. predicted first and final subsidence along the actual survey lines CS-22 & CS-23 for LW25b to 29 is presented in **Table 2B** (First) and **Table 2C** (Final).

Table 2B - Summary of Predicted v. Measured First Maximum Subsidence

LW #	Survey Line (CS)	Panel Width W (m)	Cover Depth H (m)	Panel W/H	Face Height T (m)	SRP	First Panel S_{max} (m)		First Chain Pillar S_p (m)	
							Predicted mean-U95%CL	Measured	Predicted mean - U95%CL	Meas.
Mod 9 Report Prediction Model (based on LW1 - 27 survey data)										
25b	22	180	295	0.61	4.3	M	0.57 - 0.73	0.63	0.54 - 0.63	0.28
26b	22	180	320	0.56	4.3	M	0.66 - 0.89	*0.94*	0.64 - 0.83	0.28
27b	22	180	330	0.55	4.2	M	0.67 - 0.90	0.81	0.60 - 0.78	0.25
28b	22-23	180	286	0.63	4.0	M	0.71 - 0.85	*1.01*	0.47 - 0.56	0.19
29	23	180	280	0.64	4.0	M	0.97 - 1.13	1.11	-	-
Modified Prediction Model (based on LW25b to 29 survey data)										
25b	22	180	295	0.61	4.3	M	0.62 - 0.84	0.63	0.39 - 0.49	0.28
26b	22	180	320	0.56	4.3	M	0.68 - 0.95	0.94	0.50 - 0.71	0.28
27b	22	180	330	0.55	4.2	M	0.69 - 0.94	0.81	0.45 - 0.65	0.25
28b	22-23	180	286	0.63	4.0	M	0.82 - 1.04	1.01	0.31 - 0.41	0.19
29	23	180	280	0.64	4.0	M	0.79 - 1.02	*1.11*	-	-

italics - measured value < 15% above predicted value; **bold** - measured value > 15% above predicted value;

Table 2C - Summary of Predicted v. Measured Final Maximum Subsidence

LW #	Survey Line (CS)	Panel Width W (m)	Cover Depth H (m)	Panel W/H	Mining Height T (m)	SRP	Final Panel S_{max} (m)		Final Chain Pillar S_p (m)	
							Predicted mean - U95%CL	Measured	Predicted mean - U95%CL	Meas.
Mod 9 Report Prediction Model (based on LW1 - 24a survey data)										
25b	22	180	295	0.61	4.3	M	0.91 - 1.07	0.88	0.65 - 0.75	0.32
26b	22	180	320	0.56	4.3	M	1.07 - 1.30	1.29	0.77 - 0.98	0.52
27b	22	180	330	0.55	4.2	M	1.04 - 1.26	1.04	0.72 - 0.92	0.35
28b	22-23	180	286	0.63	4.0	M	0.99 - 1.14	*1.18*	0.57 - 0.66	0.19
29	23	180	280	0.64	4.0	M	1.05 - 1.20	1.11	-	-
Modified Prediction Model (based on LW25b to 29 survey data)										
25b	22	180	295	0.61	4.3	M	0.93 - 1.16	0.88	0.47 - 0.57	0.32
26b	22	180	320	0.56	4.3	M	1.12 - 1.39	1.29	0.61 - 0.81	0.52
27b	22	180	330	0.55	4.2	M	1.07 - 1.32	1.04	0.54 - 0.74	0.35
28b	22-23	180	286	0.63	4.0	M	1.04 - 1.26	1.18	0.37 - 0.47	0.19
29	23	180	280	0.64	4.0	M	0.81 - 1.04	*1.11*	-	-

italics - measured value < 15% above predicted value; **bold** - measured value > 15% above predicted value.

The measured first and final maximum subsidence values along Survey Line CS-22 and CS-23 were within 15% of the predicted U95%CL values for LW25 to 29, based on the previous prediction model. However, it is apparent that the previous model overpredicted the chain pillar subsidence (and therefore underpredicted the sag subsidence) by approximately 200 mm. The modified model has assumed lower bound limits of the chain pillar subsidence database (see **Figure 4d**).

The modified model predictions are shown with the measured values in **Figure 4g** (U95%CL) and **Figure 4h** (mean).

The assessed SRP of 'Moderate' for the panels to-date is considered to be reasonably correct, with LW29 possibly starting to develop 'Low' SRP (note the borehole logs indicate the Mandalong Beam is only 22 m thick above the proposed LW30 to the south, compared to ~30 m for the extracted panels to-date); see **Figure 3c**.

A review of the strata unit thickness and location data above the mine workings is provided in **Appendix A**. The key SRP assessment variables (Mandalong Beam thickness (t) and distance (y) above the mine workings are re-presented in **Figures 3b** and **3c**). It is apparent that the beam is more affected by mudstone beds in the southern areas of the mine, however, the subsidence data indicates that the beam has continued to modify (reduce) the subsidence expected for 'Moderate' SRP and the sub-critical 180 m wide longwall panel geometries.

It is expected that a mix of Low and Moderate SRP outcomes will occur for the proposed 200 m wide LW30 to 32 and 34.

It is also noted that the presence of sub-vertical dykes in nearly all of the longwalls to-date have not affected the observed subsidence profiles significantly.

The results of the tilt data review for LW25b to 29 are presented in **Table 2D**.

Table 2D - Summary of Predicted v. Measured Maximum Tilts

LW #	Survey Line (CS)	Panel Width W (m)	Cover Depth H (m)	Panel W/H	Mining Height T (m)	SRP	Predicted First & (Final) Maximum Tilt T_{max} (mm/m)		Measured Maximum Tilt T_{max} (mm/m)	
							Mean	U95%CL	Side 1	Side 2
Mod 9 Report Prediction Model (based on LW1 - 24a survey data)										
25b	22	180	295	0.61	4.3	M	6 (12)	9 (18)	8.2	12.7
26b	22	180	320	0.56	4.3	M	8 (15)	11 (23)	13.4	19.1
27b	22	180	330	0.55	4.2	M	8 (14)	12 (22)	9.5	10.8
28b	22-23	180	286	0.63	4.0	M	8 (13)	12 (20)	16.8	18.2
29	23	180	280	0.64	4.0	M	13 (15)	20 (22)	17.0	17.1
Modified Prediction Model (based on LW25b to 29 survey data)										
25b	22	180	295	0.61	4.3	M	7 (13)	10 (19)	8.2	12.7
26b	22	180	320	0.56	4.3	M	5 (13)	8 (20)	13.4	19.1
27b	22	180	330	0.55	4.2	M	7 (14)	11 (21)	9.5	10.8
28b	22-23	180	286	0.63	4.0	M	11 (15)	17 (23)	16.8	18.2
29	23	180	280	0.64	4.0	M	11 (11)	17 (17)	17.0	17.1

U95%CL - Upper 95% Confidence Limit; Measured Side 1,2 - Measured peak value(s) above longwall panel on each side; *italics* - < 15% prediction exceedance; ***Bold*** - Measured value exceeded maximum prediction by > 15%.

It is assessed that the measured tilts over LW25 to 28 range between the first and final predicted tilt values for both models. The modified model predictions are shown with the measured profiles in **Figure 4g** (U95%CL) and **Figure 4h** (mean).

The strain data for LW25b to 29 is summarised in **Table 2E** (tensile) and **2F** (compressive).

Table 2E - Summary of Predicted v. Measured Maximum Tensile Strain

LW #	Survey Line (CS)	Panel Width W (m)	Cover Depth H (m)	Panel W/H	Mining Height T (m)	SRP	Maximum Tensile Strain E_{max} (mm/m)			
							Predicted		Measured	
							mean	*U95%CL*	*Panel Side1*	*Panel Side2*
Mod 9 Report Prediction Model (based on LW1 - 24a survey data)										
25b	22	180	295	0.61	4.3	M	4	7	2.0	4.6
26b	22	180	320	0.56	4.3	M	3	5	3.3	4.3
27b	22	180	330	0.55	4.2	M	3	5	3.4	-
28b	22-23	180	286	0.63	4.0	M	3	5	1.5	2.8
29	23	180	280	0.64	4.0	M	5	7	2.7	5.1
Modified Prediction Model (based on LW25b to 29 survey data)										
25b	22	180	295	0.61	4.3	M	5	7	2.0	4.6
26b	22	180	320	0.56	4.3	M	2	4	3.3	4.3
27b	22	180	330	0.55	4.2	M	3	5	3.4	-
28b	22-23	180	286	0.63	4.0	M	4	6	1.5	2.8
29	23	180	280	0.64	4.0	M	4	6	2.7	5.1

italics - Measured value exceeded predicted U95%CL value by < 15%; **Bold** - Measured value exceeded predicted U95%CL value by > 15%.

The measured tensile strains were between or below the predicted mean and U95%CL values for both models. The modified model predictions are shown with the measured profiles in **Figure 4g** (U95%CL) and **Figure 4h** (mean).

Table 2F - Summary of Predicted v. Measured Maximum Compressive Strain

LW #	Survey Line (CS)	Panel Width W (m)	Cover Depth H (m)	Panel W/H	Mining Height T (m)	SRP	Maximum Compressive Strain E_{max}(mm/m)		
							Predicted		Measured
							mean	*U95%CL*	*Central Panel*
Mod 9 Report Prediction Model (based on LW1 - 24a survey data)									
25b	22	180	295	0.61	4.3	M	6	8	4.6
26b	22	180	320	0.56	4.3	M	4	6	5.0
27b	22	180	330	0.55	4.2	M	4	6	4.9
28b	22-23	180	286	0.63	4.0	M	4	6	5.6
29	23	180	280	0.64	4.0	M	6	9	5.3
Modified Prediction Model (based on LW25b to 29 survey data)									
25b	22	180	295	0.61	4.3	M	6	9	4.6
26b	22	180	320	0.56	4.3	M	3	5	5.0
27b	22	180	330	0.55	4.2	M	4	6	4.9
28b	22-23	180	286	0.63	4.0	M	5	8	5.6
29	23	180	280	0.64	4.0	M	5	8	5.3

italics - Measured value exceeded predicted U95%CL value by < 15%; **Bold** - Measured value exceeded predicted U95%CL value by > 15%.

The measured compressive strains plot between or below the predicted mean and U95%CL values for both models. The modified model predictions are shown with the measured profiles in **Figure 4g** (U95%CL) and **Figure 4h** (mean).

5.4 Model Review Summary

The review has identified several modifications that were used to improve the model's performance over future longwalls in regard to the following:

- apparent overprediction of measured chain pillar subsidence and under prediction of the sag subsidence by +/- 200 mm. The predicted maximum subsidence values however were within 15% of the measured values and still considered reasonable for impact assessment purposes.

- It was apparent that the measured chain pillar subsidence values were plotting closer to the Lower 95% Confidence Limits of the database (see **Figure 4d**). It is considered that the difference is probably due to stronger mine floor materials than a significant proportion of the database cases. It was noted in the EIS Report that the Awaba Tuff at Mandalong is moisture resistant with medium to high strength (a UCS of 40 MPa and high slake durability was recorded by laboratory testing on core samples).

- Due to the significantly lower chain pillar compression effects observed, it was decided to adopt the Lower bound 95%CL limit line as the model 'mean' and then add the error margin to obtain the Upper bound 95%CL result for the proposed LW30 to 32 and 34 predictions; see **Figure 4d** and **Table 1**.

- There were several tilt underpredictions over the middle panels where only the first tilt predictions were provided in previous reports. The first and final tilt values have now been adopted for the proposed panels. It was noted that the first and final tilt

predictions for LW25b to 29 bracket the measured tilt values (see **Table 2D** & **Figures 4g - 4h**).

- The predicted mean and U95%CL strains bracketed all of the measured strains. The predicted strains were derived from 10 times the U95%CL curvature or 15 times the mean curvature, indicating that the same multiplying factors are still appropriate for the future longwalls.

- The potential for re-distribution of strain towards the high side of the future longwalls under steep terrain has also been considered and further discussed in **Section 6**.

- The additional survey data was also used to re-calculate the 'a' and 'b' ratios for estimating the contributions of the chain pillar and goaf edge subsidence to estimate the first and final subsidence over multiple longwalls as follows:

  First S_{max} = Single S_{max} + 0.5b(First S_{p-1})

  Final S_{max} = First S_{max} + b(Final S_p - aFirst S_{goe})

  The data for LW25b to 29 indicates a = 0.74 and b = -0.159(W/H)+0.974 (b_{min} =0.5 and b_{max}=1) for the sub-critical longwalls.

  Values of a = 1 and b = $1.0544e^{(-0.0015*H)}$ were estimated from shallower longwalls in previous reports and have now been superseded.

The result of the model changes has resulted in an increase in maximum subsidence for Low SRP cases by ~ 200 mm (~15%). The increase is 'unlikely' to change the previous impact assessments presented in the Mod 9 Report for LW30 to 33.

For completeness, the measured v. predicted subsidence effects along Mandalong Road (survey line CS-21) due to LW25a,b to 29 are shown in **Figure 4i** to **4k**. The modified model predictions indicate lower chain pillar subsidence and increased maximum subsidence between 100 mm to 250 mm. No cracking impacts were detected above LW26ab to 29 due to measured subsidence of 0.1 to 0.98 m, tilt from 4 to 11.6 mm/m and horizontal strain from -3.0 to 3.9 mm/m.

The review of the borehole data (geophysics logs are presented in **Appendix A**) has resulted in an update to the Mandalong Beam thickness and its distance above mine workings contours as shown in **Figures 3b** and **3c** respectively. The beam thickness is considered to range between 22 m to 34 m above the proposed study area and have an average UCS of 70 MPa based on sonic velocity and UCS testing data. The beam is located between 94 m and 100 m above the Wallarah Seam workings.

6.0 Predicted Subsidence Impacts on Surface Features within the LW34 Zone of Influence

6.1 Surface Cracking & Non-Conventional Subsidence Effects

It is noted in **DgS, 2013** that the predicted final maximum panel subsidence magnitudes of 0.9 m to 1.3 m may result in the occasional surface crack developing within the limits of the extracted panels in undulating terrain. It was assessed that based on predicted maximum tensile strains of 3 mm/m to 7 mm/m, crack widths are estimated to range from 30 mm to 70 mm wide where shallow or exposed rock exists. Cracking is unlikely to occur where deep soil or alluvium profiles exist, as the strain will be more uniformly distributed and absorbed.

Valley closure movements are considered to be non-conventional subsidence effects that can occur along water courses that have been undermined. The closure across creek beds may cause cracking due to 'uplift' or buckling of exposed rock units by up to 100 mm. Possible valley closure impacts have only been detected above longwall LW28 with measured compressive strains ranging between 3 and 4 mm/m (see details further below).

It was also noted in **DgS, 2020a** that surface cracking has been rare above the Mandalong LW1 to 24a, and it was likely to be due to the presence of thinly bedded, near surface strata of the Tuggerah and Patonga Claystone Formations that tend to 'shear' into thinner beams during subsidence development instead of generating fresh vertical cracks.

However, since the extraction of LW25 to 29 surface cracks and surface heave movements of up to 100 mm were observed on Mandalong Road and the southern mine extension mine site access road above LW25b. The cracks were remediated in accordance with the management plans. The impacted slopes above the extracted LW25b ranged from 15^{o} to 18^{o} and were in the 'moderate' range.

An inspection of an ephemeral creek bed above LW28b in April 2021 identified an apparent 1 mm wide crack in the exposed sandstone rock bar adjacent to a grinding Groove Site (TBM34). The crack was actually an existing NE/SW striking joint and was tapered vertically, indicating tensile strain had opened it after mining (pre-mining photo indicates a closed joint or 'hairline' crack existed before mining).

The nearest survey lines (CS-22 and CS-23) indicated tensile strains may have ranged between 1.8 mm/m and 4.3 mm/m between the rib-side and the groove site, which was 22 m from the rib over the goaf. Compressive strain of 2.9 mm/m was also recorded across the creek bed, suggesting valley closure effects may have affected the joint through buckling-type deformation. The predicted strain of 2 mm/m at the groove site was assessed in the 'possible' cracking impact category in **DgS, 2020b**.

Several other heritage sites, including a grinding groove site (TBM31) on the creek bed and a stone arrangement (TBM32) were not impacted by measured strains ranging between -3.5 mm/m (compressive) and 1.5 mm/m (tensile). 'Possible' cracking impacts were also indicated in the previous report.

6.2 Steep Slopes

There are four steep slopes above the proposed LW34 that range between 18^{o} and 30^{o}. The four slopes are labelled 1a, 1b, 1d and 1e as shown in **Figure 2b**. The slopes face towards the SW, NE, S and N (in order of longwall retreat direction).

There are also several rocky sandstone outcrops between 3 m and 10 m high on the steep slopes which form terraced, continuous profiles of lengths > 20 m. Loose sandstone boulders and talus with side dimensions of up to 5 m exist on the crests of ridges and on the foot slopes in the area.

The indicative surface geology on steep slopes in the study area is presented in **Figure 2d** and shows the slopes are situated within the interbedded mudstone and sandstone beds of the Patonga Claystone and Tuggerah Formations. The borehole logs in the area indicate the bedding dips towards the south-west at 1^{o} to 2^{o}. There are several concave and convex breaks in slope due to transitioning of sandstone dominant to claystone dominant lithologies.

LW34 will cause subsidence of the steep slopes of up to 1.39 m with tilting up to 15 mm/m (+/- 1^{o}) and strain of +/- 3 mm/m. It was noted in **DgS, 2020a** that cracking has not been detected on the steep slopes and ridges above the Mandalong Mine's longwalls 1 to 24a after subsidence of up to 1.2 m.

However, the occurrence of cracking is strongly influenced by near surface lithology and topography such that differential subsidence effects should not be ruled out above the steep slopes in the Mandalong South area. Based on the 1 mm to 100 mm wide subsidence cracks observed above LW 25a,b to 29, surface cracks ranging from 150 mm to 320 mm width are predicted to occur on the slopes above LW34. Tensile strains are also expected to migrate up-slope and concentrate along undermined ridges. Compressive strains are expected to migrate downslope or the low sides of the longwalls.

The approved longwalls were previously assessed as 'unlikely' to cause deep seated or shallow instability on the slopes due to tilting and/or cracking impacts with saturated slope FoS > 1.5 indicated by translation and wedge sliding analysis theories presented in **Das, 1998**.

The predicted post-mining surface slope gradient changes (based on U95%CL values) for the proposed mining layout is presented in **Figure 8** and are consistent with previous assessments (**DgS, 2020a/b**).

It is evaluated that the changes to the previously assessed factors of safety are only 'slightly' decreased (<1%) and the likelihood of instability will therefore remain unchanged as 'unlikely' to occur.

6.3 Potential Rock Falls

The predicted subsidence and associated tilt and strains could result in minor cracking along the existing rock faces or rock outcrops on steep slopes and along watercourses. Observations of the talus slopes indicates that the majority of boulder-sized rock with dimensions ranging from 0.5 m to 3 m released from the rock faces due to natural weathering processes have been limited by tree impacts or concave breaks in slope within 200 m from the release points (see **Figure 2b**, which shows a group of boulders (RF19) down slope from a minor cliff line (RF18) along the Crest of steep slope No. 1b.

It is therefore 'possible' that there could be a release of sandstone wedges or boulders from several of the rock faces due to natural weathering processes once every 20 to 200 years or more (an annualised probability range of 0.05 to 0.005). Whilst the rock fall rolling hazard is already present due to natural weathering processes, it is indicated by this study that the frequency (and hence opportunities for interaction with property and people) may increase due to the proposed mining effects from LW34.

As was indicated in the EIS Report (**DgS, 2013**) a review of the proposed mining layout indicates the following surface features within the angle of draw from LW34 may be vulnerable to rock rollout:

- House No. 55 is located 200 m to 230 m downslope of a 3 m to 5 m high rock face (RF15) above LW34 on steep slope No. 1d (see **Figure 2b)**. Section AA on **Figure 2d** indicates the slope consists of a 90 m to 130 m long steep section of 25^{o} and a 50 m to 70 m length of firm soil slope of 7^{o} to 10^{o}. The steep slope section has a dense cover of mature trees and the property includes a shed and house in a cleared area below the toe of the steep slope.

Based on the observed boulder roll out distances, it is considered that the release of sandstone boulders could reach the cleared area around the property. However, based on the presence of trees and the results of a rock-roll out simulation study for LW30 to 31 Extraction Plan (**DgS, 2021b**) the maximum rollout distance of 0.5 m to 1.5 m diameter boulders were estimated to range from 120 m to 140 m.

The likelihood of a boulder impacting the shed or house and causing damage to the property or loss of life is assessed to be 'very unlikely' ($<10^{-5}$) to 'barely credible' ($<10^{-6}$).

The risk of property damage due to rock rollouts is assessed to be 'Very Low' or no worse than for the 'no mining case'.

6.4 Watercourses

6.4.1 Gradient Changes

First, second and third-order tributaries of Morans Creek and Mannering Creek are located within the angle of draw to the proposed LW34. The cover depth along the creek bed ranges from 330 m to 335 m.

Pre and post-mining creek bed profiles of level and in-line gradient changes are presented in **Figures 9a,b** for Mannering and Morans Creek. A summary of predicted creek gradients and the gradient changes are summarised in **Table 3**.

Table 3 - Changes to Gradients along Mannering and Morans Creek

Creek	Case	Gradient (o)	Gradient (%)	Gradient Change (o)	Gradient Change (%)
Proposed LW30 to 32 & 34 (Mod 10)					
Mannering	Pre-LW30	4.1 - 11.4	7.1 - 20.2	-	-
	Post-LW30	**4.1 - 11.4**	**7.1 - 20.1**	**-0.1 to -0.09**	**-0.18 to -0.15**
	Pre-LW34	1.9 - 17	2.4 - 31.4	-	-
	Post-LW34	**1.5 - 18**	**2.9 - 31.9**	**-0.5 to 0.36**	**-0.87 to 0.63**
Morans	Pre-LW30	3.4 - 4.9	5.9 - 8.6	-	-
	Post-LW30	**2.6 - 5.1**	**4.5 - 8.9**	**-1.7 to 1.7**	**-2.9 to 2.9**
	Pre-LW34	6.77	11.9	-	-
	Post-LW34	**6.88**	**12.1**	**+0.11**	**+0.19**
Approved LW30 to 33 (Mod 9)					
Mannering	Pre-LW30	4.1 - 11.4	7.1 - 20.2	-	-
	Post-LW30	**4.1 - 11.4**	**7.1 - 20.1**	**-0.1 to -0.09**	**-0.18 to -0.15**
Morans	Pre-LW30	3.4 - 4.9	5.9 - 8.6	-	-
	Post-LW30	2.8 - 5.1	4.9 - 8.9	*-1.4 to 1.4*	*-2.5 to 2.4*

bold - post-mining results; **shaded** - results for LW34 (Mod 10); *italics* - Mod 10 predictions are higher than those presented in Mod 9 due to changes in prediction model methodology (see **Section 5.3**)

For Mod 10, changes to the creek beds are as follows:

- Mannering Creek gradients above LW34 are expected to increase by 0.6% (0.4°) and decrease by 0.9% (0.4°). The creek gradients above LW30 are estimated to decrease by 0.2% (0.1°).
- Morans Creek gradients above LW34 are expected to decrease by 0.2% (0.1°). The creek gradients above LW30 are estimated to increase and decrease by +/- 2.9% (1.7°).

For Mod 9, the following changes to the creek beds were as follows:

- Mannering Creek gradients above LW30 were expected to decrease by 0.2% (0.1°).
- Morans Creek gradients above LW30 were expected to increase and decrease by +/- 2.9% (1.7°).

It is noted that the slight increase in creek bed gradient for Morans Creek in the Mod 10 assessment is due to the changes to prediction methodology only and is discussed in **Section 5.3**.

Overall, it is predicted that changes to surface gradients along creek beds will result in 'minor' to 'negligible' erosional impacts along the creek. The predicted gradient changes for the creeks are therefore unlikely to result in significant impact differences between the proposed and approved mining layouts.

6.4.2 Ponding

The pre-mining and predicted post-mining ponding depths for the proposed mining layout have been estimated from the surface level contours shown in **Figures 7a** and **7b**.

There are no pre or post mining ponding or erosion impacts expected along the Mannering Creek. The predicted ponding depths above LW30 will increase by ~0.2 m but remain in-channel as described in the Mod 9 Assessment.

6.4.3 Valley Closure

Valley uplift and closure movements of up to 100 mm may occur along the drainage gullies present above the proposed mining area. However, due to the observed low horizontal stress regime in the Mandalong workings, it is considered unlikely that significant magnitude movements will occur in the gullies and broad crested valleys.

Uplift movements of 100 mm have occurred in compressive strain zones above Mandalong panels to-date at depths of cover of 180 m to 370 m. The majority of these movements are not considered to be due to the valley closure mechanism but related to systematic subsidence development of compressive strains and cantilevering of the bending rock mass.

Minor cracking in creek beds may cause some shallow sub-surface re-routing of surface flows due to the valley closure mechanism if it does occur.

A similar assessment was presented in the Mod 9 report.

6.5 Natural Feature Management Strategies

Each of the key features have been assessed and provided with impact management strategies as follows:

- **Surface cracking:**

  Surface crack repair works may need to be implemented around the affected areas of the site, and, if public roads, watercourses and steep slopes are impacted. Crack repairs in the flatter areas may involve ripping, backfilling and top dressing works or the pouring of cement-modified sand or fly-ash grout or unbound crushed rock into wider, deeper cracks. Temporary crack repairs may be required before active mine subsidence has finished.

- **Steep Slopes:**

  Subsidence that results in cracking > 50 mm wide on steep slopes, will probably require repair to limit further deterioration of slope stability, increased erosion or safety impacts. The cracks will probably require the use of tracked equipment to back fill or re-grade affected areas with erosion resistant materials, such as imported crushed rock or low strength, cement-modified sand or flyash grout. Impact management strategies for steep slopes should include surface monitoring and visual inspections, with placement of signs along public access ways that warn of mine subsidence impacts.

- **Watercourses:**

  Extraction Plans will need to include Trigger Action Response Plans and remediation strategies for the unlikely occasions when cracking does occur along creeks and streams. Surface piezometers will be necessary to monitor ground water level adjustment and recovery for several years after each panel undermines a creek.

  Based on Mandalong Mines impact experience to-date, it is assessed that the proposed subsidence beneath the watercourses and Groundwater Dependent Ecosystems (GDEs) areas above the proposed mining layout is unlikely to cause significant, long-term impacts due to the presence of strain-absorbing alluvium and low levels of surface cracking experienced to-date.

  Surface flows between sections of creek that have become ‘disjointed’ due to ponding impacts, may require engineered channel earth works. Local experience to-date suggests that if increased in-channel ponding occurs it can either remain as an ‘additional’ pond along the creek or be remediated in consultation with the relevant government agency.

6.6 Power Infrastructure

A suspended domestic power line exists on the property with House No. 34 and is assessed to be outside the 20mm angle of draw due to LW34. The assessment of the subsidence effects for the poles due to LW30 to 32 will be given in the appropriate extraction plans.

6.7 Private Dwellings

There are two private dwellings within the potential zone of influence from the proposed LW34 (No. 34 and 55 in **Figure 1a**).

The predicted final subsidence effect results for each house (subsidence, tilt, curvature and horizontal strain) due to the proposed mining layout are summarised in **Table 4** and based on the U95%CL contours in **Figures 6a** to **6c**.

Table 4 - Predicted U95%CL Subsidence Effects at Existing Residences (Values at Building Centres) due to the Proposed LW34

House No.#	LW#	Easting (m)	Northing (m)	Surface RL (AHD)	Cover Depth (m)	Final Subsidence S_{max}	Final Max Tilt T_{max} (mm/m)	Final Max Curvature C_{max} (km^{-1})	Final Max Strain E_{max} (mm/m)
Current Study (Mod 10)									
34	34	351851	6328277	63	312	0.09	0.5	0.01	0.1
55	34	351591	6327543	122	387	0.18	6	0.15	1.5
Mod 9 Report (DgS, 2020a)									
34	30	351851	6328277	63	312	0.03 - 0.065	0.0	0.0	0.0
55	30	351591	6327543	122	387	0.01 - 0.04	0.0	0.0	0.0

shaded - predicted values increased by proposed mining layout and fault effects.

The predicted values for Houses 34 and 55 after LW34 are still within 'Safe, Serviceable and Repairable' (SSR) limits and unlikely to exceed 'negligible' or 'Category 0' Damage in accordance with **AS2870 - 2011**.

The above impact assessment is consistent with the outcomes presented in the Mod 9 Report (**DgS, 2020a**). Current impact management strategies will remain unchanged.

6.8 Roads and Tracks

There are two public unsealed Crown roads (Toepfers Road and Kiar Ridge Road) present within the study area (see **Figure 1a**). The roads are unsealed with reinforced concrete pipe culverts at watercourse crossings. There are also several unsealed, gravel fire trails and private access roads.

The current condition of the roads and culverts has been assessed as good by mine site representatives.

The subsidence effects for Kiar Ridge and Toepfers Road above the approved and proposed mining layouts are summarised in **Table 5**.

Table 5 - Summary of U95%CL Subsidence Predictions for Toepfers and Kiar Ridge Roads (Unsealed Tracks)

LW	Final Maximum Subsidence S_{max} (U95%CL) (m)		Final Maximum Tilt T_{max} (mm/m)		Final Maximum Tensile Strain* (mm/m)		Final Maximum Compressive Strain* (mm/m)	
	Toepfers Road	Kiar Ridge	Toepfers Road	Kiar Ridge	Toepfers Road	Kiar Ridge	Toepfers Road	Kiar Ridge
Proposed Modified Mining Plan Layout LW30 to 32 & 34 (Mod 10)								
34	1.07	0.62	13 - 7	7 - 8	2	2	3	3
30	1.04	0.05	5 - 6	2 - 6	1	1	1	0
31	1.07	1.01	4 - 7	6 - 7	2	2	3	2
32	0.65	0.62	2 - 7	2 - 6	1	2	2	2
Approved Mining Layout for LW30 to 33 (Mod 9)								
30	1.13	1.14	13 - 4	13 - 5	3	2	4	3
31	1.25	1.22	5 - 2	5 - 2	1	1	2	2
32	1.16	1.15	1 - 4	4 - 2	1	1	1	1
33	0.97	0.94	3 - 11	2 - 9	2	2	3	3

shaded - values based on Moderate SRP due to fault zone effects.
* - Measured tensile and compressive strains may increase up to 2 times the predicted smooth profile strain if cracks develop.

The impacts due to the predicted subsidence effects may include:

- Tensile crack widths of between 10 mm and 20 mm.
- Compressive shearing or heaving between 10 mm and 30 mm.
- Increase of super-elevation in the road of 0.2% to 1.3%.
- Cracking of culverts and fill embankments.

The predicted subsidence effects and impacts due to the proposed LW30 to 32 and 34 are consistent with the and Mod 9 report.

Current impact management strategies will remain unchanged.

6.9 Aboriginal Heritage Sites

There are twelve Aboriginal Heritage Sites (AHS) located within the zone of influence of the proposed LW34. Impact Potential definitions and subsidence parameter criteria are given in **Table 6A**.

Table 6A - Impact Potential Criteria for Aboriginal Heritage Sites

Cracking Damage Potential - Indicative Probabilities of Occurrence	**Predicted 'smooth profile' Horizontal Strain (mm/m)**	
	Tensile^	**Compressive^**
Very Unlikely (<5%)	< 0.5	< 2
Unlikely (5 - 10%)	0.5 - 1.5	2 - 3
Possible (10 - 25%)	1.5 - 2.5	3 - 5
Likely (>25%)	> 2.5	> 5
Erosion Damage Potential - Indicative Probabilities of Occurrence	**Predicted Surface Gradient Change or Tilt Increase**	
Very Unlikely (<5%)	<0.3% (< 3 mm/m)	
Unlikely (5 - 10%)	0.3-1% (3 - 10 mm/m)	
Possible (10 - 25%)	1-3% (10 - 30 mm/m)	
Likely (>25%)	>3% (>30 mm/m)	

The predicted subsidence effects (U95%CL) and impacts at each feature due to the Proposed LW34 are summarised in **Table 6B** and based on **Figures 11a** to **11c**.

Several strain mitigating (reducing) effects have also been identified during the site inspections and noted where relevant below the potential impact assessment. Where these conditions are present the predicted impact potential has been decreased by one category (i.e. a likely strain impact is decreased to a 'possible' impact).

The mitigating features for grinding groove sites in order of strain isolating effectiveness are:

- the grooves are located on a loose boulder.
- the grooves are located on an elevated sandstone ledge within the creek bed and 'open' on one side sub-parallel to the creek centreline.
- the grooves are located between persistent orientated joints that are likely to open or shear before buckling or fresh cracking occurs.

Where jointing or open-ledge ends are not present the groove sites are considered to be "locked" into the rock mass and vulnerable to ground strains.

Based on thirteen subsided rock shelter cases presented in **Shepherd and Sefton, 2001**, it is assessed that the mitigating features for rock shelter sites at Mandalong of strain isolating effectiveness (in descending order) are:

- the shelters have been formed in large boulders and have soil foundations.

- the shelter overhangs are supported on three sides (i.e. cavernous) and less likely to collapse than single-sided shelters (i.e. blocky overhangs).

- the shelters are not directly located above longwall ribs.

- the longwall retreat directions are face-on or end-on with the long-axis of the shelter, so the shear strains are minimised relative to half-on longwall directions.

- rock shelters are typically 'dry'.

Shepherd and Sefton, 2001 indicate that 'rock shelters with art' on the back walls are vulnerable to damage where compressive strains may concentrate and cause spalling damage. Shearing may develop in the weaker sandstone beds at the back of a shelter where stress notches are likely to occur from both natural weathering processes as well as mine subsidence deformation.

Table 6B - Predicted Subsidence Impacts due to U95%CL Values at Aboriginal Heritage Sites (with transient strains included)

Site Name	Site Type	AHIMS #	Groove Site Plan Dimensions or Shelter Span (m)	Subsidence (m)	Horizontal Strain (mm/m)^	Cracking Damage Potential*	Tilt (mm/m)	Erosion Damage Potential*
Proposed LW34 (Mod 10)								
MS9-GG-3	Grinding Groove	45-3-4545	3 x 1	0.84	1.5	Possible	15.4	Possible
RPS CYL05		45-3-3492	3 x 9	0.29	1.3	Unlikely	7.4	Unlikely
RPS PS26		45-3-3512	2 x 3	0.52	1.1	Unlikely	12.4	Possible
RPS PS27	Habitation Structure (no PAD or objects)	45-3-3594	4.9	0.39	0.4	V.Unlikely	9.0	Unlikely
RPS PS30		45-3-3596	4.6	0.62	-2.5 (1.5)	Possible	2.2	*V.Unlikely*
RPS PS31		45-3-3645	N/S	0.46	-0.7 (1.5)	Possible	7.7	*Unlikely*
RPS PS07		45-3-3643	N/S	0.10	0.6	Unlikely	1.1	V.Unlikely
RPS PS28	Rock Shelter with PAD	45-3-3513	7.0	0.02	0.6	Unlikely	1.3	V.Unlikely
MS9-RS-2		45-3-4546	6.0 (7 m diam)	0.19	2.5	Unlikely (boulder)	7.9	Unlikely
MS9-RS-3	Rock shelter with artefacts & PAD	45-3-4544	5.0 (7 m diam)	0.09	1.9	Unlikely (boulder)	4.6	Unlikely
Morans Creek (location corrected)	Rock Shelter with Art	45-3-1228	5.0 (6 m diam)	0.09	1.6	Unlikely (boulder)	4.0	Unlikely
Olney (Corrected)		45-3-1229	N/S	0.03	0.5	Unlikely	1.4	V.Unlikely

^ - Tensile strain is positive; (brackets) - transient or dynamic strains in brackets.
* - see **Table 6A** for Impact Potential definitions. **bold** - cracking and/or erosion impact assessed as 'likely'. Shaded - risk of impact has increased slightly since the Mod 9 assessment (see **Table 6B**); Underlined - the risk of impact has decreased since the Mod 9 Assessment. The changes are due to the modifications to the mining layout; *italics* - site may be impacted by erosion if cracking occurs; N/S - Not seen.

The assessment indicates that one Grinding Groove, two Habitation Structures (rock shelters with no PAD or objects), may 'possibly' be impacted by the proposed LW34.

Two Grinding Grooves, two Habitation Structures, three Rock Shelters with PAD / Artefacts and two Rock Shelters with Art are 'unlikely' or 'very unlikely' to be impacted by subsidence cracking.

The previously predicted impacts given in the Mod 9 Report are summarised in **Table 6C**.

Table 6C - Predicted Subsidence Impacts due to U95%CL Values at Aboriginal Heritage Sites for LW30 to 33 (Mod 9) with transient strains included

Site Name	Site Type	AHIMS #	Subsidence (m)	Horizontal Strain (mm/m)^	Cracking Damage Potential*	Tilt (mm/m)	Erosion Damage Potential*
Approved Mining Layout for LW30 - 33 (Mod 9)							
MS9-GG-3	Grinding Groove	45-3-4545	0.8	2.6	Likely	4.6	Unlikely
RPS CYL05		45-3-3492	0.24	3.2	Likely	8.2	Unlikely
RPS PS26		45-3-3512	0.09	1.7	Possible	2.2	V.Unlikely
RPS PS27	Habitation Structure (no PAD or objects)	45-3-3594	0.1	1.1	Unlikely	1.3	V. Unlikely
RPS PS30		45-3-3596	0.05	0.4	V. Unlikely	0.5	V. Unlikely
RPS PS31		45-3-3645	0.1	0.0	V.Unlikely	0.5	V. Unlikely
RPS PS07		45-3-3643	0.0	0.1	V. Unlikely	0.3	V. Unlikely
RPS PS28	Rock Shelter with PAD	45-3-3513	0.54	1.5	Possible	13.4	Possible
MS9-RS-2		45-3-4546	0.05	0.1	V. Unlikely	0.3	V. Unlikely
MS9-RS-3	Rock shelter with artefacts & PAD	45-3-4544	0.04	0.0	V. Unlikely	0.6	V. Unlikely
Morans Creek (location corrected)	Rock Shelter with Art	45-3-1228	0.05	0.1	V. Unlikely	0.5	V. Unlikely
Olney (Corrected)		45-3-1229	0.0	0.0	V. Unlikely	0.0	V. Unlikely

^ - Tensile strain is positive; (brackets) - transient or dynamic strains in brackets. * - see **Table 6A** for Impact Potential definitions.

The potential cracking impact assessments due to the proposed LW34 and the previous assessments given in the MOD 9 Report are compared below:

- Two Habitation Shelters (no PAD/Art or Artefacts) have been **increased** from 'Very Unlikely' to 'Possible'.
- Two Rock Shelters with PAD / Artefacts have been **increased** from 'V.Unlikely' to 'Unlikely'.
- One Habitation Structure has been **increased** from 'Very Unlikely' to 'Unlikely'
- The potential for cracking damage or erosion damage potential at two grinding groove sites have been **decreased** from 'Likely' to 'Possible' and 'Unlikely'. A third site has been **decreased** from 'Possible' to 'Unlikely'.
- One Rock Shelter with PAD has been decreased from 'Possible' to 'Unlikely'.
- One Habitation Structure has been decreased from 'Unlikely' to 'Very Unlikely'.
- Two Rock Shelters with ART and one with PAD have increased from 'Very Unlikely' to 'Unlikely'.

It is understood that the impact management strategies for the above AHS sites will be developed in consultation with Aboriginal stakeholders and their consultants prior to mining impact.

6.10 European Heritage Sites

There are no European Heritage Sites affected by the proposed longwall.

7.0 Sub-Surface Cracking

7.1 Sub-Surface Fracturing Zone Description

Estimates of subs-surface fracture zones above the proposed LW34 have been based on the subsurface fracture models applied in the EIS and Mod 9 reports.

The caving and subsidence development processes above a longwall panel usually results in sub-surface fracturing and shearing of sedimentary strata in the overburden according to **Kendorski, 1993**; see **Figure 12a**. The extent of fracturing and shearing up through the strata is dependent on the mining geometry and overburden geology.

International and Australian research on longwall mining interaction with groundwater systems indicates that the overburden may be divided into essentially four or five zones of surface and subsurface fracturing and strata dilation; see **Figures 12b** and **12c**. The zones are based on the **Forster, 1995** and **ACARP, 2007** models and are defined (in descending order) in **Table 7A**.

Table 7A - Sub-Surface Fracture Zone Summary

Zone Type	Zone	Fracture and Groundwater Response Description	Typical Vertical Strain (mm/m)
Surface (un-constrained)	D	Vertical cracking due to horizontal strains extending to 10 - 15 m depth. Surface waters may be diverted below affected area and resurface downstream.	<3
Elastic (constrained)	C	Generally unaffected by strains with some bedding parting dilation. Horizontal strains constrained by overlying/underlying strata. Groundwater levels may be lowered temporarily due to new storage volume in voids between beds, but likely to recover at a rate dependant on climate. Elastic Zone may not be present if B or A Zones extend up to Surface Zone.	<3
Discontinuous Fractures (constrained)	B	Minor vertical cracking due to bending that do not extend through strata units. Increased bedding parting dilation and similar groundwater response to Zone C. Some groundwater leakage may occur to B Zone, however, losses likely to be recharged by surface hydro-geological system.	<8
Continuous Fractures (unconstrained)	A	Major vertical cracking due to bending that pass-through strata units and allow a direct hydraulic connection to workings below.	>20
Caved (included in the A-Zone)	A	Caved strata up to 3 to 5 x Mining Height above the workings. Collapsed roof bulks in volume to provide some support to overlying strata.	>80

In summary, the A-Zone represents the area above the workings with connective cracking that will probably drain groundwater present within the zone to the workings. The B and C-Zones are constrained with strata dilations and discontinuous cracks present in the strata units. The fractures are only discontinuous because the bending of the strata is not great enough to cause them to penetrate right through the individual units. This is why spanning strata units usually limit the height of continuous or A-Zone fracturing above the longwall goaf.

The differences between the B and C-Zones are subtle and have the same characteristics of bedding parting separations and shearing with low levels of vertical strain (< 8 mm/m). The two zones may essentially be assumed to act as one Constrained Zone for prediction purposes.

Ground water flow to the A-Zone is likely to be restricted by the overlying Constrained Zone, which limits vertical flow into the workings to very low levels. The Constrained Zone therefore acts as a 'barrier' to drainage of overlying water bodies and its thickness is a very important element in surface to seam connection control. At Mandalong, the Munmorah Conglomerate defines the upper limit of the A-Zone, and acts as a barrier to significant water flow from overlying strata into the workings.

The D-Zone is usually affected by vertical fracturing due to unconfined strata bending at the surface. Surface waters or shallow groundwater aquifers may re-route or drain down to dilated strata in the C and/or B zones if cracking in the D-Zone intersect with bedding parting dilations in these zones. The Surface Zone extends to depths ranging from 5 m to 15 m in the Newcastle Coalfield, and is dependent on near-surface geology.

Two empirically based models (**Forster, 1995** and modified **ACARP, 2003**) have been used in this study to predict the A and B-Zone heights above the workings within the study area. In some cases, the mine workings may not be deep enough for a C-Zone to develop.

Forster, 1995 and **Wardell, 1975** suggest that the minimum Constrained Zone thickness above the Fractured Zone to rock head (i.e. including the surface zone) should be the greater of 12T + 10 m or 17T - the surface zone thickness beneath water bodies such as lakes.

Based on a proposed mining height of 3.7 m to 3.8 m, a minimum Constrained Zone thickness of 54 m to 56 m (i.e. 12T+10) has been adopted for the proposed mining layouts beneath watercourses in the study area. It is therefore considered necessary to maintain the height of continuous or connective cracking to a similar depth range below all creeks and watercourses in the relevant mining areas.

The **Forster, 1995** model was developed from deep multi-piezometer data from subsided overburden above supercritical-width pillar extraction panels in the Central-Coast area of the Newcastle Coalfield and indirectly defines the A-Zone as a function of the mining height. In this model of the overburden, the A Zone occurs at the top of the Fractured Zone and the B-Zone is considered to exist within the Constrained Zone (see **Figure 10b**).

The **Forster, 1995** model predicts that the height of the Fractured or A-Zone will generally range between 21 and 33 times the mining height (T) for super-critical panel geometries with 30 to 40 m thick Munmorah Conglomerate beds. The predicted extent or height of the Constrained Zone thickness may be estimated as the difference between the cover depth and height of A-Zone fracturing at Mandalong.

Predictions of the heights of continuous and discontinuous fracturing (the A and B-Zone horizons) have been analysed using the panel width, the mining height and simple parabolic profile formulae as follows:

- Continuous Fracture Zone Height, $A = W'/(4\tan(\text{theta}_A))$

- Discontinuous Fracture Zone Height, B = W'/(4tan($theta_B$))

The model has been adapted from a physical model in **Whittaker and Reddish, 1989** (referred to as the UK model herein). When the UK model's fracture height data is plotted as an effective caving angle (estimated from an assumed parabolic fracturing profile between rib abutments), a strong correlation is apparent with the mining height for a given panel width and cover depth (W/H = 1.34); see **Figures 13a** and **13b** for A and B-Zone Horizons respectively.

The regression analysis indicates the following effective caving angles (in degrees) apply for estimating A and B Zone fracture heights:

$theta_A = 25.083T^{-0.401}$ (lower bound) and $41.174T^{-0.444}$ (mean)

$theta_B = 17.795T^{-0.243}$ (lower bound) and $21.806T^{-0.233}$ (mean)

For real-world database mining heights of 1.9 m to 6.0 m (median of 3.0 m) the calibrated caving angles range from 18^o to 34^o for the A-Zone, and from 13^o to 22^o for the B-Zone. One A-Zone case had an effective caving angle of 58^o due to the 'truncating' effect of a spanning strata unit.

The above equations are referred to as the Caving Angle method herein and it is considered to provide a reasonably robust approach to estimate height of continuous and discontinuous fracturing and constrained zone thicknesses above sub-critical to supercritical longwall panels.

7.2 Sub-Surface Fracture Height Predictions for LW30 to 33

The predicted values for continuous (A-Zone) and discontinuous (B-Zone) sub-surface fracturing heights and Constrained Zone thickness above the proposed 200 m wide longwall panels are summarised in **Table 21** for the Effective Caving Angle (i.e. modified **ACARP, 2003**). Predicted A-Zone Horizons for Critical to Supercritical panel width geometries from **Forster, 1995** are also provided for comparison with the proposed sub-critical panel width outcomes.

The *continuous* sub-surface fracture heights (A-Horizon) have been plotted against depth of cover in **Figure 14a** for the range of proposed longwall widths.

The *discontinuous* sub-surface fracture heights (B-Horizon) have also been plotted against depth of cover in **Figure 14b** for the range of proposed longwall widths.

Minimum Constrained Zone (B/C Zone) thicknesses are also indicated on the above figures.

Table 7B - Summary of Predicted Sub-Surface Fracturing Heights above LW34

XL. No LW	LW Panel No.	T (m)	Effective Panel Width W (m)	Cover Depth H (m)	A-Zone Horizon (m)				B-Zone Horizon (m)		Minimum Constrained Zone Thickness*	
					Caving Angle Model^		Forster 1995		Caving Angle Model^		B+C-15 (m)	(B+C-15)/T
					mean	U95% CL	33T	43T	mean	U95% CL		
3	34	3.8	200	440	112	191	125	163	175	219	234	62
4	34	3.7	200	380	110	189	122	159	173	217	176	48

W' = Effective Panel Width = lesser of actual width and 1.4H (i.e. the super-critical width). ^ - Adapted from **Whittaker and Reddish, 1989**; **Bold -** Mean or U95%CL A-Horizon prediction is within 15 m of the surface.
Italics - Mean or U95%CL B-Horizon prediction is within 15 m of surface.
***** - excludes the 15 m deep surface cracking (D) zone.

7.3 Discussion of A-Zone Horizon Model Predictions

The mean predictions for the A-Zone horizon above the proposed LW34 range from 110 m to 112 m for cover depths of 380 m to 440 m respectively and mining heights of 3.7 m to 3.8 m (i.e. 32T to 42T). The U95%CL predictions range from 189 m to 191 m (or approximately equal to the panel width).

The upper limit of the **Forster, 1995** model (i.e. 33T) indicates a range of connective cracking heights from 122 m to 125 m above the workings. The results of Forster model are within 13 m of the mean Caving Angle model predictions. The CSIRO assessed connective cracking above subcritical longwalls at Springvale mine to be approximately 43T (**ACARP, 2007**) where cover depths ranged from 350 m to 420 m; see **Figure 11c**. The U95%CL predictions for LW30 to 32 & 34 are higher again, ranging between 50T to 52T.

The corollary to the above assessment is the minimum depth to the height of A-Zone fracturing ranges from 191 m to 249 m. The minimum Constrained Zone thickness is equal to the A-Zone depth less the surface cracking zone depth of 15 m or 176 m to 234 m. The predicted longwall geometries therefore satisfy the minimum recommended constrained zone thickness of 12T + 10 (>55 m) below a permanent water body (Lake Macquarie) according to **Forster, 1995**.

It is assessed that it is 'very unlikely' that the A-Zone will interact with surface cracking zone (within 15 m of the surface), regardless of any adverse conditions (such as a fault) being present. Any aquifers below the predicted A-Zone fracture heights however, are likely to drain into the workings after longwall mining is completed.

Further discussion on the prediction models and measured sub-surface fracturing response at Mandalong to-date is provided in **Section 7.6**.

7.4 Discussion of B-Zone Horizon Model Predictions

The predictions for the mean and U95%CL B-Zone horizon above the proposed LW34 ranges from 173 m and 219 m (i.e. 46T to 59T); see **Figure 14b**.

The corollary to the above assessment is the predicted depth to the worst-case depth to B-Zone fracturing ranges from 163 m to 221 m. The B-Zone predictions indicate that an Elastic or non-fractured C-Zone will develop between the surface cracking zone and B-Zone Horizon above all the proposed longwalls.

7.5 Impact on Rock Mass Permeability

In regard to changes to rock mass permeability, **Forster, 1995** indicates that horizontal permeability in the fractured A-Zone above longwall mines (see **Figure 12b**) could increase by 2 to 4 orders of magnitude (e.g. pre-mining $k_h = 10^{-9}$ to 10^{-10} m/s; post-mining $k_h = 10^{-7}$ to 10^{-6} m/s).

Vertical permeability could not be measured directly from the boreholes discussed in the **Forster, 1995** model, but could be inferred where direct hydraulic connection to the workings occurs. Only a slight increase in the 'B-Zone' or indirect / discontinuous fracturing develops (mainly due to increase in storage capacity) from bedding parting separation. It is possible however, that vertical flows (i.e. leakage) could occur from B-Zone into the A-Zone (and workings) as well, but at a significantly lower rate than in the A-Zone itself.

Overall, bedding parting separation would be expected to increase rock mass storage capacity and horizontal permeability without direct hydraulic connection to the workings in the B and C-Zones.

Rock mass hydraulic conductivity is unlikely to increase significantly outside the angle of draw from the extraction limits.

7.6 Measured v. Predicted Heights of Fracturing above Mandalong Mine

The measured heights of fracturing of the A, B and C- Zones above Mandalong Mine's LW5 were based on deep borehole extensometer anchor displacements (provided by the mine) and screened (slotted pipe) piezometers presented in **GHD, 2012**.

The results are presented in the EIS Report and demonstrate the height of continuous fracturing (A Horizon) is probably located within the dilated Munmorah Conglomerate beam unit between 86 m and 118 m above the mine workings. The dilated or discontinuous fracture zone is estimated to have extended to within 17 m to 25 m from the surface. It was assessed that the height of fracture prediction models are in good agreement with the fracture zones above LW5.

7.7 Comparison of Mod 10 Predictions to Mod 9 & EIS Predictions

The predicted height of fracture zones for the proposed LW30 to 32 & 34 are compared to EIS and Mod 9 Predictions in **Table 7C**.

Table 7C - U95%CL Prediction Comparisons for Current Study and Previous Assessments

Parameter	EIS Report (DgS, 2013)	Mod 9 Report (DgS, 2020)	Current Study (Mod 10)
Height of A-Zone (m)	182 - 189	187 - 191	189 - 191
Height of B-Zone (m)	220 - 223	221 - 224	217 - 219

The predicted values in the current study are consistent with the EIS & Mod 9 Reports.

7.8 Impact Management Strategies

It is understood that the surface alluvium and sub-surface aquifers are not considered to be a groundwater resource of significance due to their brackish water quality (**GHD, 2012**). The surface alluvium along the creeks is estimated to range from 5 m to approximately 20 m below the surface. The overburden stratum has low permeability generally with both higher and lower conductivities in the vicinity of persistent geological structure (i.e. faults, dykes and joints).

The prediction model outcomes have been assessed in accordance with the Likelihood of Occurrence that continuous fracturing will intersect with surface alluvium or cracks that extend 15 m depth below the surface. Based on the results of the previous sections it is 'Not Credible' that A-Zone cracking will affect the surface alluvium beneath the study area. It is also considered 'unlikely' that surface watercourses will be subject to sub-surface flow re-routing due to interaction with sub-surface bed separation or discontinuous fracturing in the B - Zones.

Based on discussions with the specialist groundwater consultants for the assessment area, the absence of significant surface alluvium and ephemeral nature of the creeks/gullies is unlikely to result in significant degradation of the creeks if sub-surface fracturing / bedding separations or discontinuous cracking intersects with the bases of the alluvium along the creeks.

The presence of geological structure should be viewed with caution however, in regard to potential interaction with surface water courses. Management strategies should be prepared to deal with disproportionate water inflows into the workings if aquifers become 'perched' behind adjacent faults. Undermining significant faults may also result in higher continuous and discontinuous fracture connectivity on groundwater systems and should be avoided if possible.

8.0 Conclusions

It is concluded that the assessed range of potential subsidence and far-field displacement impacts after the mining of the proposed longwall panels will be manageable for the site features, based on the analysis outcomes and discussions with the stakeholders to-date. The outcomes are consistent with the EIS and Mod 9 Reports.

Furthermore, it is concluded that the proposed MOD 10 mining layout will not change the previous assessments of impact for any of the natural or built features by more than 10%.

Impact management plans and strategies will be developed to allow appropriate Trigger Action Responses and mine planning adjustments or mitigation measures necessary to deliver satisfactory outcomes.

9.0 References

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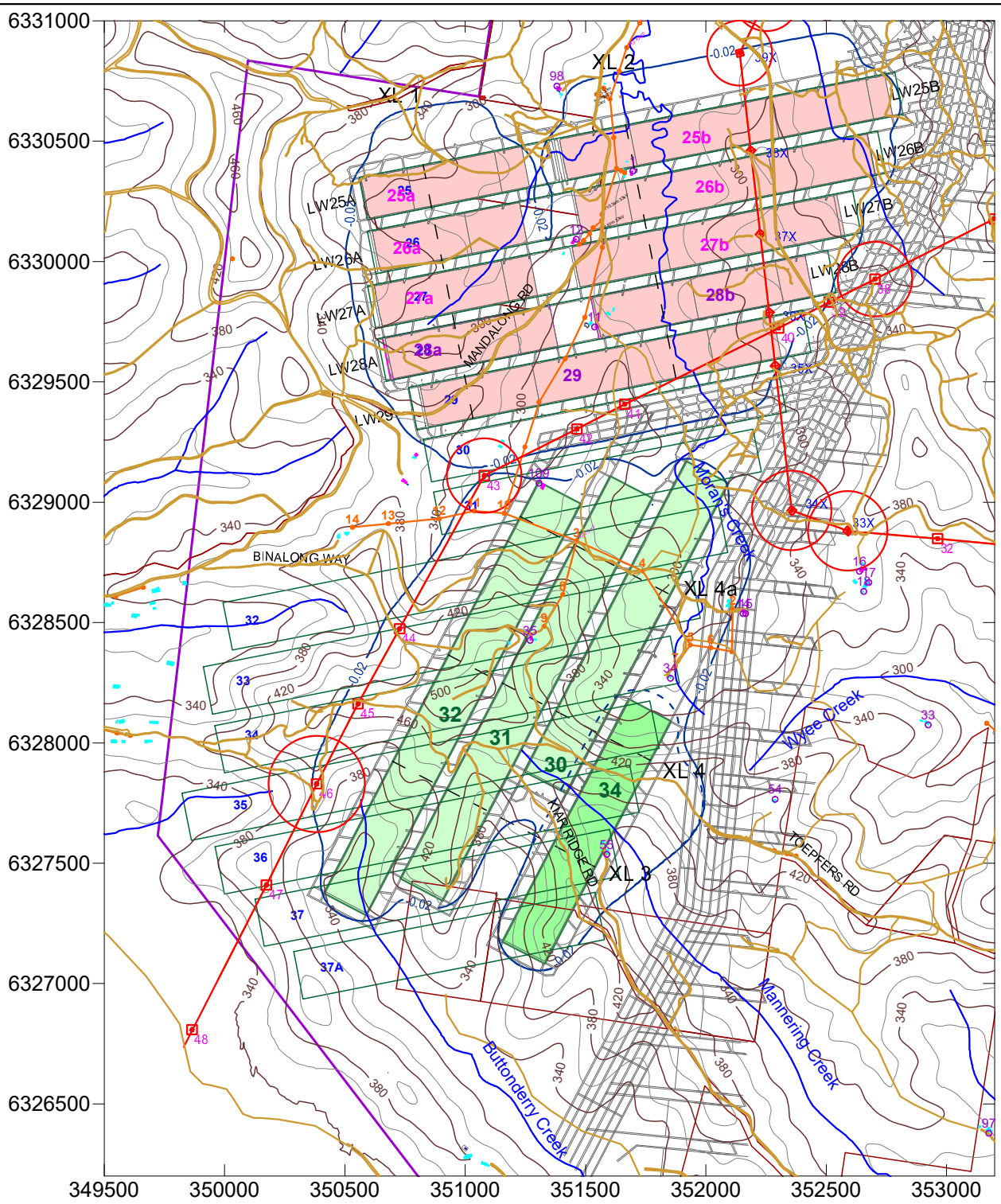
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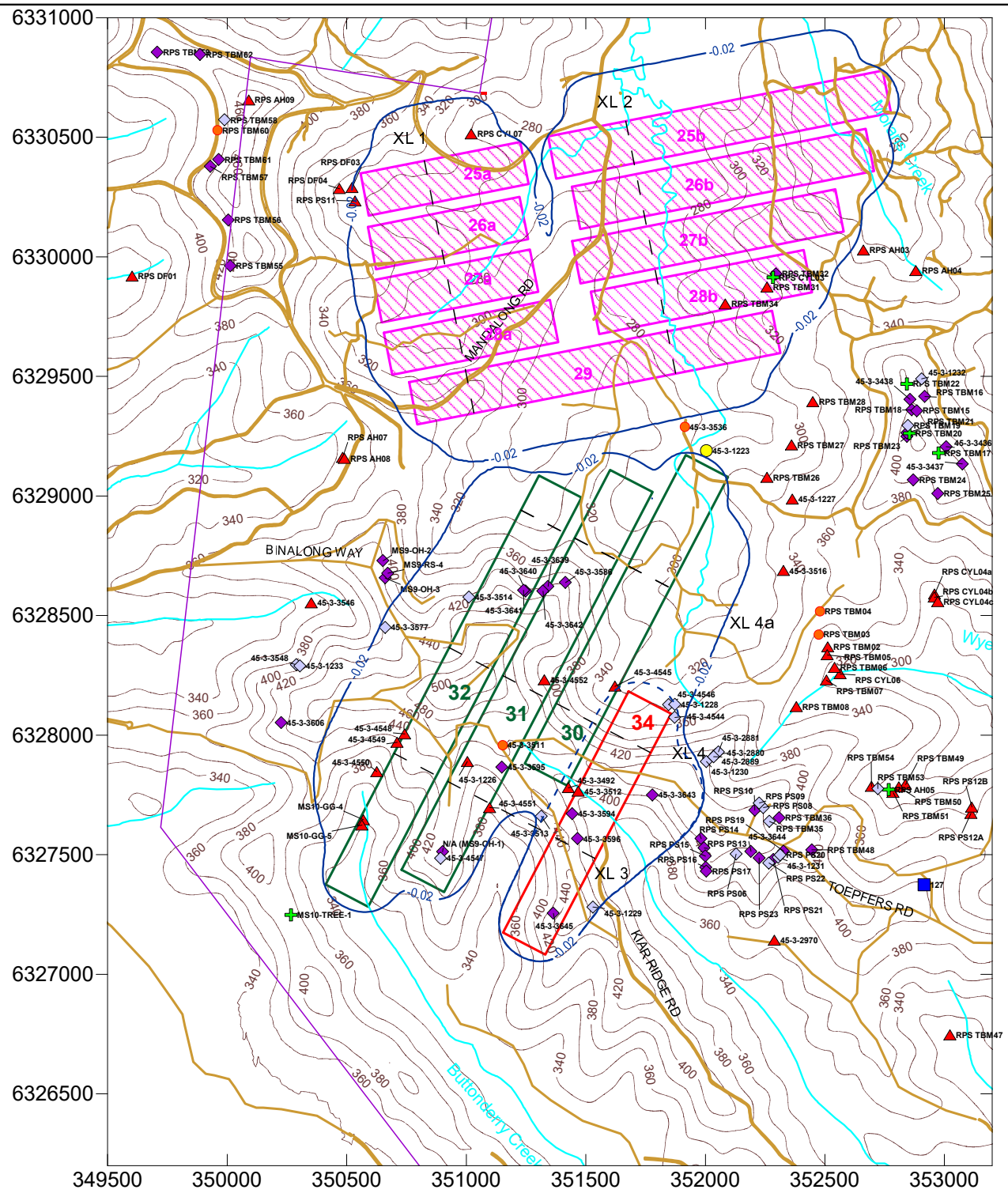
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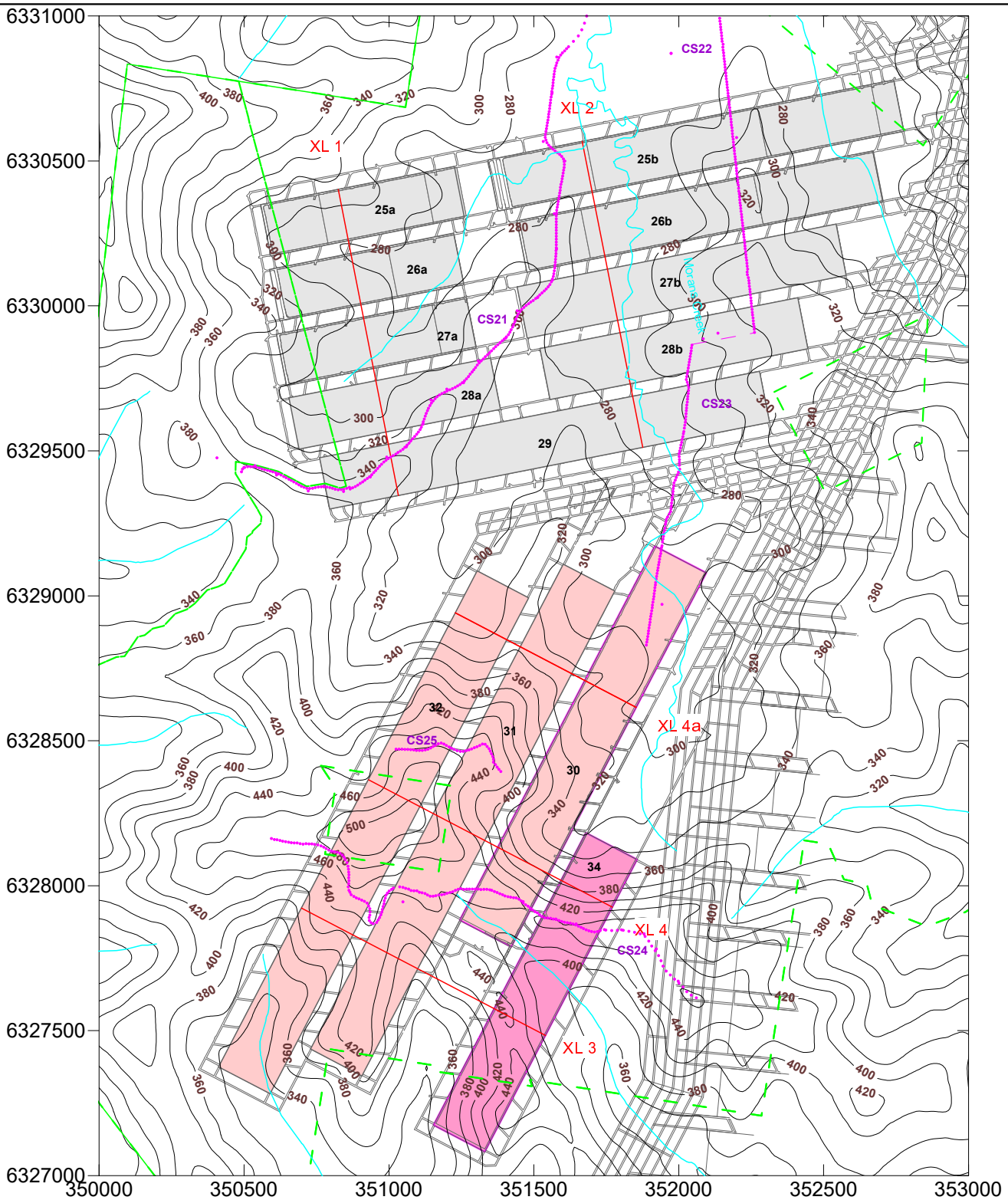
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- Extracted Longwall Limits
- Approved LW30 to 32
- Proposed LW34
- Creeks
- Houses
- Mine Lease Boundary (ML1744/1722)
- Cover Depth Contours (m)
- Prediction Lines (XL3a)
- Roads & Tracks
- Transgrid TL & Towers
- Tension Tower 26.5° AoD Buffer Zones
- Ausgrid Powerlines
- 20mm subsidence contour
- Olney State Forest Boundaries

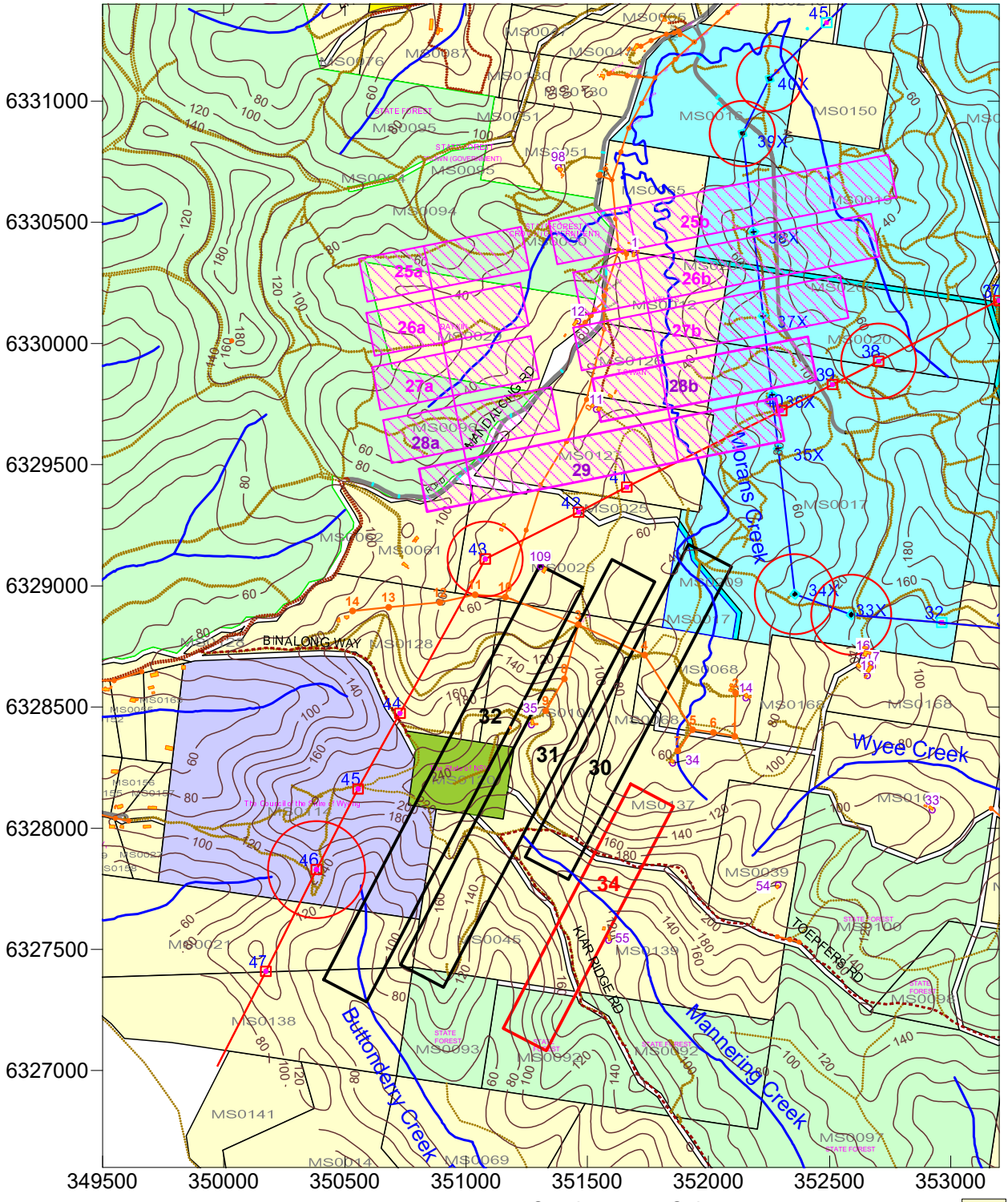
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	Date:	15.07.21	Title:	Cover Depth Contours & Built Features above the Proposed LW30 to 32 & 34 (Mod 10) at the Mandalong Mine	
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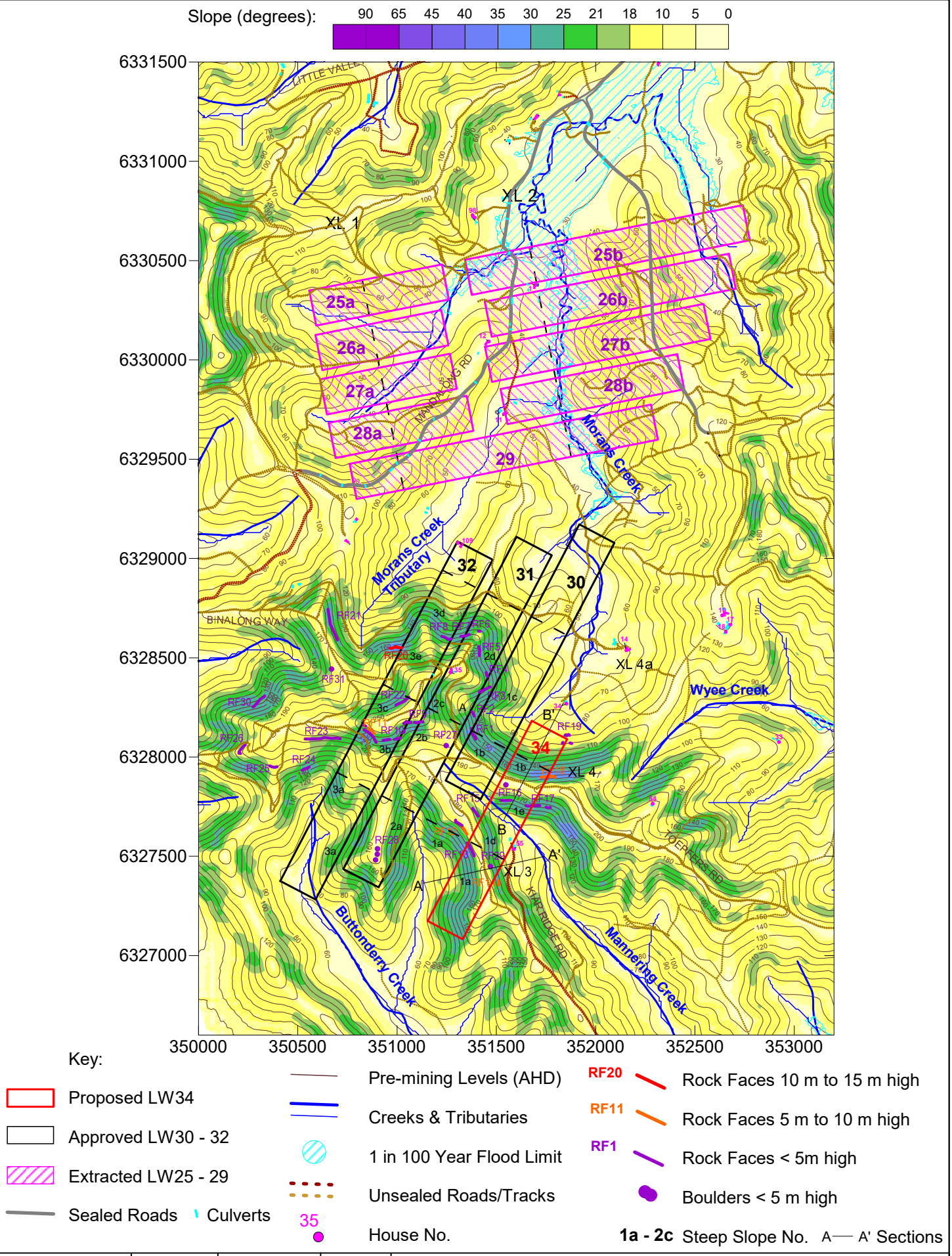
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Ditton Geotechnical Services Pty Ltd			Scale:	1:25,000 (A4)	Figure No: 1b



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	Drawn:	S.Ditton			
	Date:	15.07.21	Title:	Monitoring & Prediction Lines above Approved Longwalls LW25-32 and Proposed LW34 at the Mandalong Mine	
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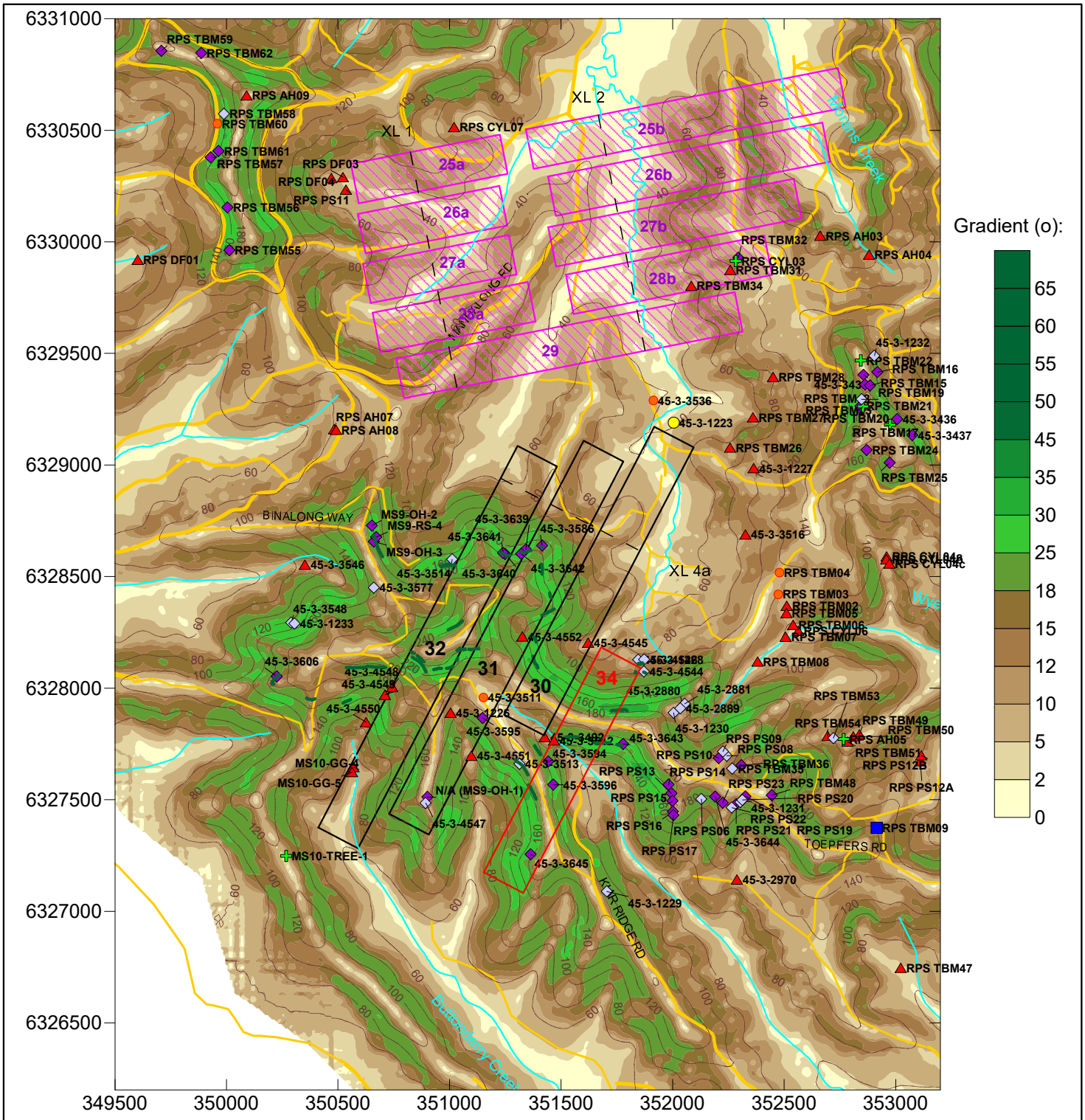
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-001/14	
	Drawn:	S.Ditton			
	Date:	15.07.21	Title:	Pre-mining Surface Levels, Landholdings & Built Features above the Proposed LW34 with at the Mandalong Mine	
	Ditton Geotechnical Services Pty Ltd		Scale:	1:25,000 (A4)	Figure No: 2a



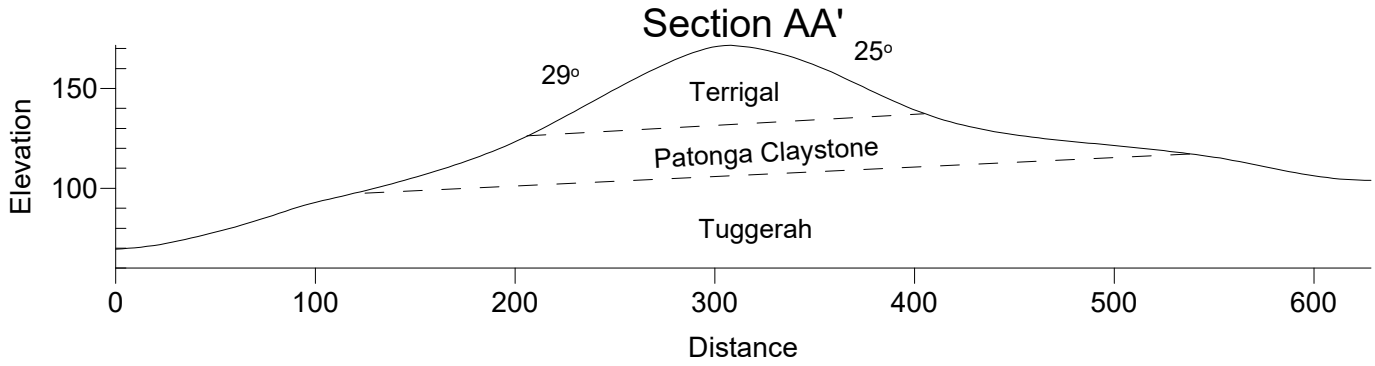
Key:

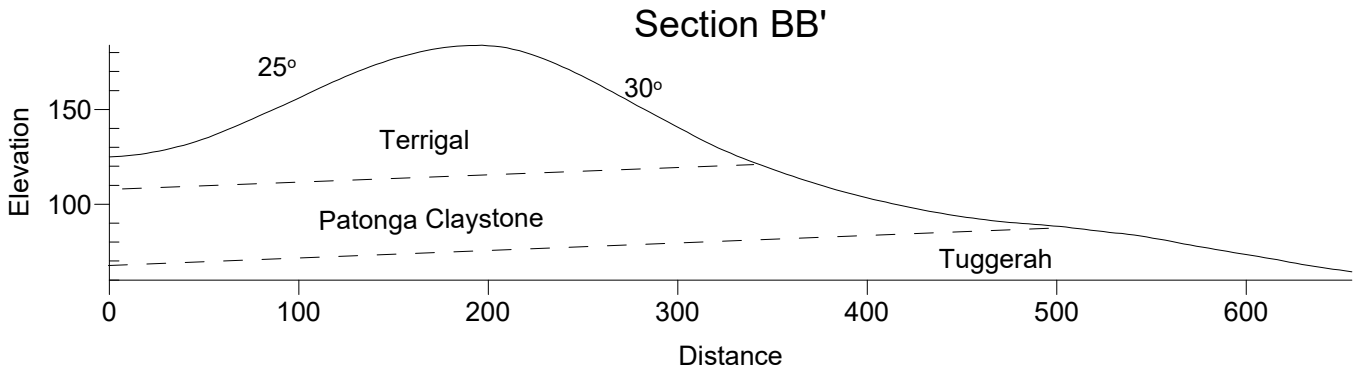
- Proposed LW34
- Approved LW30 - 32
- Extracted LW25 - 29
- Sealed Roads
- Culverts
- Pre-mining Levels (AHD)
- Creeks & Tributaries
- 1 in 100 Year Flood Limit
- Unsealed Roads/Tracks
- 35 House No.
- RF20 Rock Faces 10 m to 15 m high
- RF11 Rock Faces 5 m to 10 m high
- RF1 Rock Faces < 5m high
- Boulders < 5 m high
- 1a - 2c Steep Slope No.
- A— A' Sections

DgS Ditton Geotechnical Services Pty Ltd	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-001/14	
	Drawn:	S.Ditton			
	Date:	15.07.21	Title:	Pre-mining Surface Levels & Natural Features above the Proposed Longwalls 30 to 32 & 34 (Mod 10) at the Mandalong Mine	
			Scale:	1:25,000 (A4)	Figure No: 2b

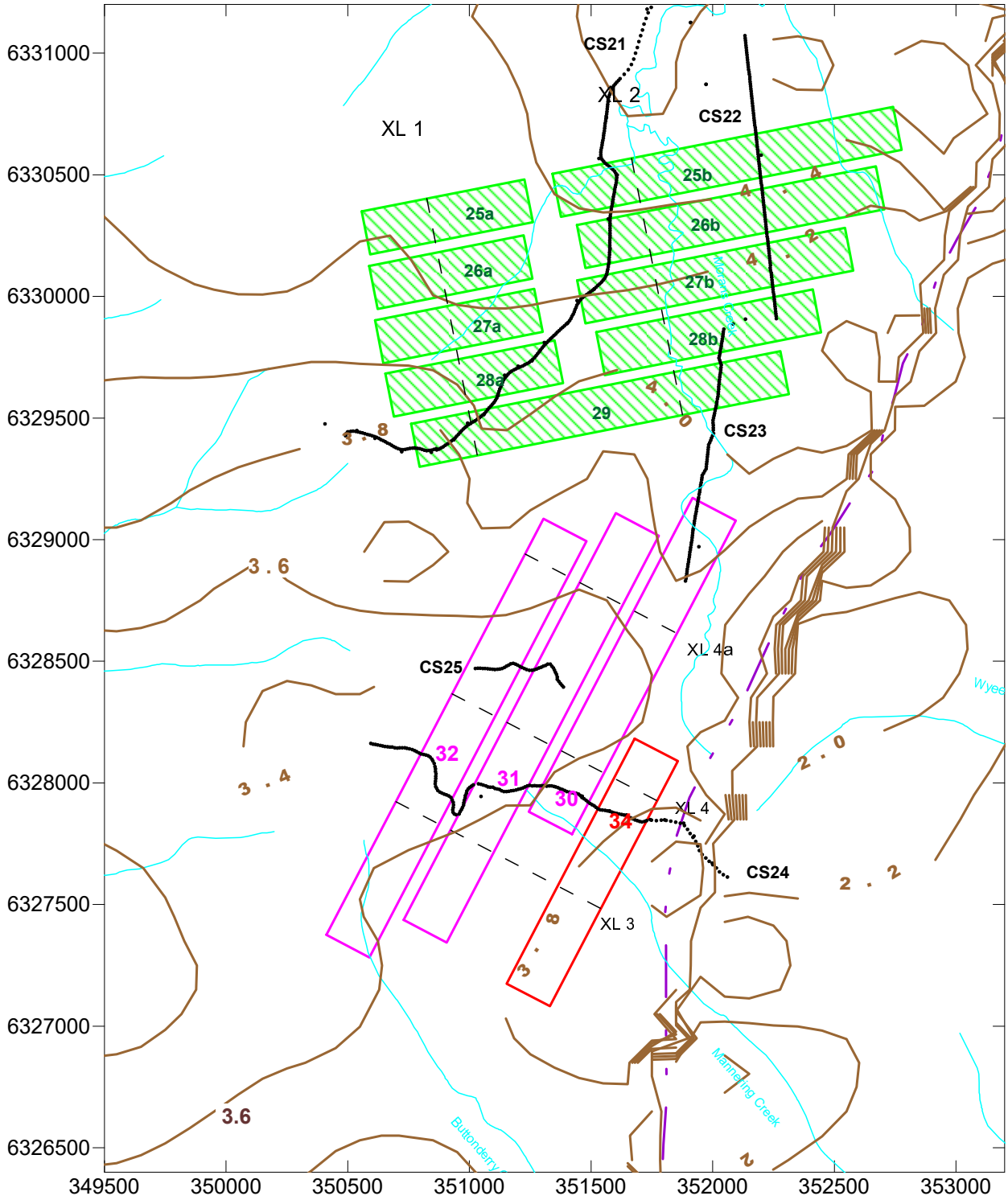


DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-001/14	
	Drawn:	S.Ditton			
	Date:	20.06.21	Title:	Surface levels, slope gradients and Aboriginal Heritage Sites above the Proposed Extensions to Longwalls 30 to 33 in the Mandalong Southern Extension Area	
Ditton Geotechnical Services Pty Ltd			Scale:	1:25,000 (A4)	Figure No: 2c





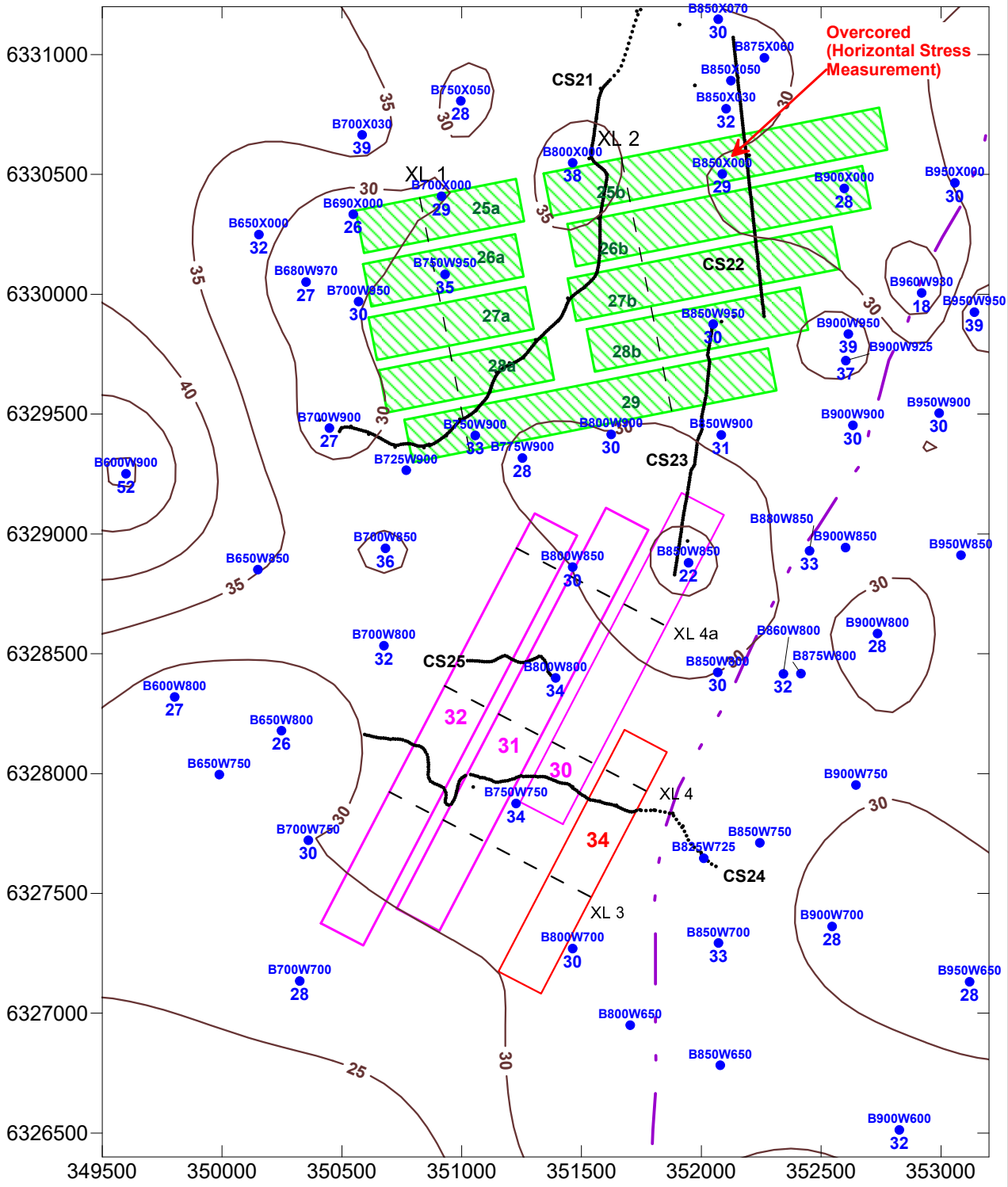
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-001/14	
	Drawn:	S.Ditton			
	Date:	15.07.21	Title:	Pre-mining Surface Profiles & Gradients above the Proposed Longwall 34 (Mod 10) at the Mandalong Mine (see Figure 2b)	
	Ditton Geotechnical Services Pty Ltd		Scale:	1:4,000 (A4)	Figure No: 2d



Key:

- Proposed LW34
- Approved LW30 to 32
- Approved LW 25 to 29
- Extracted Longwalls
- Creek Line
- Installed Survey Lines
- Prediction Cross Lines
- Seam Thickness Contours (m)

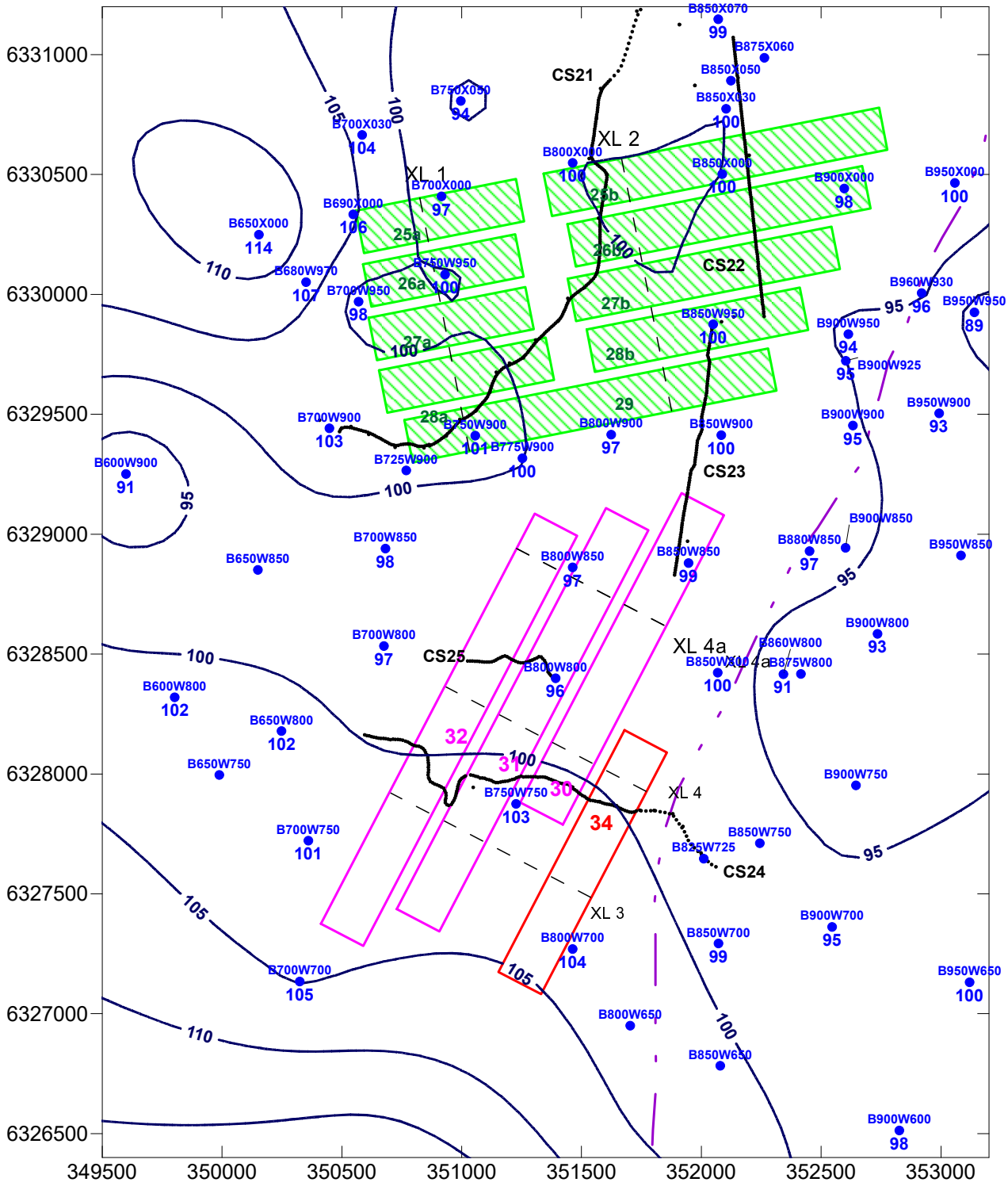
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-001/14	
	Drawn:	S.Ditton			
	Date:	01.09.20	Title:	West Wallarah Seam Thickness Contours and the Proposed Extensions to LW30 to 32 & 34 (Mod 10) at the Mandalong Mine	
Ditton Geotechnical Services Pty Ltd			Scale:	1:25,000 (A4)	Figure No: 3a



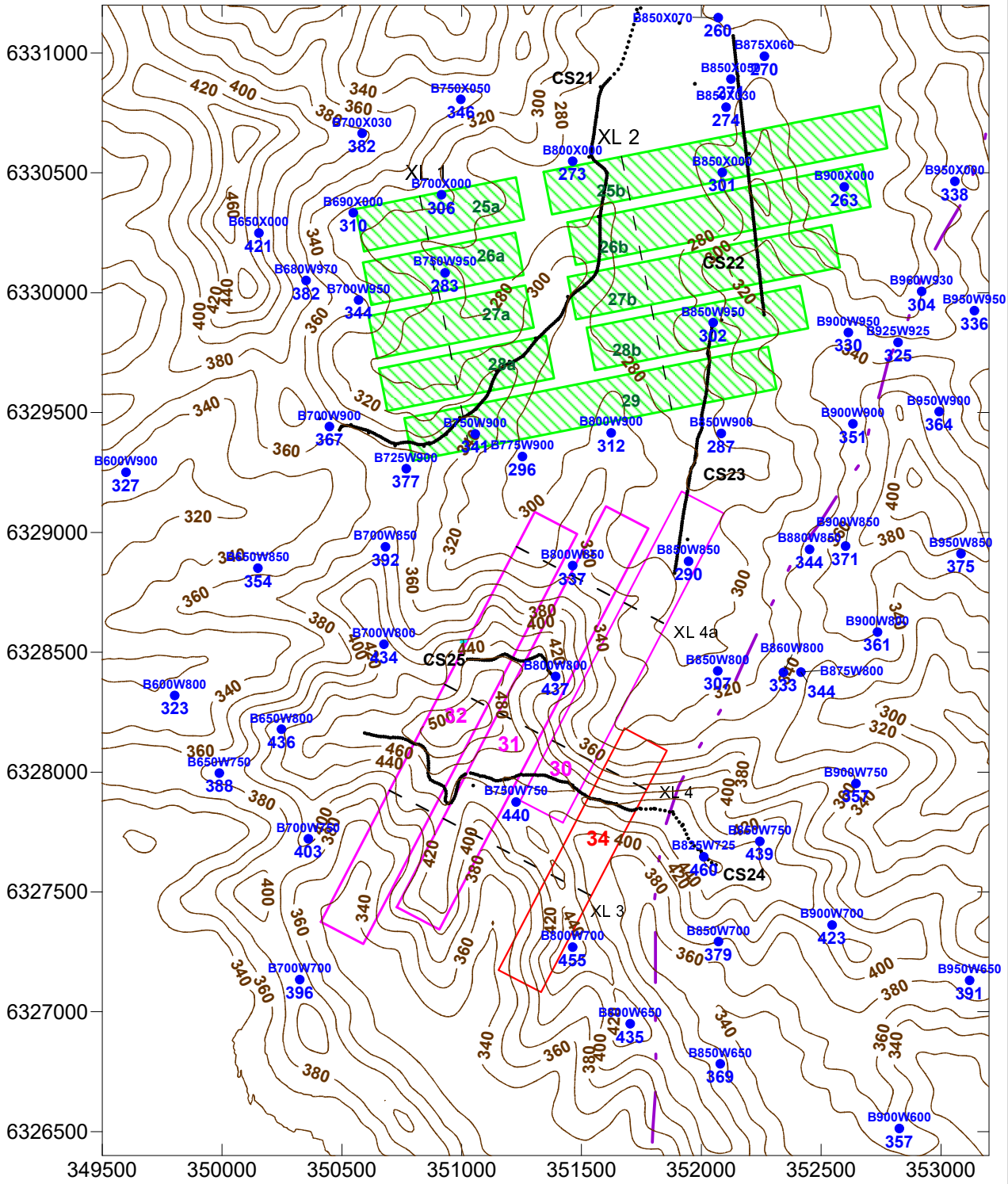
Key:

- Proposed LW34
- Approved LW30 to 32
- Approved LW 25 to 29
- Extracted Longwalls
- Seam Split Line
- Installed Survey Lines
- Prediction Cross Lines
- Borehole Locations
- Mandalong Beam Thickness Contours

DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-001/14	
	Drawn:	S.Ditton			
	Date:	15.06.21	Title:	Interpreted Conglomerate Beam Thickness Above the Proposed Longwalls 30 to 32 & 34 (Mod 10) at the Mandalong Mine	
Ditton Geotechnical Services Pty Ltd			Scale:	1:25,000 (A4)	Figure No: 3b



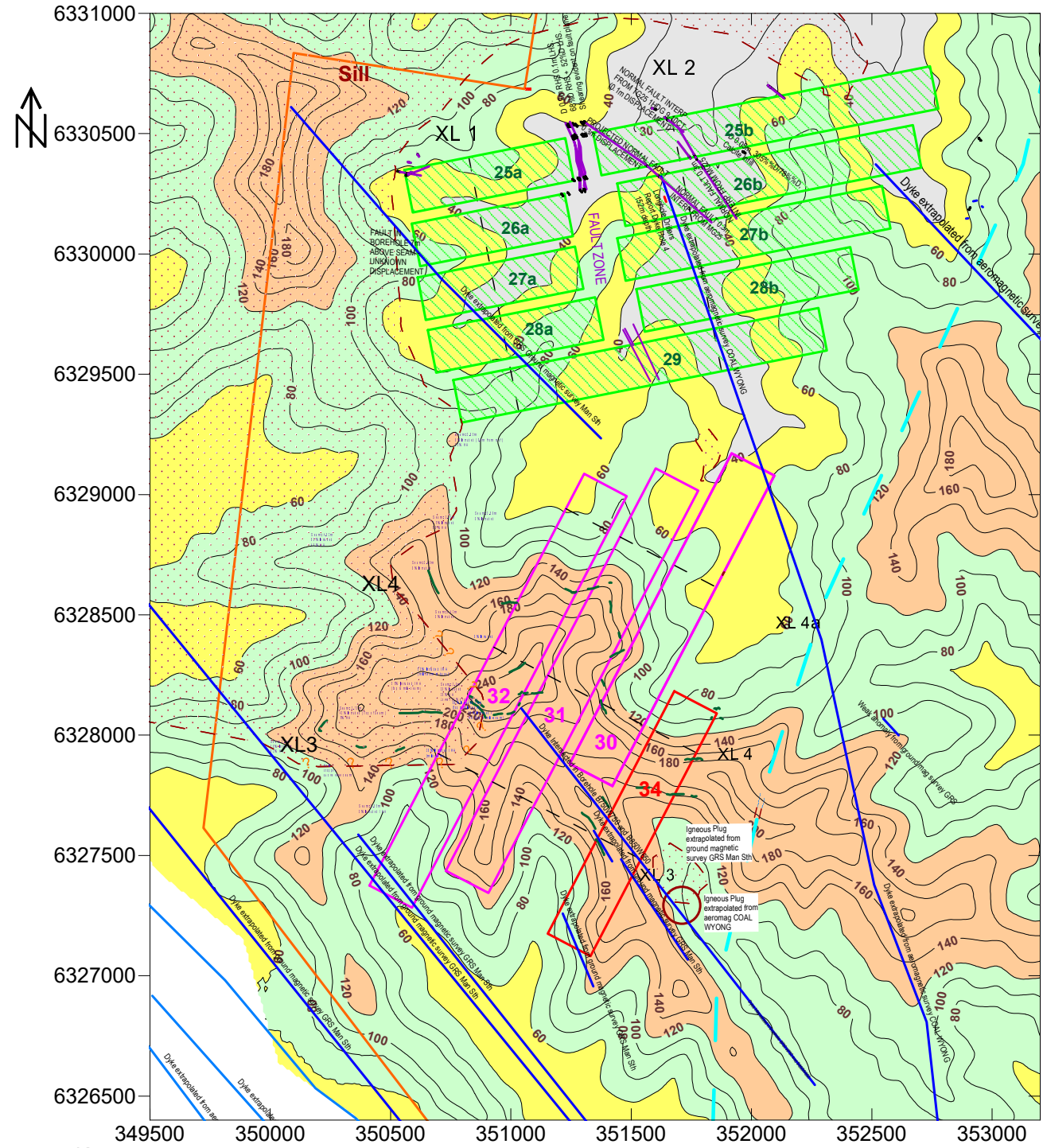
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-001/14	
	Drawn:	S.Ditton			
	Date:	01.09.20	Title:	Conglomerate Beam Distance Above the Proposed Modified Longwalls LW30 to 32 & 34 (Mod 10) at the Mandalong Mine	
Ditton Geotechnical Services Pty Ltd			Scale:	1:25,000 (A4)	Figure No: 3c



Key:

- Proposed LW34
- Approved LW30 to 32
- Approved LW 25 to 29
- Extracted Longwalls
- Seam Split Line
- Installed Survey Lines
- Prediction Cross Lines
- Borehole Locations
- Mandalong Beam Thickness Contours

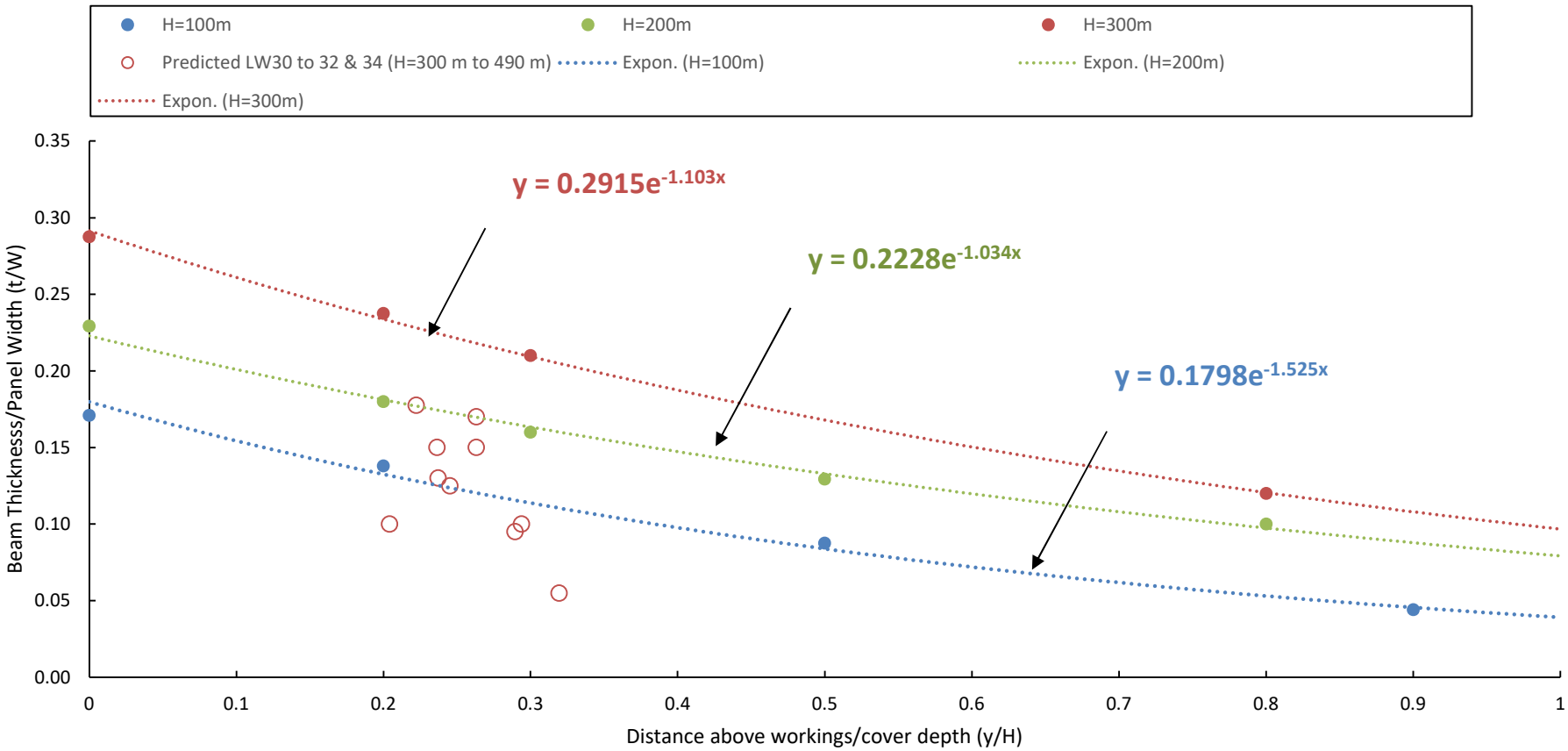
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong	
	Drawn:	S.Ditton		MAN-001/14	
	Date:	15.06.21	Title:	Cover Depth Contours & Borehole Data Above the Proposed LW30 to 32 & 34 (Mod 10) at the Mandalong Mine	
	Ditton Geotechnical Services Pty Ltd		Scale:	1:25,000 (A4)	Figure No: 3d



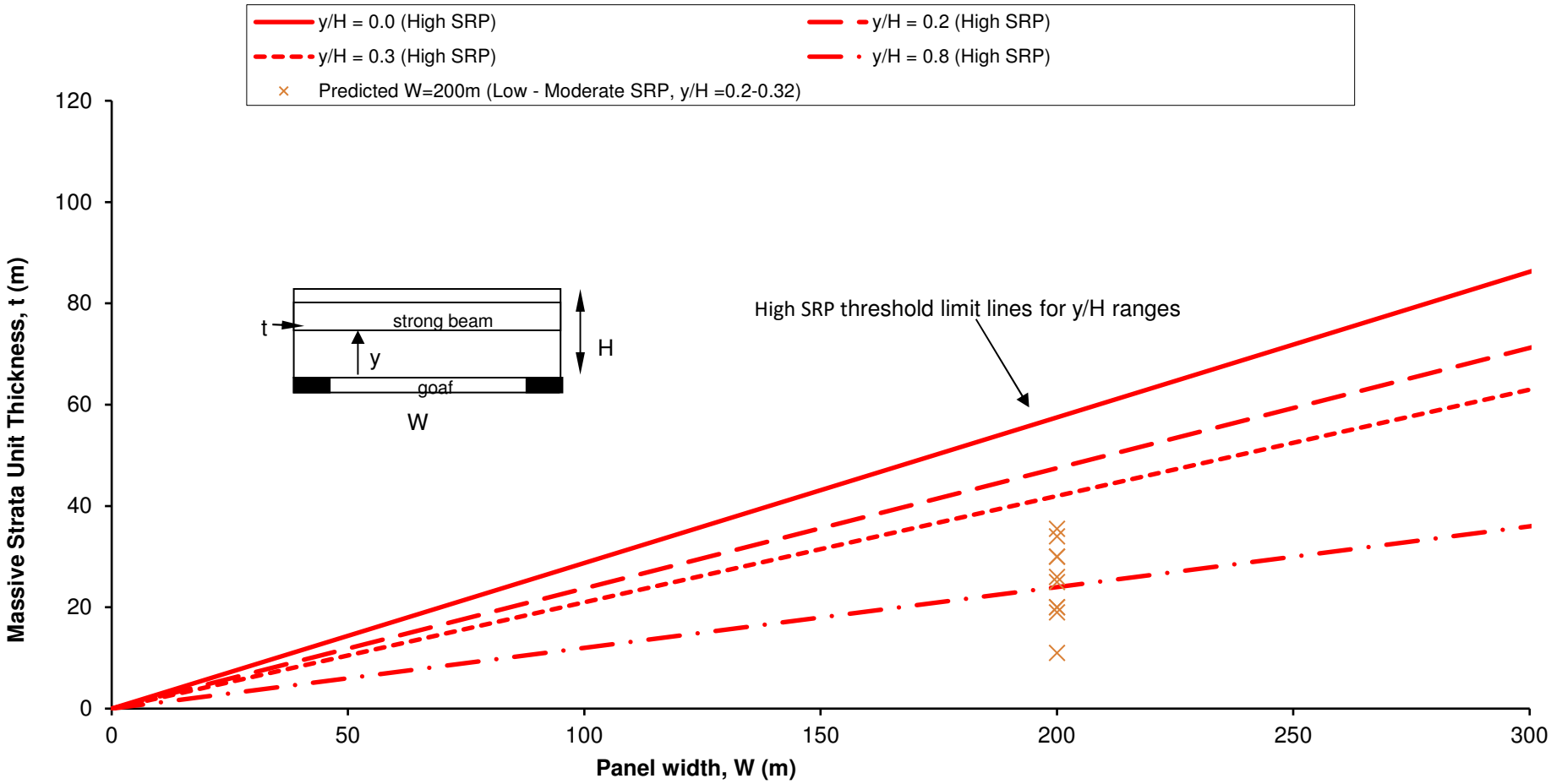
Key:

- Terrigal Formation - Sandstone,Conglomerate,Mudstone (60:30:10)
- Patonga Claystone Formation - Sandstone:Mudstone (50:50)
- Tuggerah Formation - Sandstone: Mudstone (70:30)
- Quarternary Alluvium
- Dykes / Diatremes (known & Aeromagnetic survey interpretation)
- Normal Faults (known or extrapolated)
- Proposed LW34
- Igneous Intrusion Limits
- Seam Split Line
- Rock Faces (3 m to 15 m high)
- Surface Levels (m, AHD)
- XL1 — — Prediction Cross Lines
- Approved LW25 to 29
- Extracted Longwalls
- Approved LW30 to 32

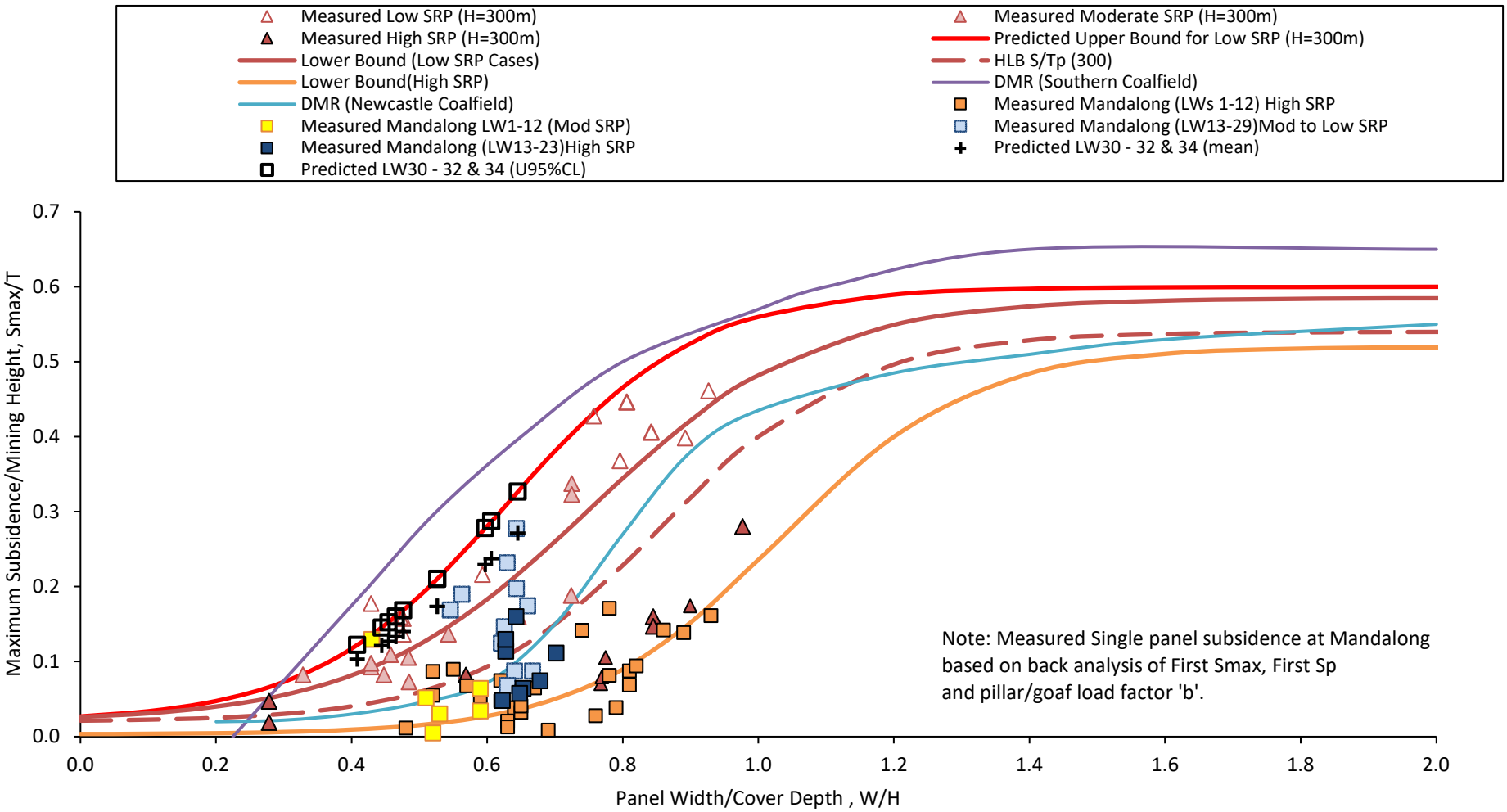
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-001/14	
	Drawn:	S.Ditton			
	Date:	15.07.21	Title:	Known/indicative Surface Lithology and In-Seam Geological Structure above the Proposed Longwalls 30 to 32 & 34 (Mod 10) at the Mandalong Mine	
Ditton Geotechnical Services Pty Ltd			Scale:	1:20,000 (A4)	Figure No: 3e



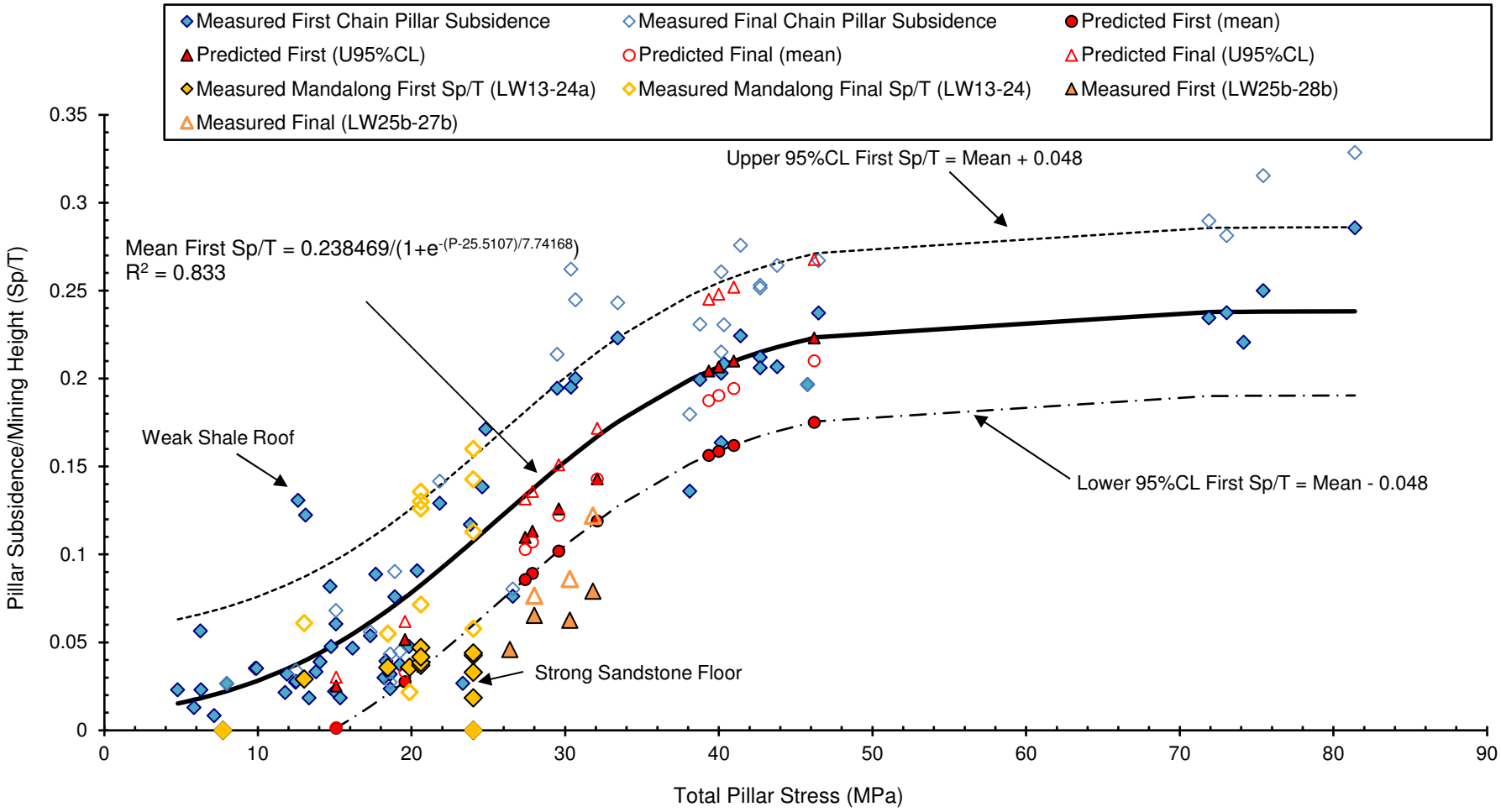
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-001/14	
	Drawn:	S.Ditton			
	Date:	20.06.21	Title:	Minimum Munmorah Conglomerate Beam Thickness for High Subsidence Reduction Potential above the 200 m Wide Longwalls at the Mandalong Mine	
	Ditton Geotechnical Services Pty Ltd		Scale:	NTS	Figure No: 4a



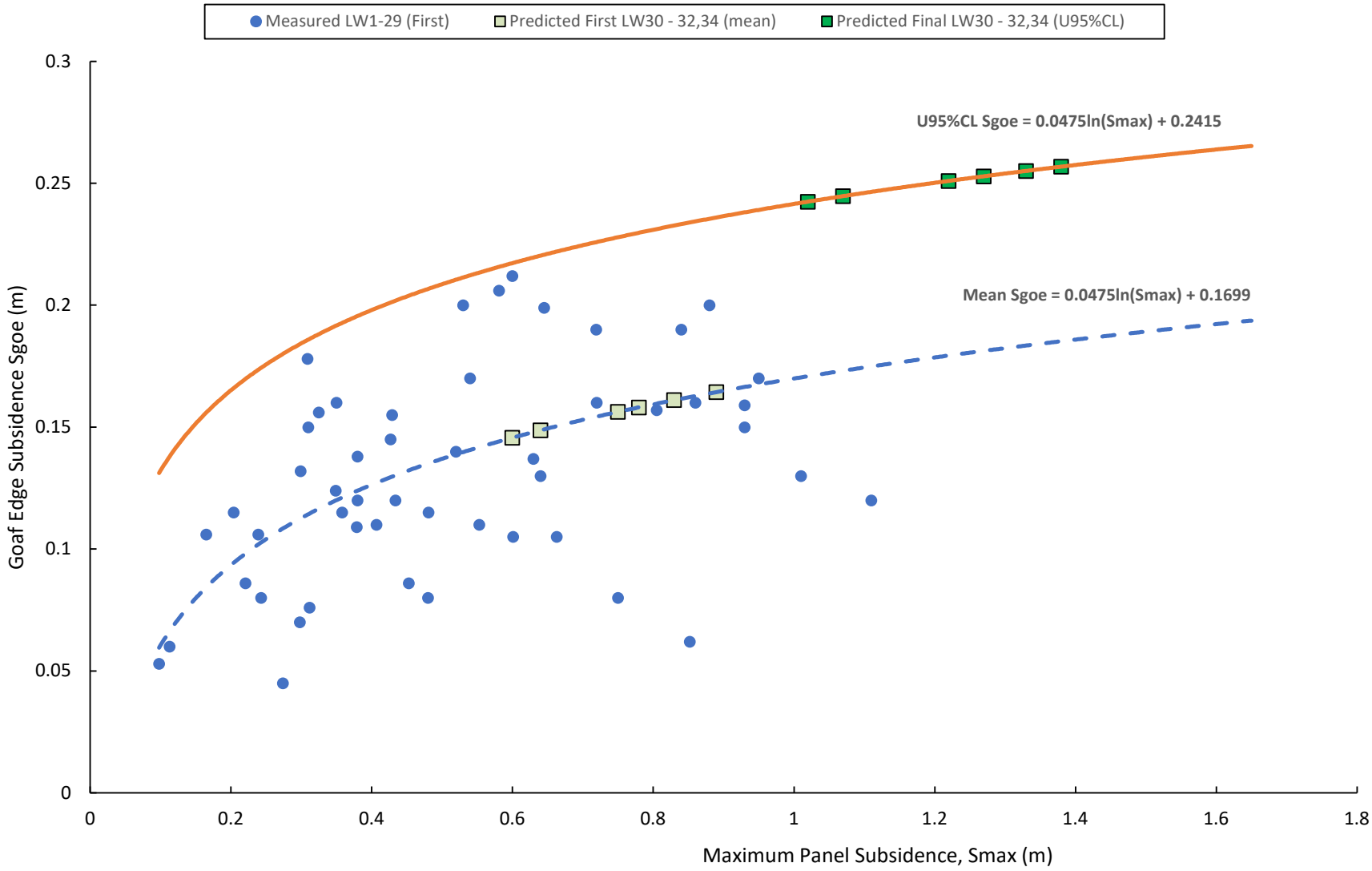
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-001/14	
	Drawn:	S.Ditton			
	Date:	20.06.21	Title:	Predicted Subsidence Reduction Potential of Sandstone Units Above Approved LWs 30 to 32 & 34 for 300 m to 500 m Depth Categories	
	Ditton Geotechnical Services Pty Ltd		Scale:	NTS	Figure No: 4b



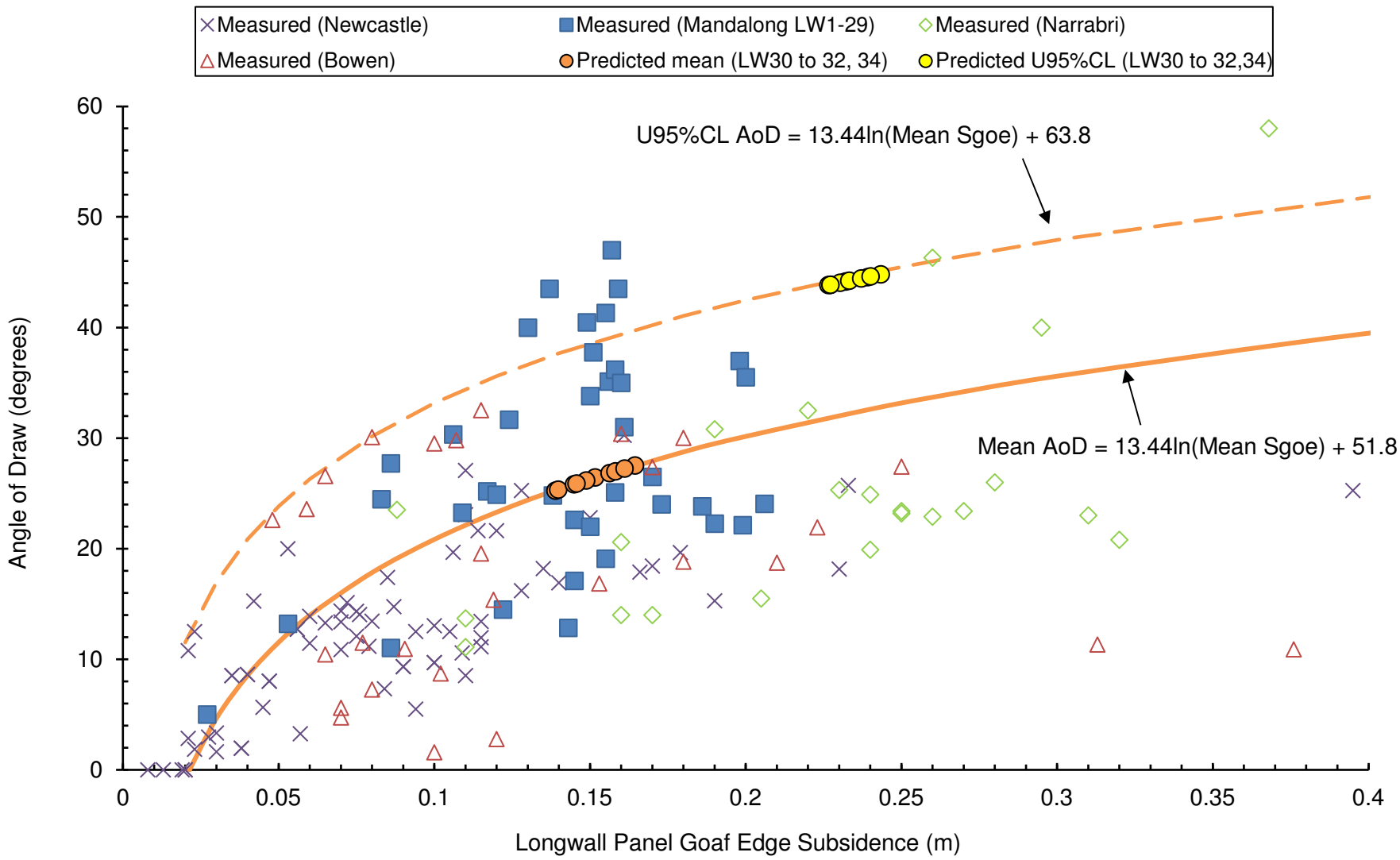
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-001/14	
	Drawn:	S.Ditton			
	Date:	01.07.21	Title:	Predicted Maximum Single Panel Subsidence for Mandalong Longwalls 30 to 32 & 34 with Cover Depths ranging between 250 m and 500 m	
	Ditton Geotechnical Services Pty Ltd		Scale:	NTS	Figure No: 4c



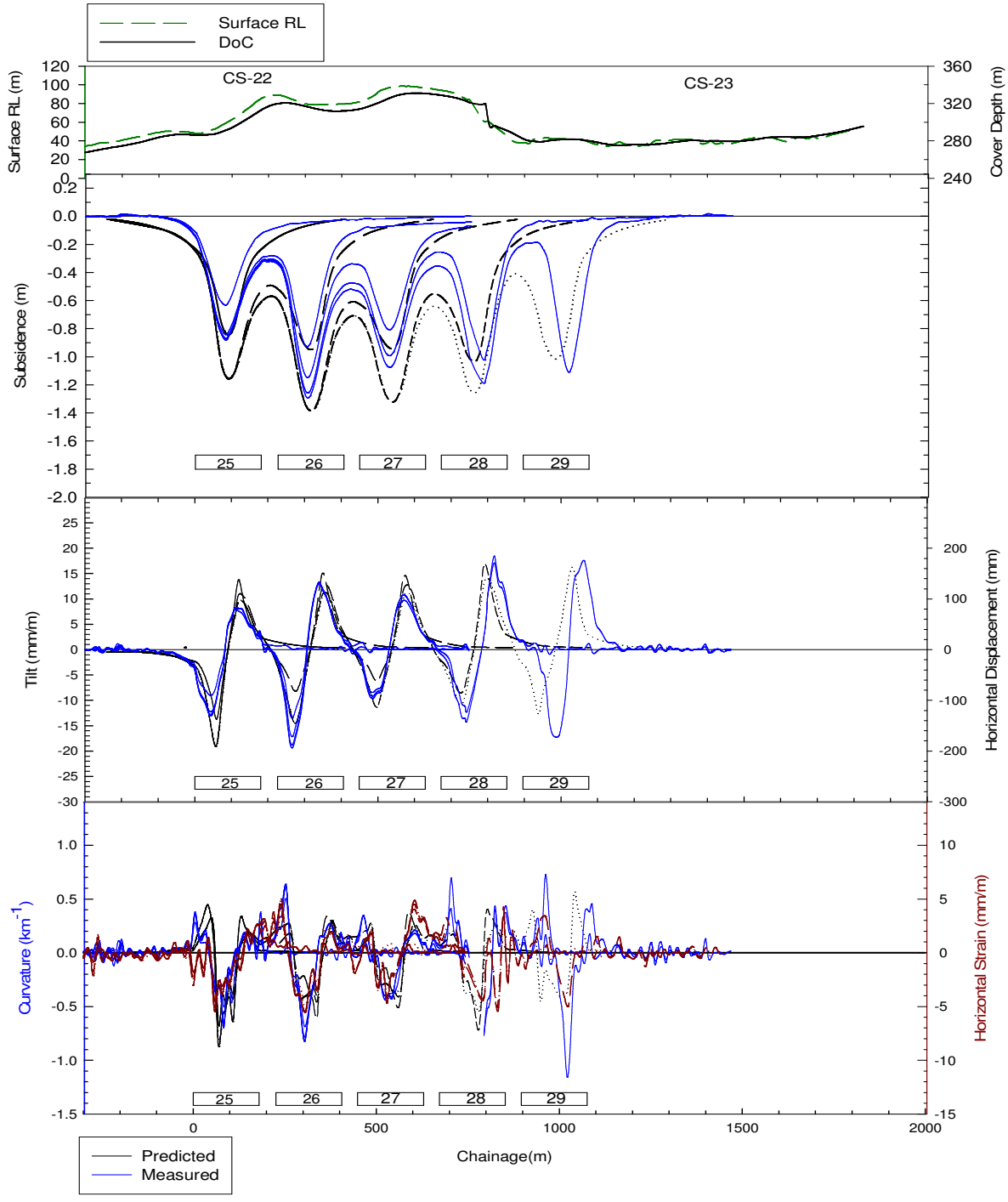
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-001/14	
	Drawn:	S.Ditton			
	Date:	20.06.21	Title:	Chain Pillar Subsidence Prediction Model based on the ACARP, 2003 and the Observed Outcomes for LW13 - 28b: Predictions for Proposed LW 30 -32 & 34	
	Ditton Geotechnical Services Pty Ltd		Scale:	NTS	Figure No: 4d



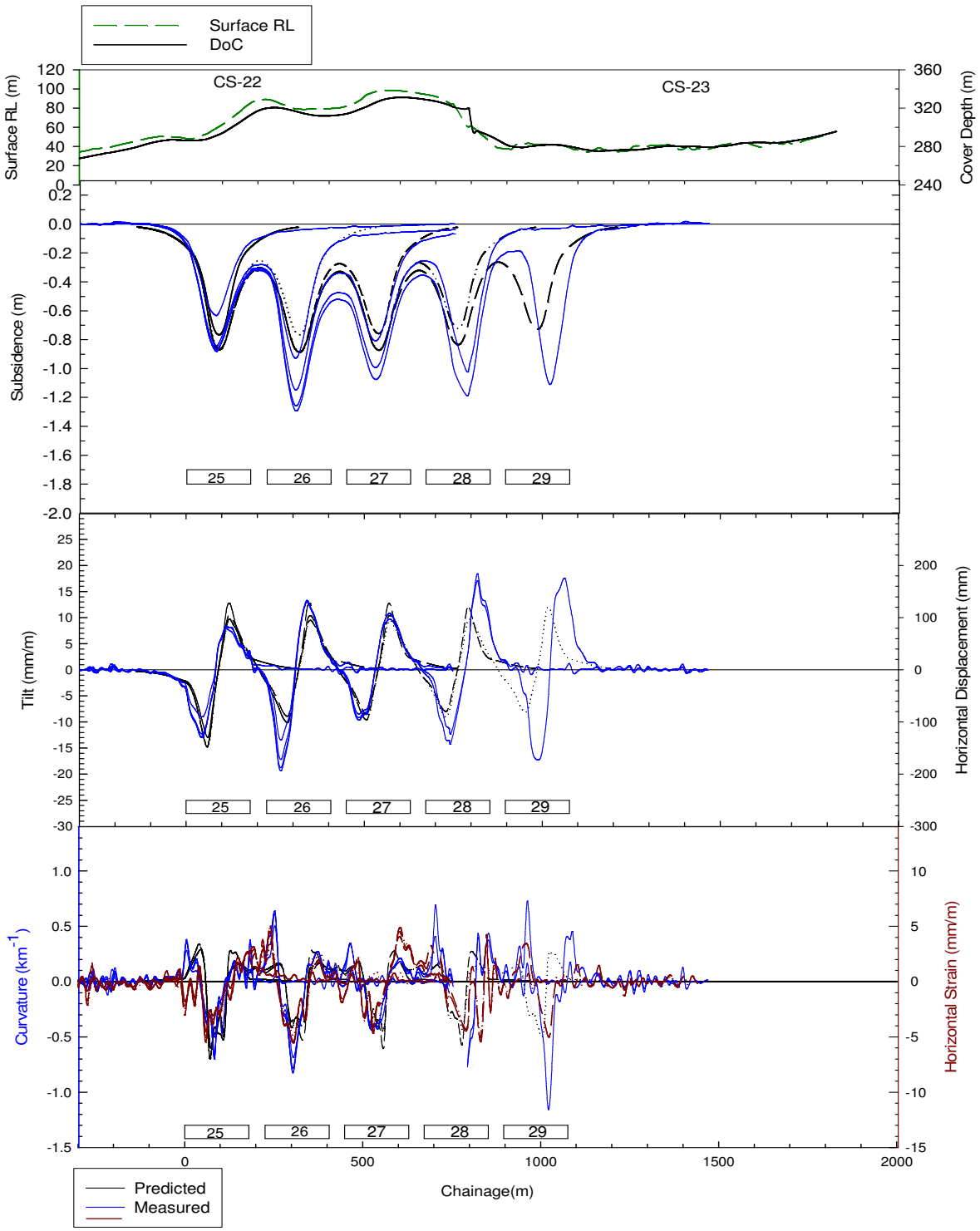
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong	
	Drawn:	S.Ditton		MAN-001/14	
	Date:	20.06.21	Title:	Empirical Model for Goaf Edge Subsidence Prediction for LW30 to 32 & 34 at the Mandalong Mine	
	Ditton Geotechnical Services Pty Ltd		Scale:	NTS	Figure No: 4e



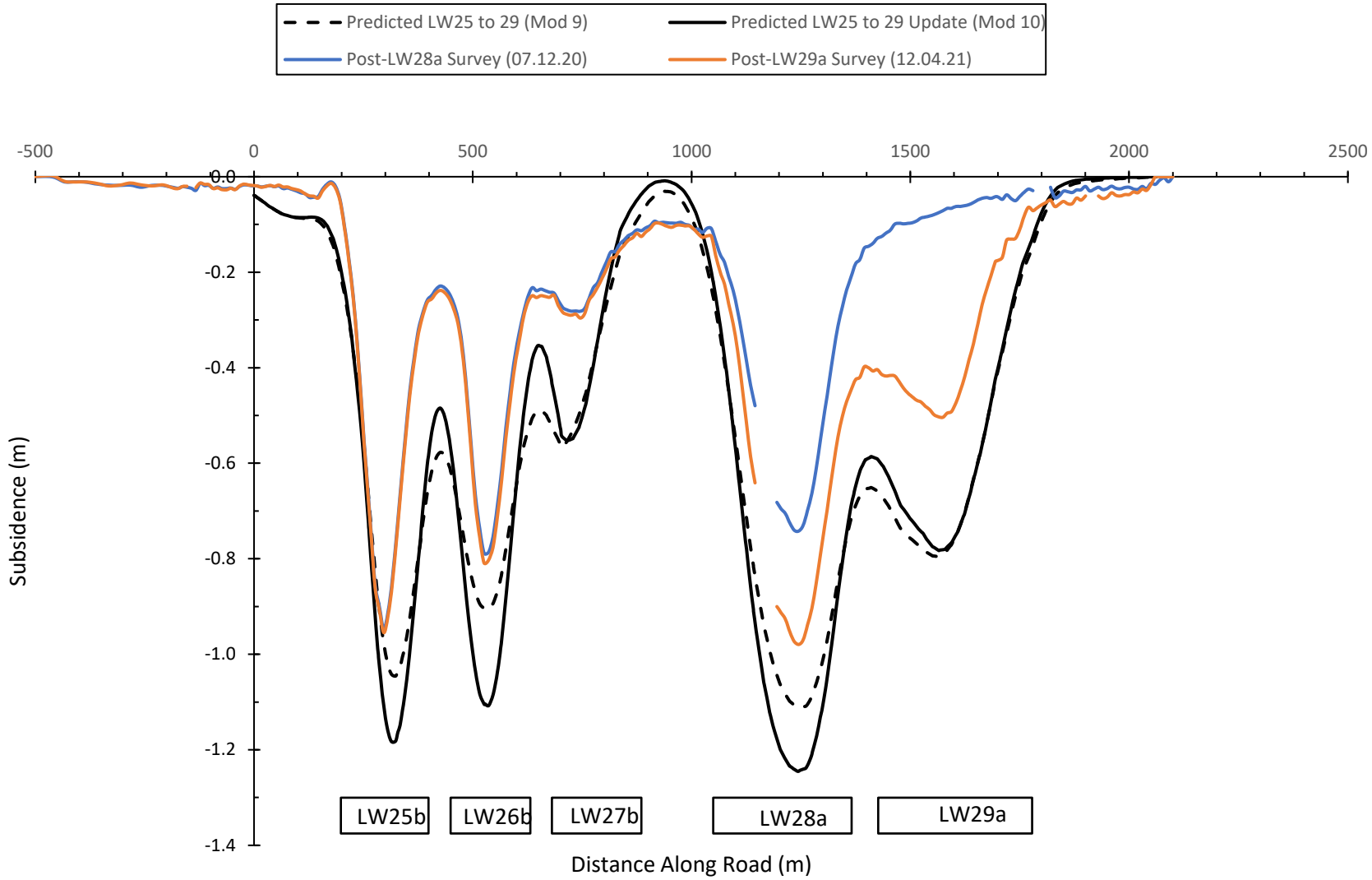
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-001/14	
	Drawn:	S.Ditton			
	Date:	20.06.21	Title:	Predicted Angle of Draw to 20 mm Subsidence for Proposed Longwall Panels 30 to 32 & 34	
	Ditton Geotechnical Services Pty Ltd		Scale:	NTS	Figure No: 4f



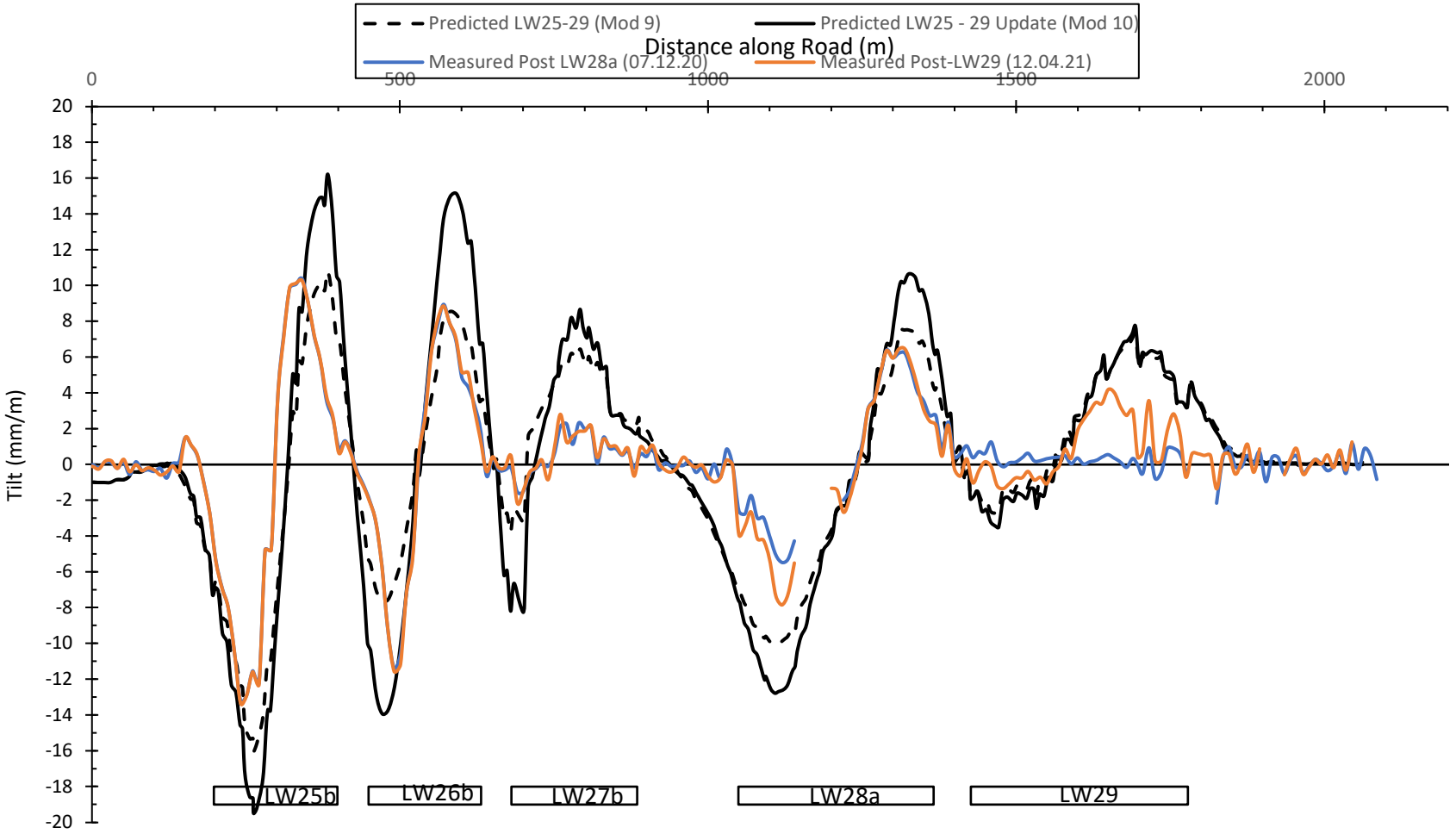
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong	
	Drawn:	S.Ditton		MAN-001/14	
	Date:	20.06.21	Title:	Predicted U95% v Measured Subsidence Effect Profiles along CS22-23 for LW25b - 29	
	Ditton Geotechnical Services Pty Ltd		Scale:		Figure No: 4g



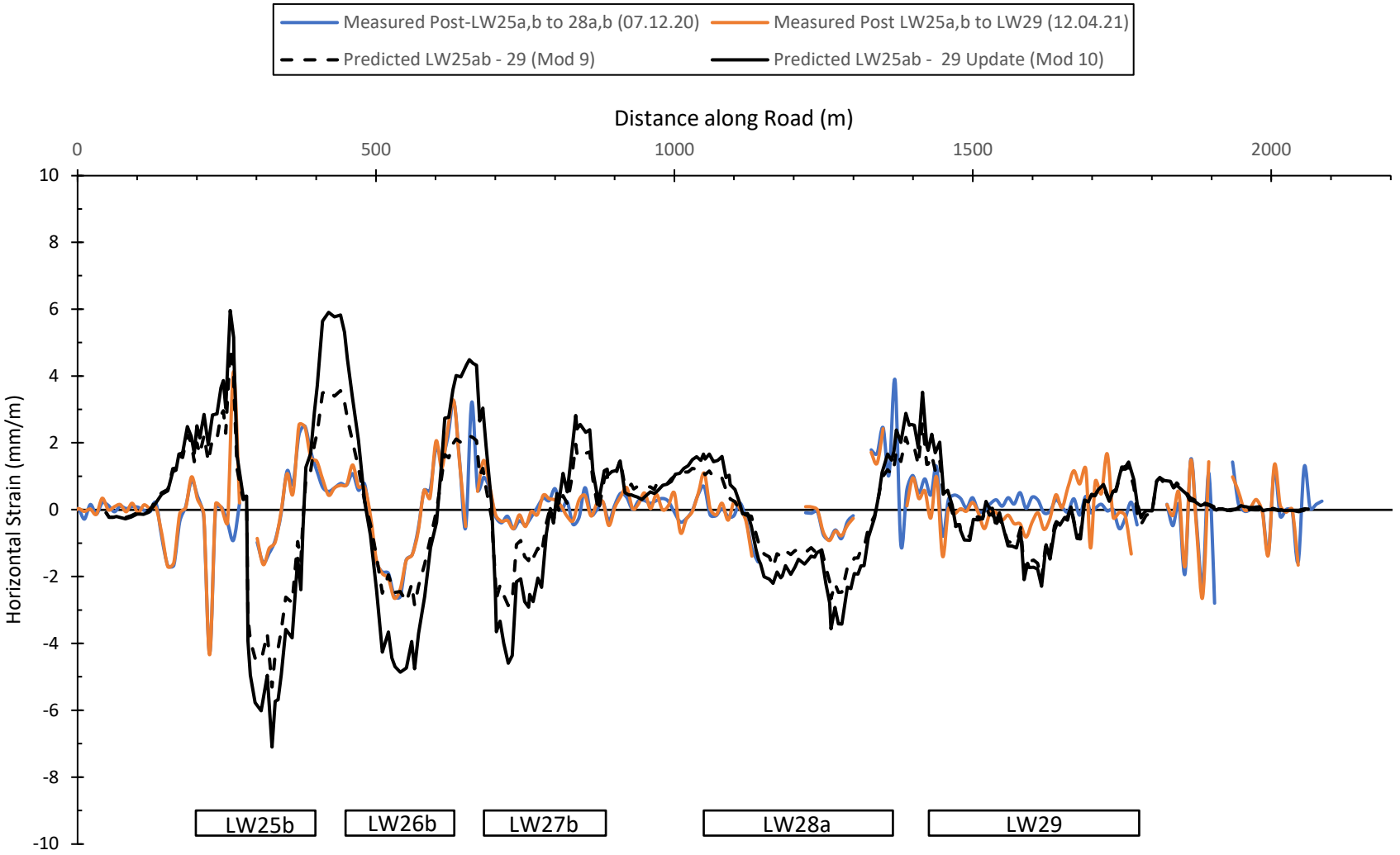
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong	
	Drawn:	S.Ditton		MAN-001/14	
	Date:	20.06.21	Title:	Predicted Mean v Measured Subsidence Effect Profiles along CS22-23 for LW25b - 29	
	Ditton Geotechnical Services Pty Ltd		Scale:		Figure No: 4h



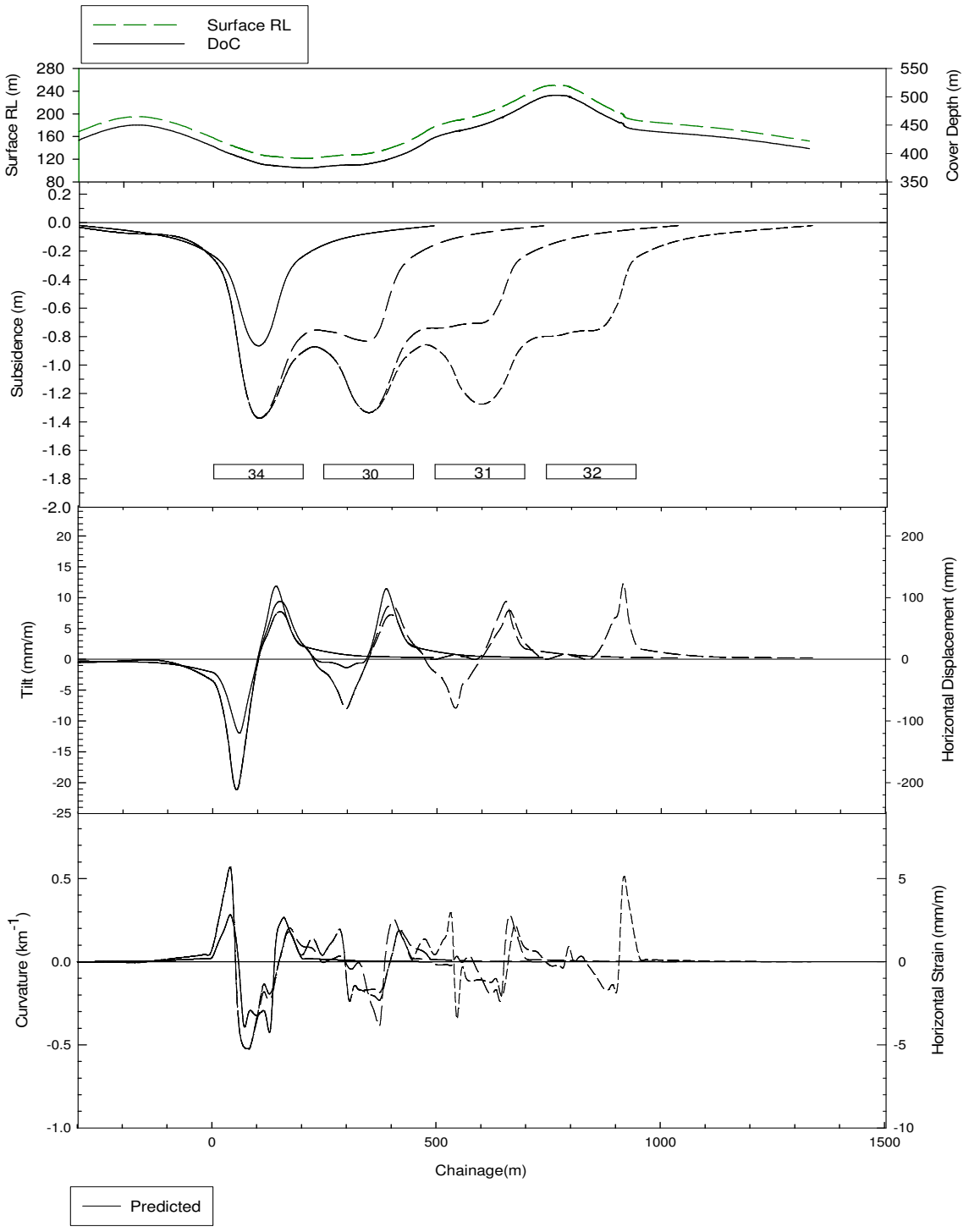
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong	
	Drawn:	S.Ditton		MAN-001/14	
	Date:	15.07.21	Title:	Measured v. Predicted U95%CL Subsidence along Mandalong Road (Survey Line CS-21)	
	Ditton Geotechnical Services Pty Ltd			due to LW25a,b to 29 at Mandalong Mine	
			Scale:	NTS	Figure No: 4i



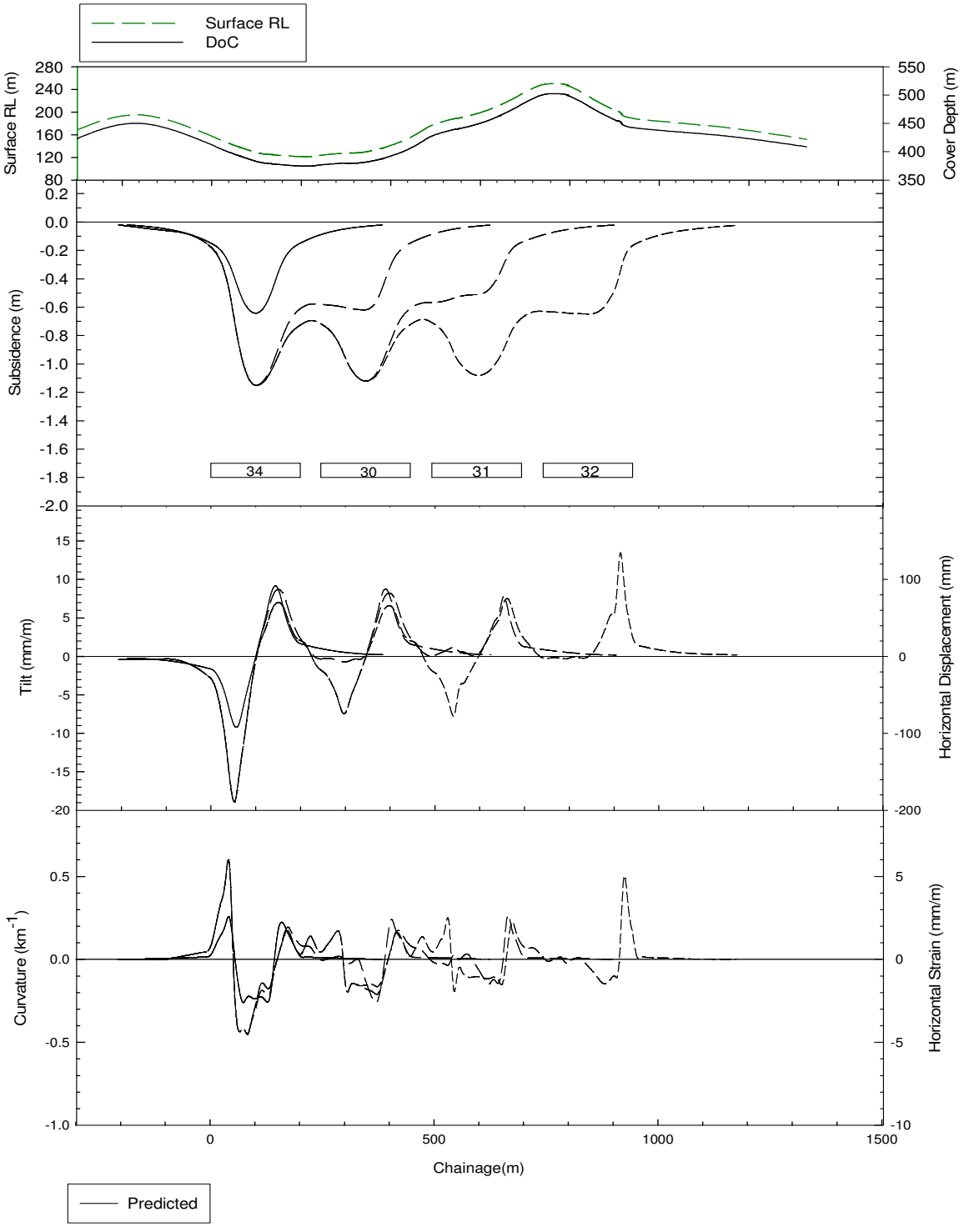
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong	
	Drawn:	S.Ditton		MAN-001/14	
	Date:	15.07.21	Title:	Measured v. Predicted U95%CL Tilt along Mandalong Road (Survey Line CS-21)	
	Ditton Geotechnical Services Pty Ltd			due to LW25a,b to 29 at Mandalong Mine	
			Scale:	NTS	Figure No: 4j



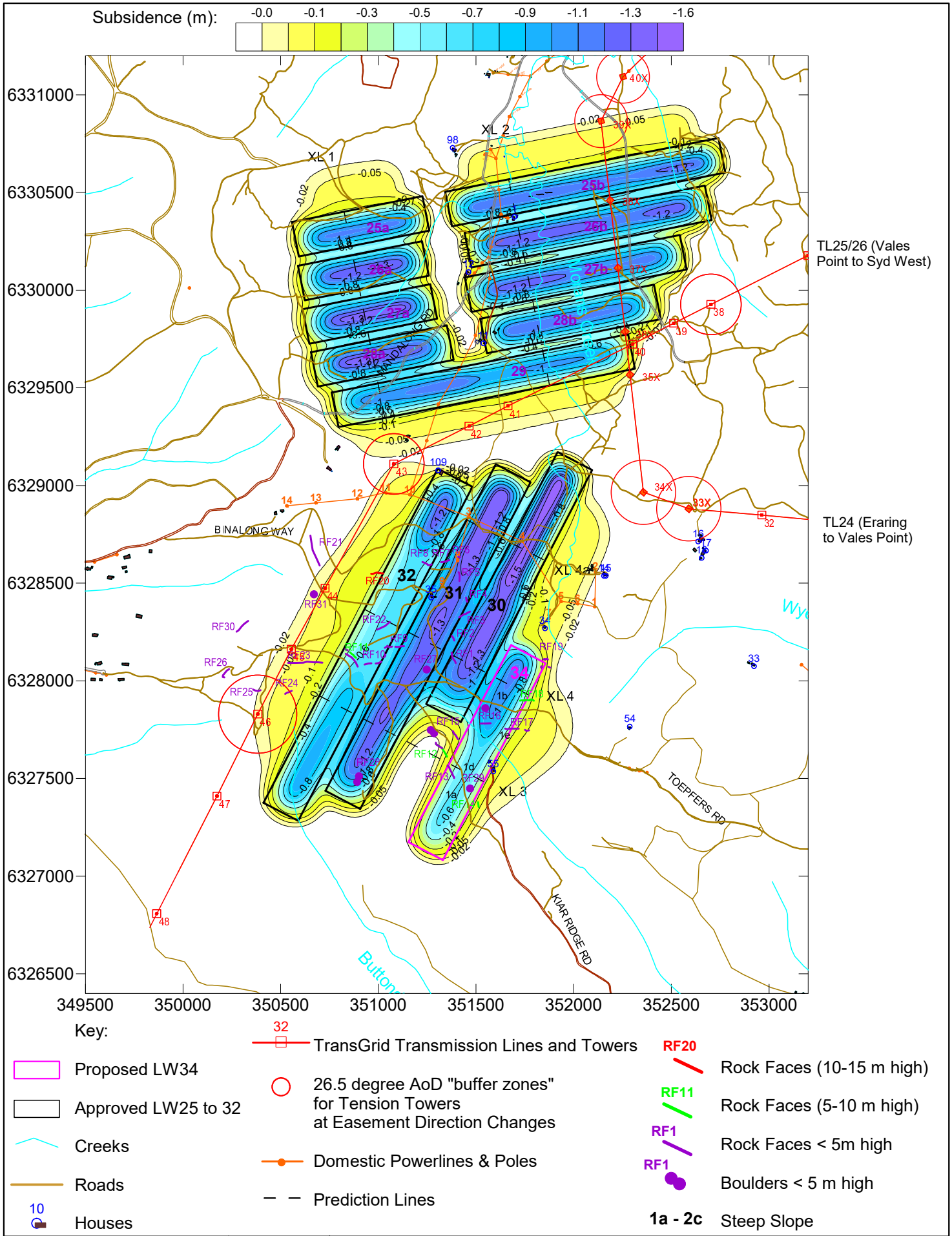
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong	
	Drawn:	S.Ditton		MAN-001/14	
	Date:	15.07.21	Title:	Measured v. Predicted U95%CL Horizontal Strain along Mandalong Road (Survey Line CS-21)	
	Ditton Geotechnical Services Pty Ltd			due to LW25a,b to 29 at Mandalong Mine	
			Scale:	NTS	Figure No: 4k



DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong	
	Drawn:	S.Ditton		MAN-001/14	
	Date:	20.06.21	Title:	Predicted U95%CL Subsidence Effect Profiles along XL4 for LWs 30 - 32 & 34	
	Ditton Geotechnical Services Pty Ltd		Scale:		Figure No: 5a



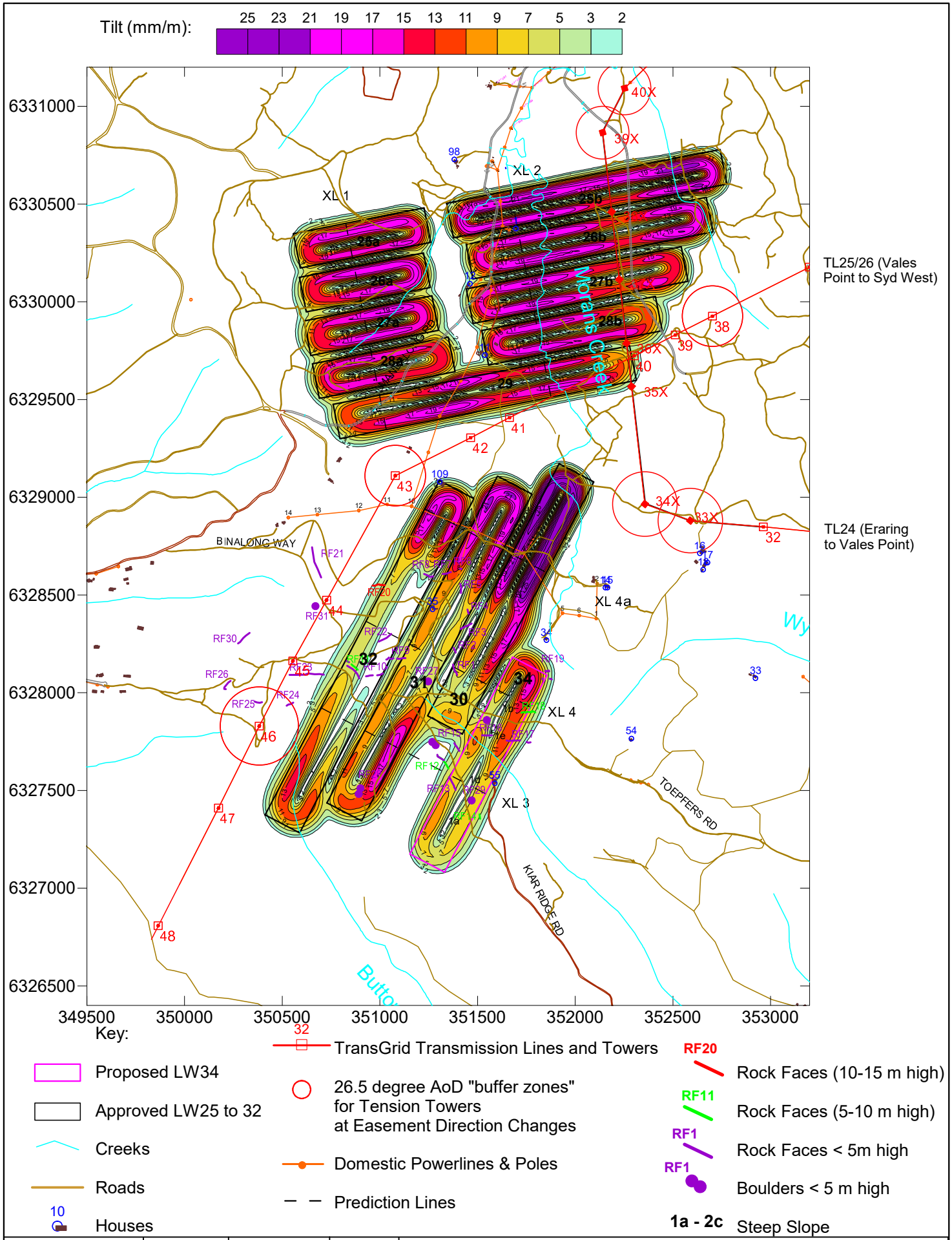
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong	
	Drawn:	S.Ditton		MAN-001/13	
	Date:	01.09.20	Title:	Predicted Mean Subsidence Effect Profiles along XL4 for LWs 30 - 32 & 34	
	Ditton Geotechnical Services Pty Ltd		Scale:		Figure No: 5b



Key:

- Proposed LW34
- Approved LW25 to 32
- Creeks
- Roads
- Houses
- TransGrid Transmission Lines and Towers
- 26.5 degree AoD "buffer zones" for Tension Towers at Easement Direction Changes
- Domestic Powerlines & Poles
- Prediction Lines
- Rock Faces (10-15 m high)
- Rock Faces (5-10 m high)
- Rock Faces < 5m high
- Boulders < 5 m high
- Steep Slope

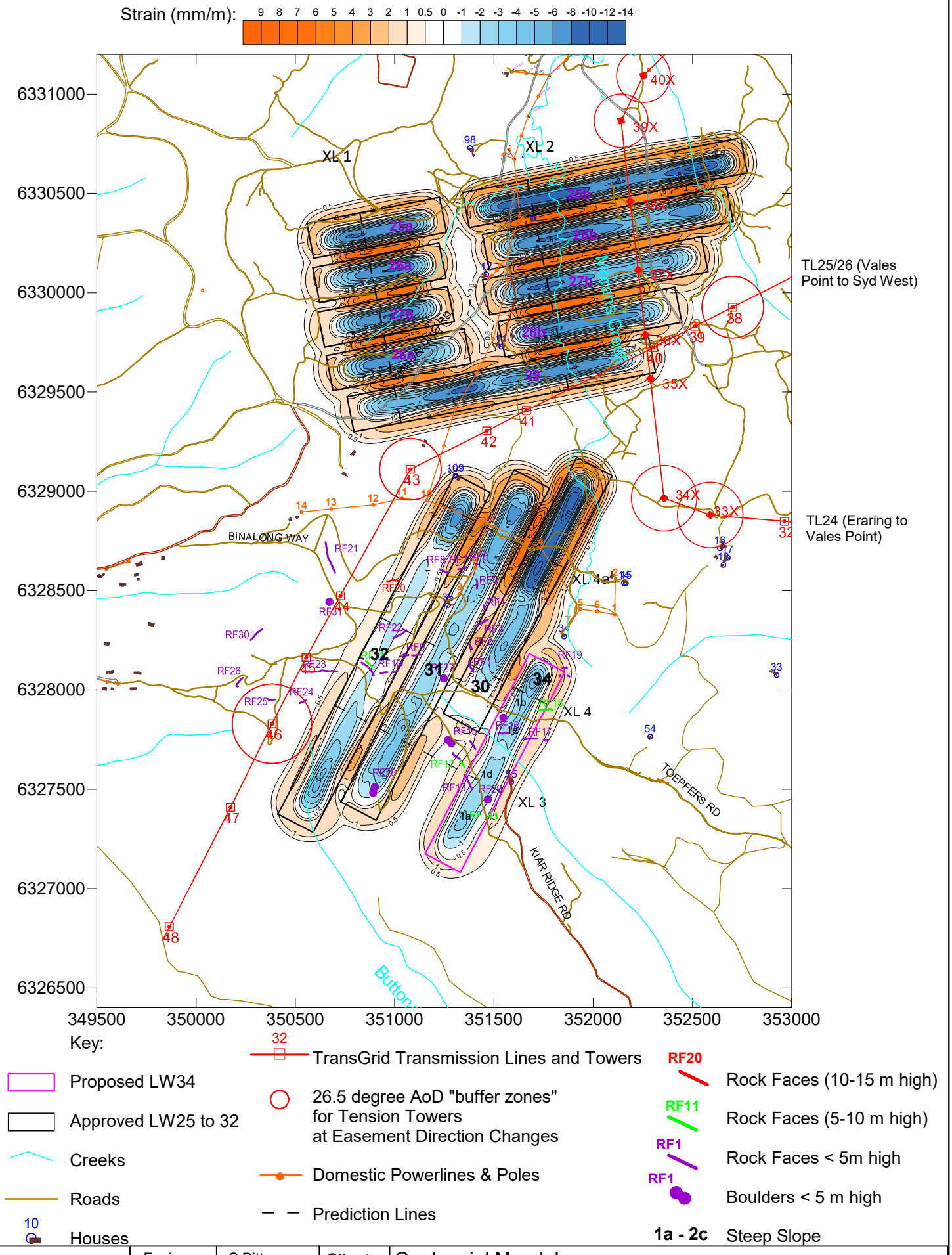
DgS Ditton Geotechnical Services Pty Ltd	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-001/14	
	Drawn:	S.Ditton			
	Date:	15.06.21	Title:	Predicted Final Subsidence Contours (U95%CL) for the Proposed Extensions to Longwalls 30 to 32 & 34 (Mod 10) at the Mandalong Mine	
			Scale:	1:25,000 (A4)	Figure No: 6a



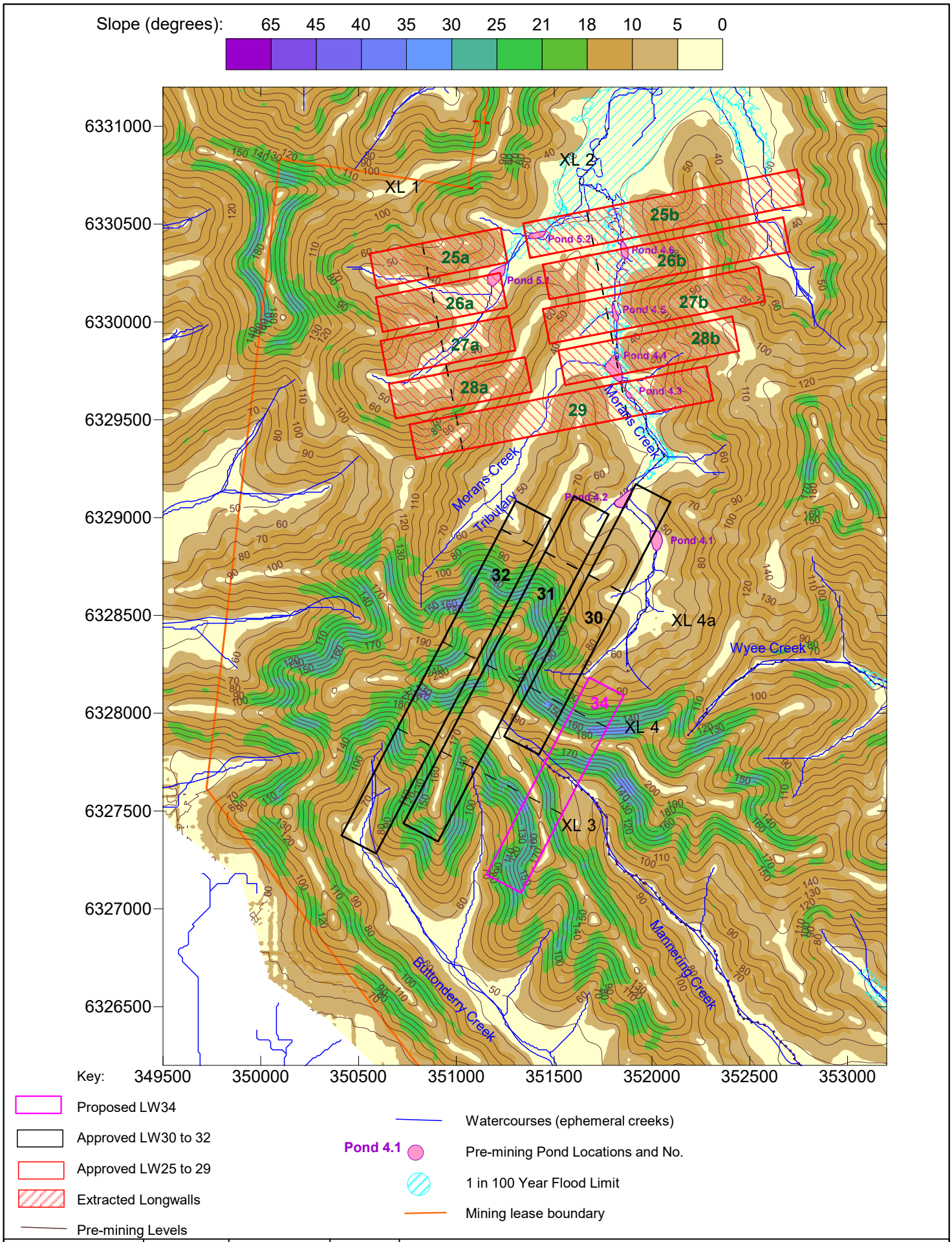
Key:

- Proposed LW34
- Approved LW25 to 32
- Creeks
- Roads
- Houses (10)
- TransGrid Transmission Lines and Towers (32)
- 26.5 degree AoD "buffer zones" for Tension Towers at Easement Direction Changes
- Domestic Powerlines & Poles
- Prediction Lines
- RF20 Rock Faces (10-15 m high)
- RF11 Rock Faces (5-10 m high)
- RF1 Rock Faces < 5m high
- RF1 Boulders < 5 m high
- 1a - 2c Steep Slope

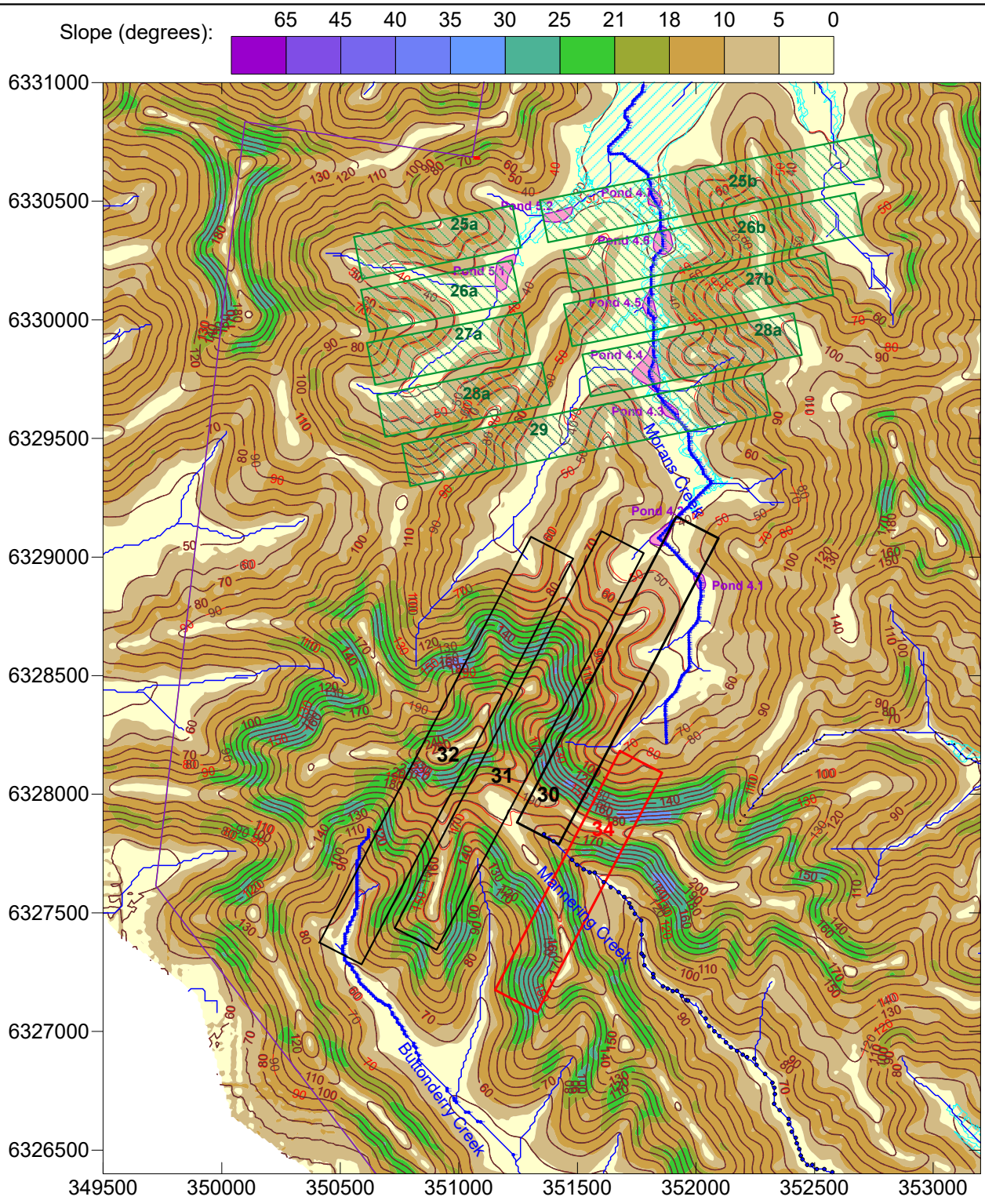
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-001/14	
	Drawn:	S.Ditton			
	Date:	15.06.21	Title:	Predicted Final Tilt Contours (U95%CL) for the Proposed Extensions to Longwalls 30 to 32 & 34 (Mod 10) at the Mandalong Mine	
Ditton Geotechnical Services Pty Ltd			Scale:	1:25,000 (A4)	Figure No: 6b



DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-001/14	
	Drawn:	S.Ditton			
	Date:	15.06.21	Title:	Predicted Final Horizontal Strain Contours (U95%CL) for the Proposed Extensions to Longwalls 30 to 32 & 34 (Mod 10) at the Mandalong Mine	
Ditton Geotechnical Services Pty Ltd			Scale:	1:25,000 (A4)	Figure No: 6c



DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-001/14	
	Drawn:	S.Ditton			
	Date:	20.06.21	Title:	Pre-mining Surface Levels & Natural Features above the Proposed Extensions to Longwalls 30 to 32 & 34 (Mod 10) at the Mandalong Mine	
Ditton Geotechnical Services Pty Ltd			Scale:	1:25,000 (A4)	Figure No: 7a



Proposed LW34

Approved LW30 to 32

Approved LW25 to 29

Extracted Longwalls

Pre-Mining Levels (AHD)

Post-mining Levels (AHD)

Watercourses

Pond 4.1 Pond Locations and No.

1 in 100 Year Flood Limit

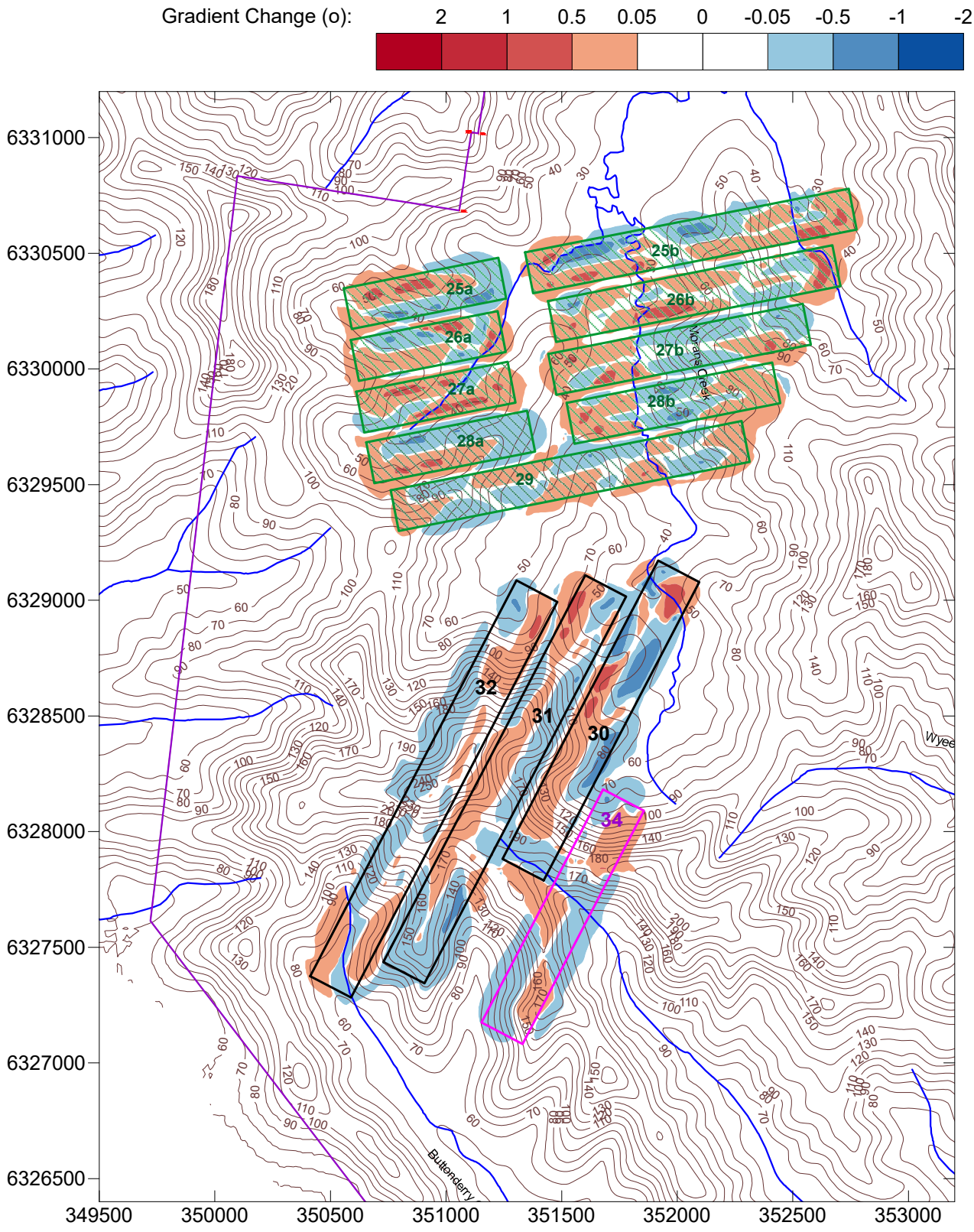
Watercourse assessment point

Mining Lease Boundary

DgS

Ditton Geotechnical Services Pty Ltd

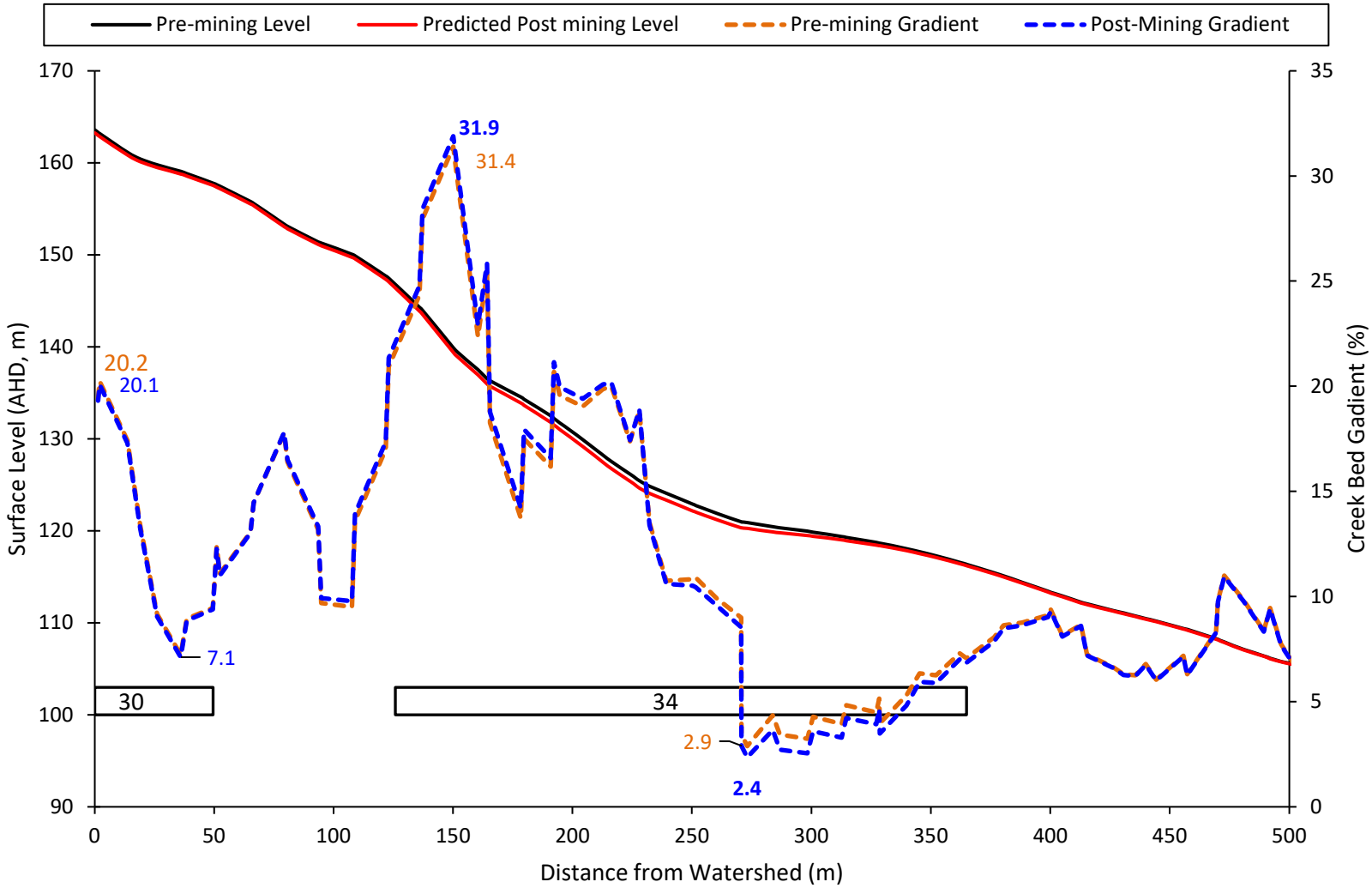
Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-001/14		
Drawn:	S.Ditton				
Date:	15.07.21	Title:	Post-mining Surface Levels and Ponding Locations along Watercourses above Proposed Longwalls 30 to 32 & 34 (Mod10) at the Mandalong Mine (based on U95%CL Subsidence Contours)		
		Scale:	1:25,000 (A4)	Figure No:	7b



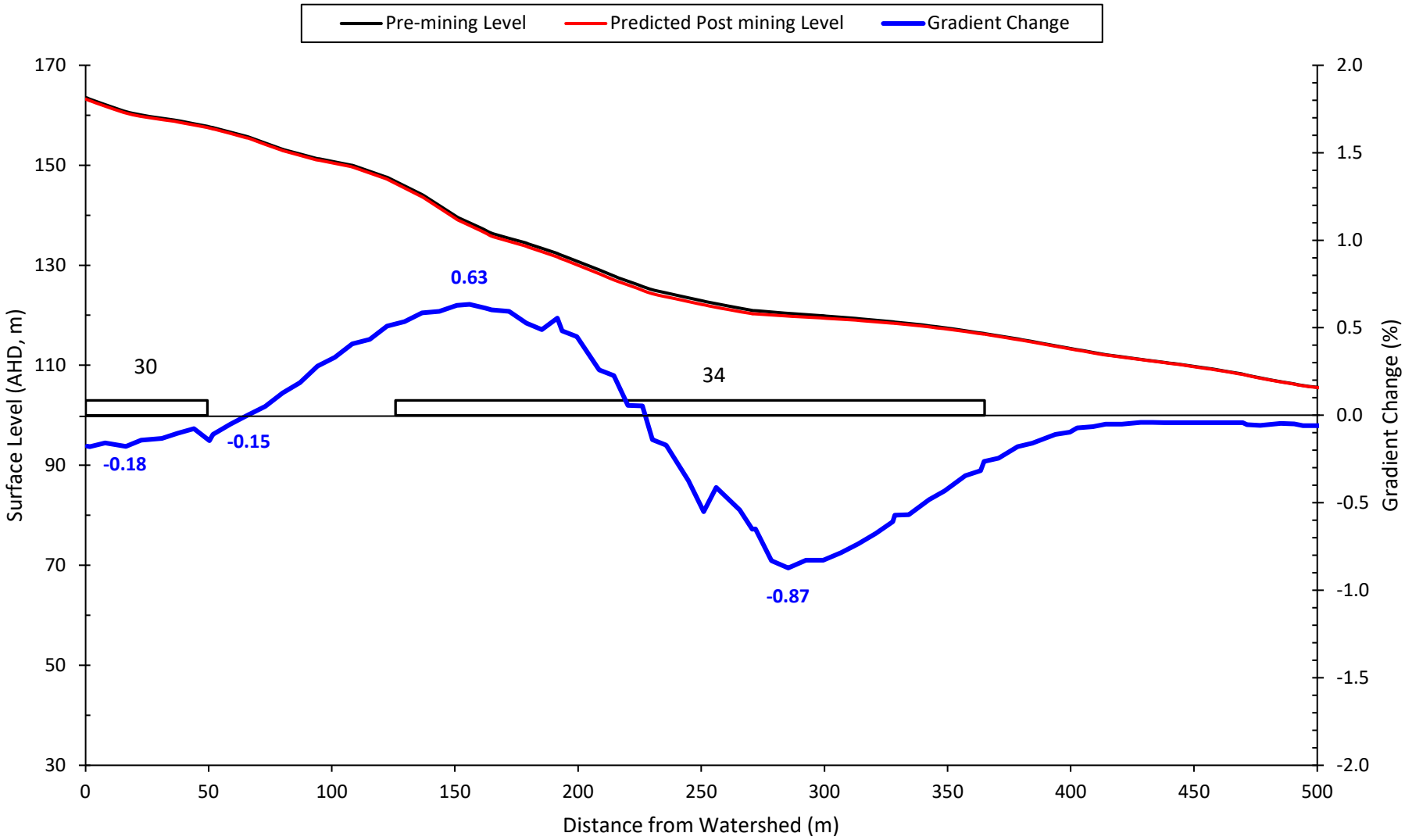
Key:

- Approved LW30 to 32
- Proposed LW34
- Extracted LW25 to 29
- Post-mining Levels
- Creeks

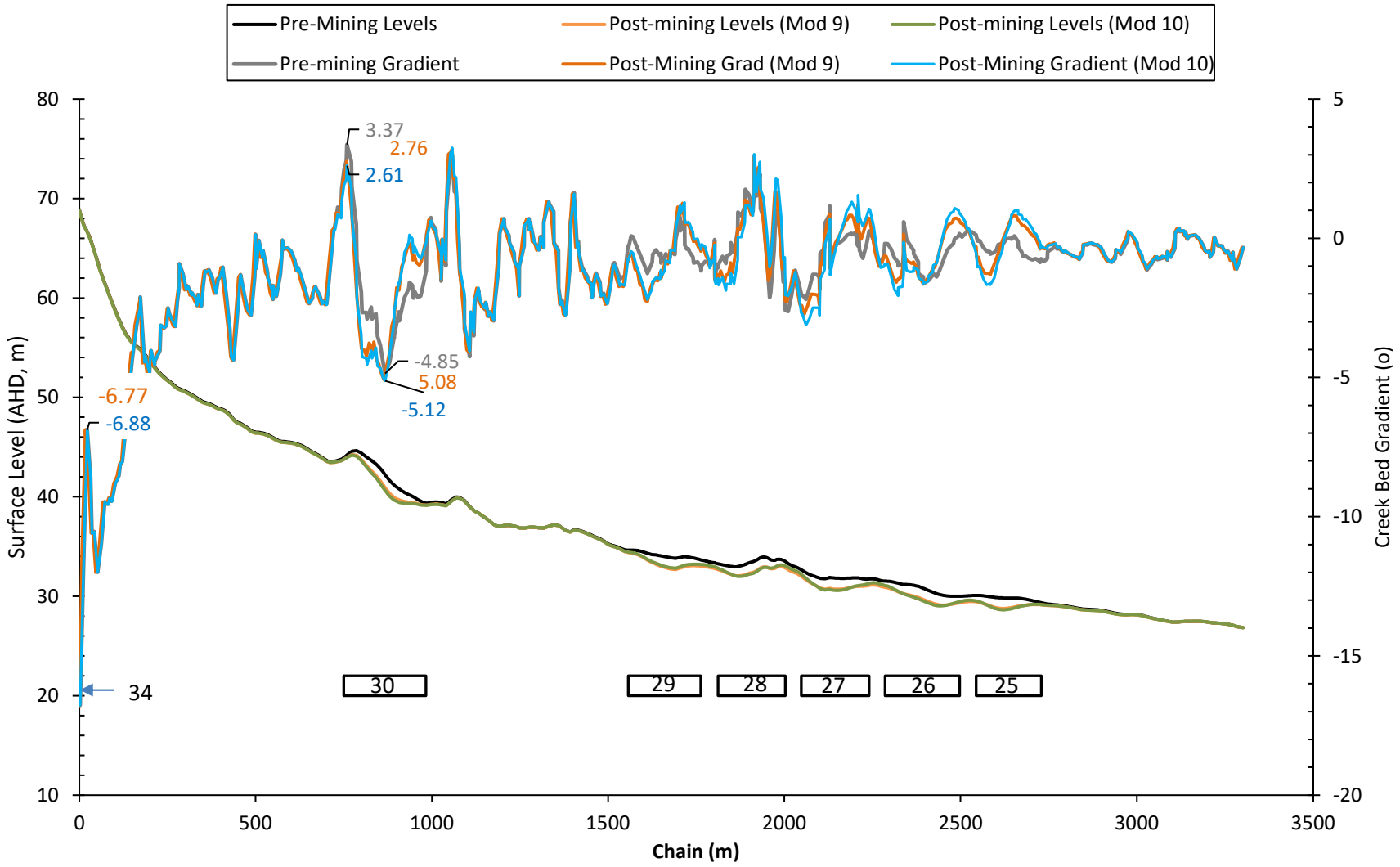
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-001/14	
	Drawn:	S.Ditton			
	Date:	15.07.21	Title:	Post-Mining Gradient Changes Above the Proposed Longwalls LW30 to 32 & 34 (Mod 10) at the Mandalong Mine	
Ditton Geotechnical Services Pty Ltd			Scale:	1:25,000 (A4)	Figure No: 8



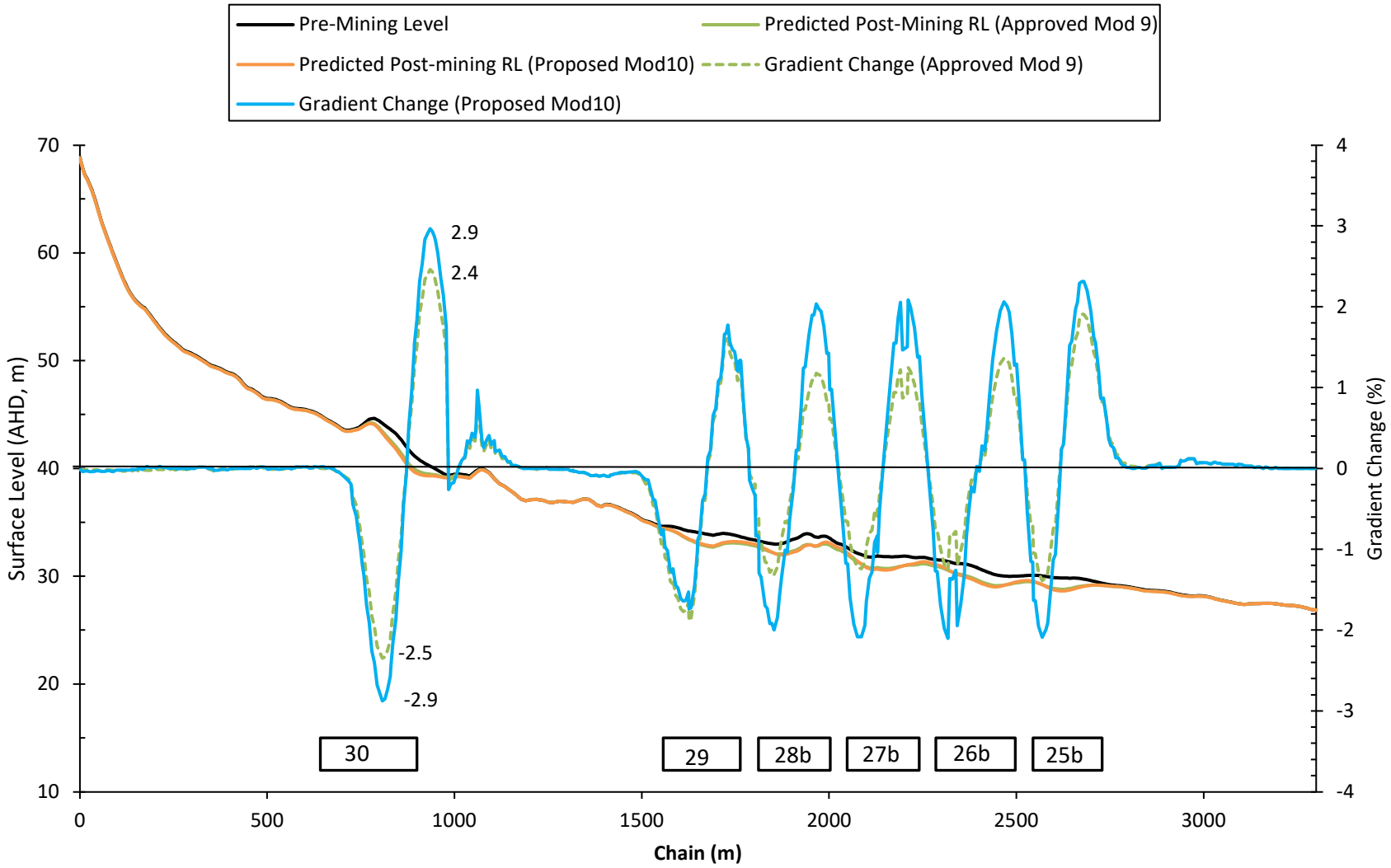
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong	
	Drawn:	S.Ditton		MAN-001/14	
	Date:	15.07.21	Title:	Predicted Level Changes and Ponding Locations along Mannering Creek	
	Ditton Geotechnical Services Pty Ltd			due to Proposed LW 34 (Mod 10) at Mandalong Mine	
			Scale:	NTS	Figure No: 9a



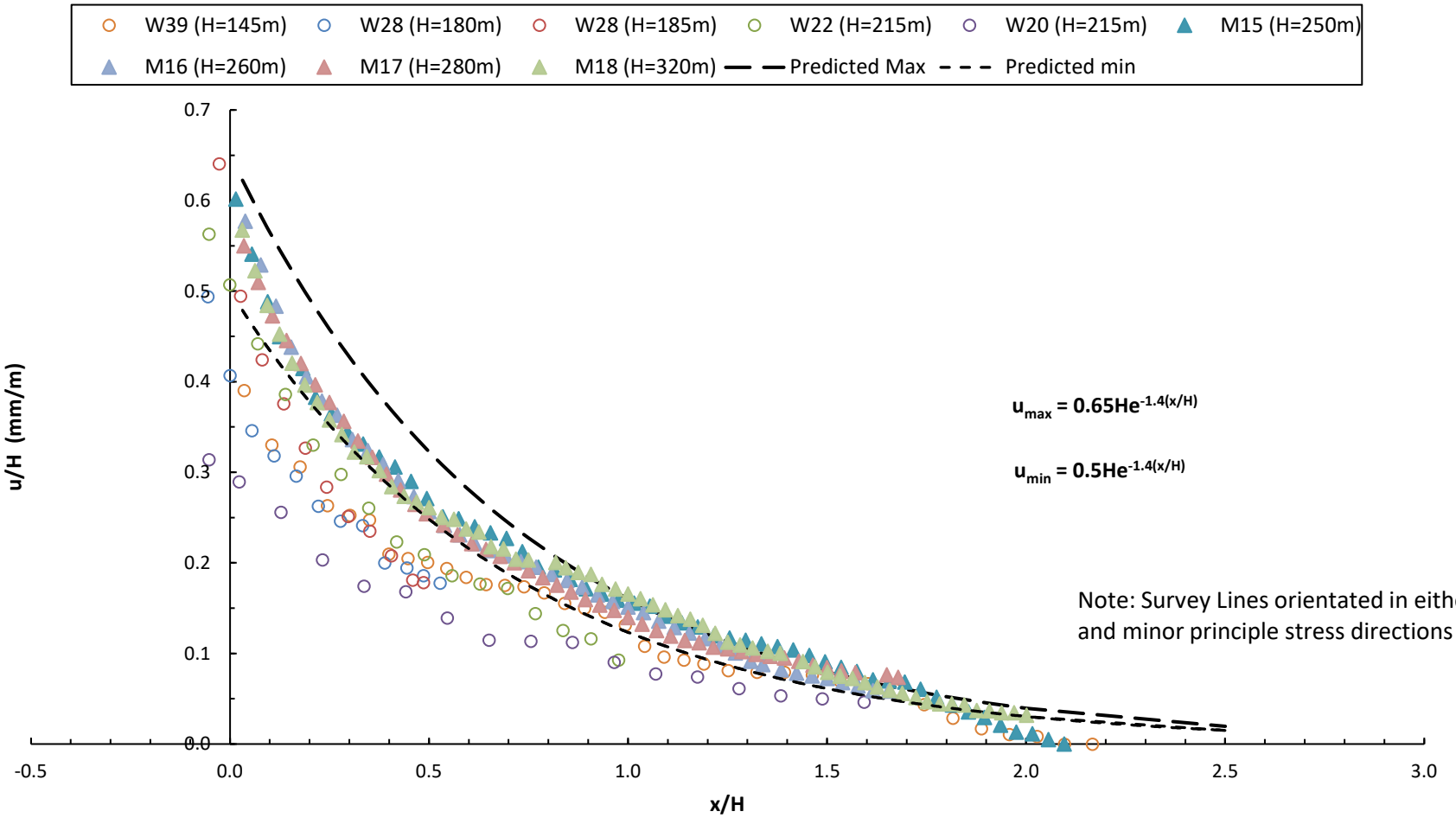
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong	
	Drawn:	S.Ditton		MAN-001/14	
	Date:	15.07.21	Title:	Predicted Level and Gradient Changes along Mannering Creek	
	Ditton Geotechnical Services Pty Ltd			due to Proposed LW34 (Mod 10) at Mandalong Mine	
			Scale:	NTS	Figure No: 9b



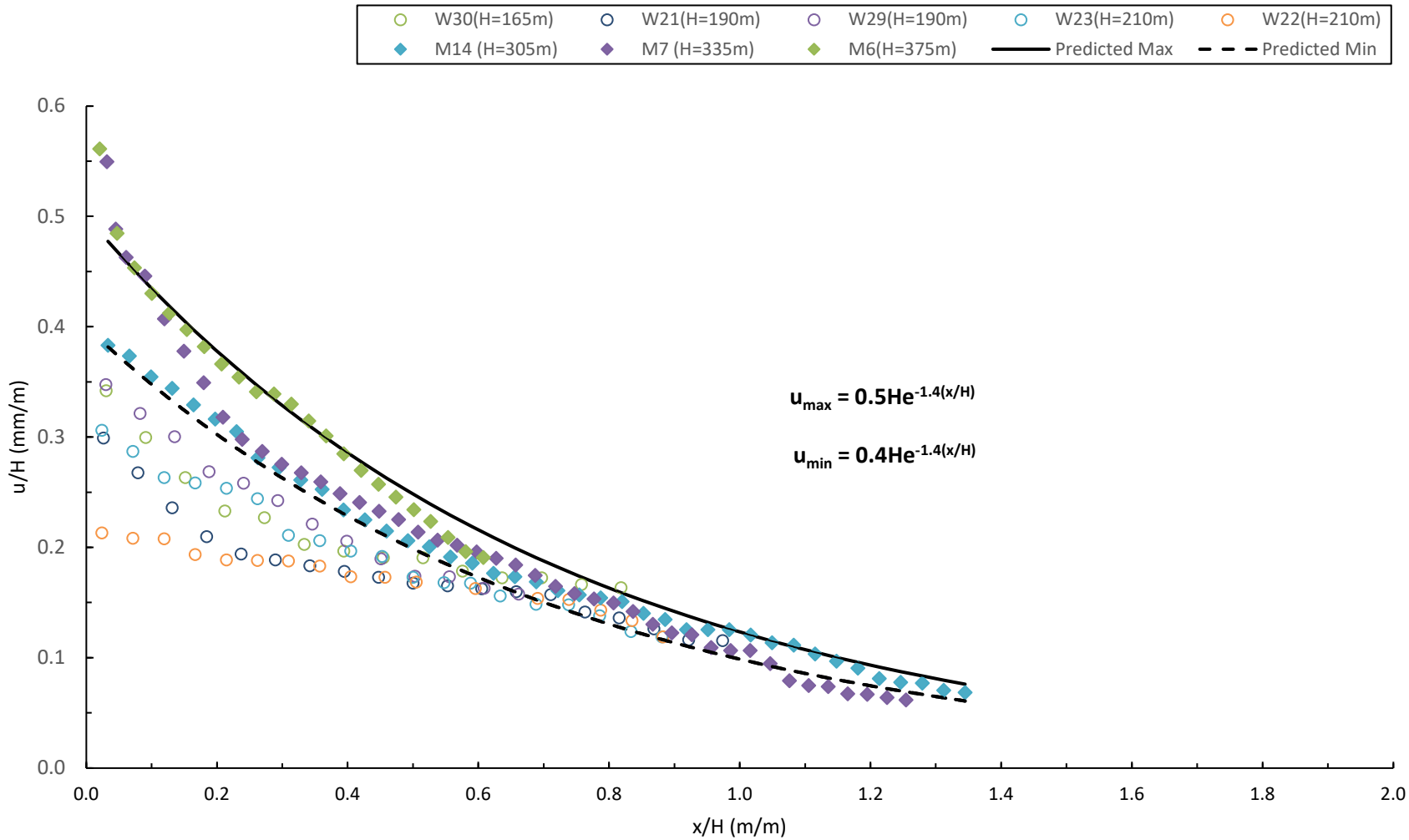
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong	
	Drawn:	S.Ditton		MAN-001/14	
	Date:	15.07.21	Title:	Predicted Level and Gradients along Morans Creek	
	Ditton Geotechnical Services Pty Ltd			due to Proposed LW30 - 32 & 34 (Mod 10) at Mandalong Mine	
			Scale:	NTS	Figure No: 9c



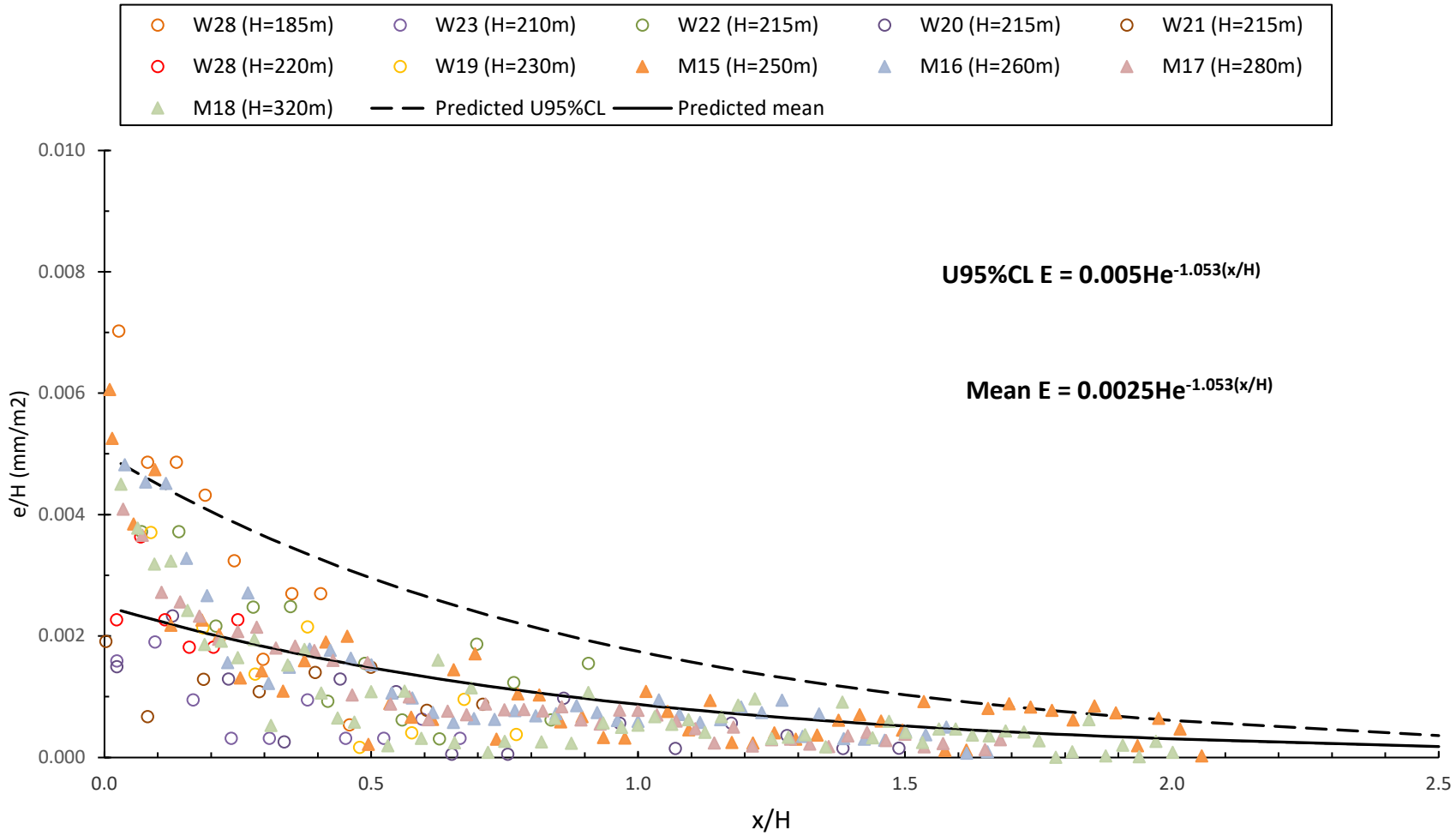
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong	
	Drawn:	S.Ditton		MAN-001/14	
	Date:	15.07.21	Title:	Predicted Level Changes and Ponding Locations along Morans Creek	
	Ditton Geotechnical Services Pty Ltd			due to Proposed LWs 30 - 32 & 34 (Mod 10) at Mandalong Mine	
			Scale:	NTS	Figure No: 9d



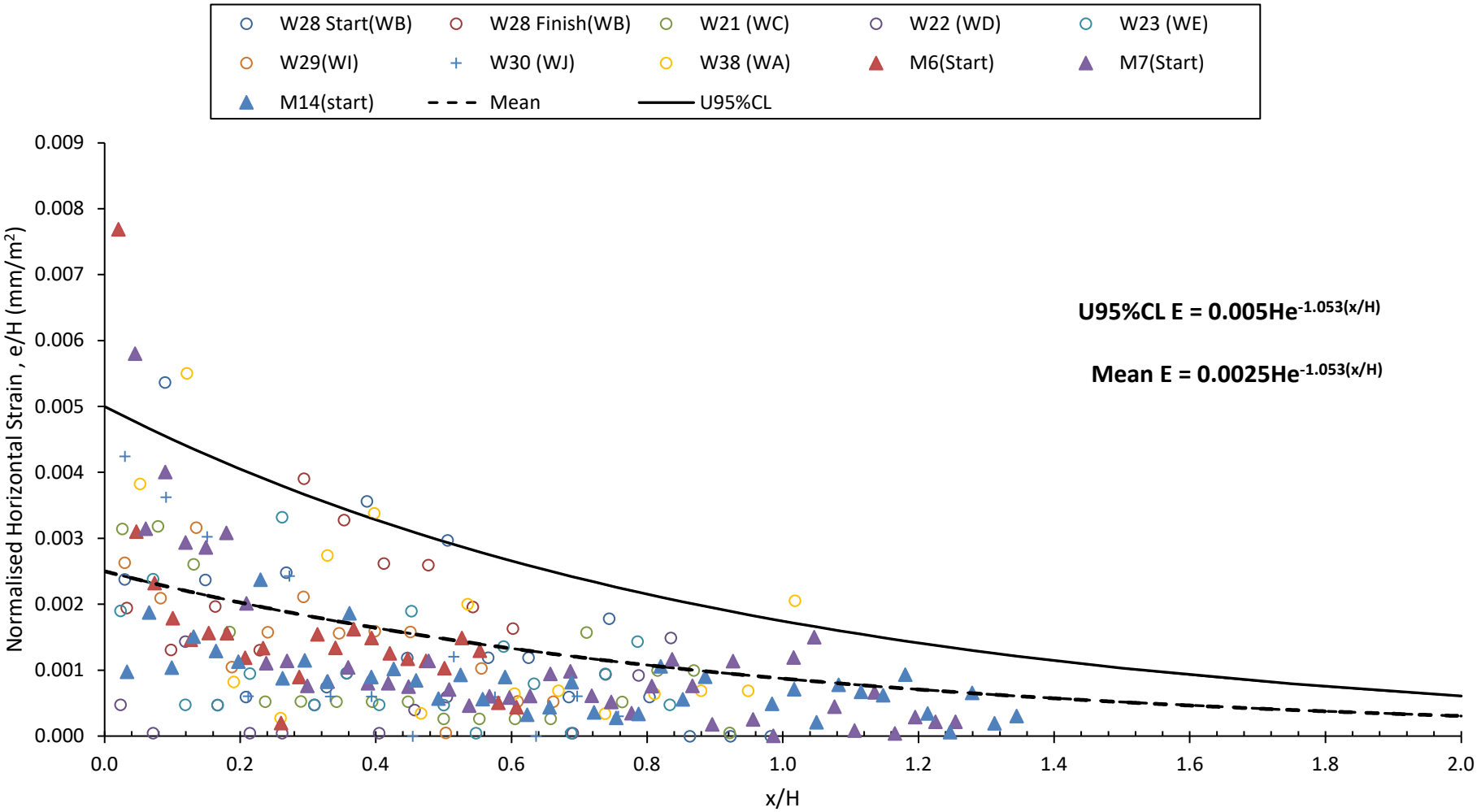
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-001/14	
	Drawn:	S.Ditton			
	Date:	20.06.21	Title:	Empirical Model and Data for Horizontal Displacement Estimates around Longwalls in Southern Newcastle Coal Field: Crossline Data normalised to Cover Depth	
	Ditton Geotechnical Services Pty Ltd		Scale:	NTS	Figure No: 10a



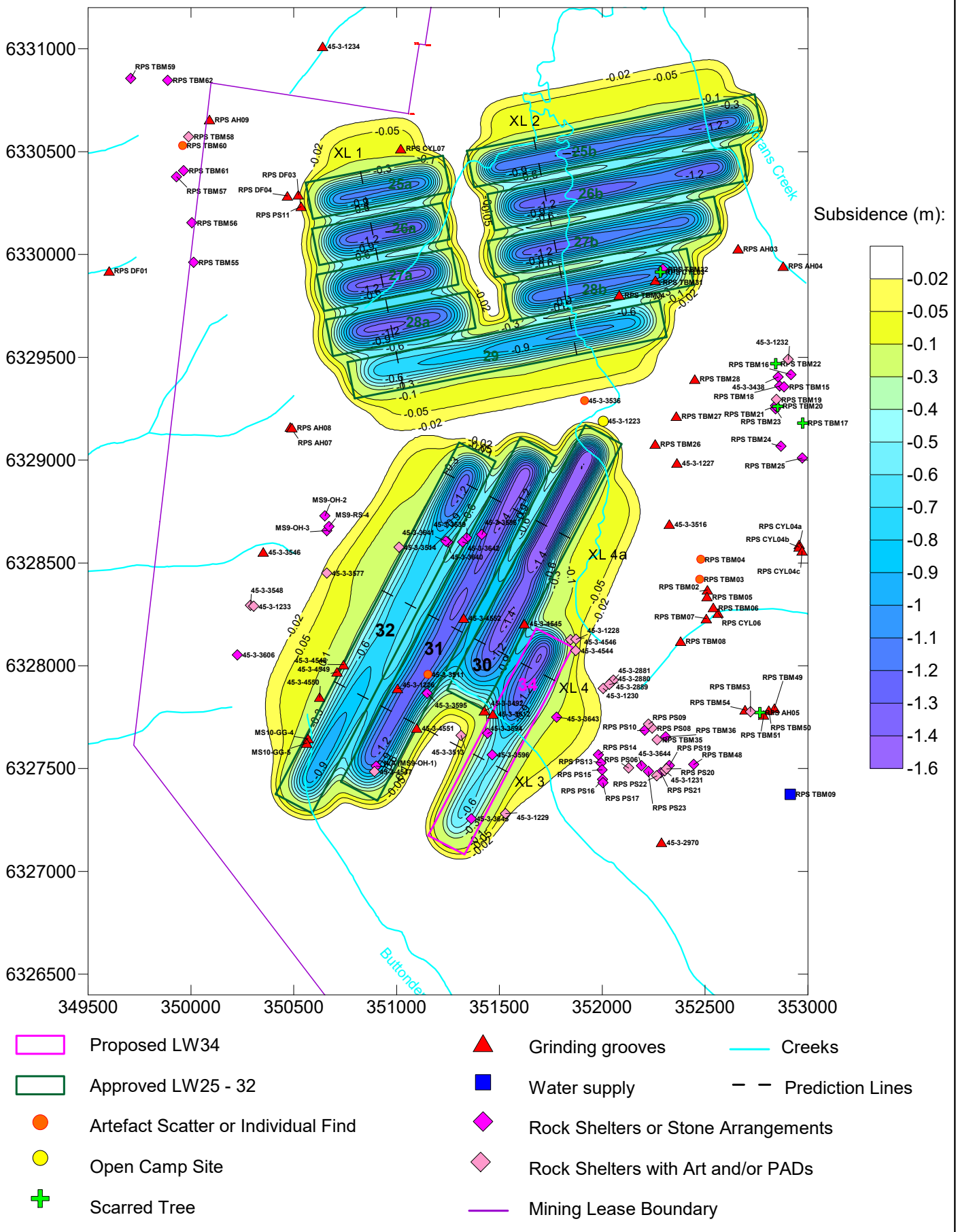
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-001/14	
	Drawn:	S.Ditton			
	Date:	20.06.21	Title:	Empirical Model and Data for Horizontal Displacement Estimates around Longwalls in Southern Newcastle Coal Field: Centreline Data normalised to Cover Depth	
Ditton Geotechnical Services Pty Ltd			Scale:	NTS	Figure No: 10b



DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-001/14	
	Drawn:	S.Ditton			
	Date:	20.06.21	Title:	Empirical Model and Data for Horizontal Strain Estimates around Longwalls in Southern Newcastle Coal Field: Crossline Data	
	Ditton Geotechnical Services Pty Ltd		Scale:	NTS	Figure No: 10c



DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-001/14	
	Drawn:	S.Ditton			
	Date:	20.06.21	Title:	Empirical Model and Data for Horizontal Strain Estimates around Longwalls in Southern Newcastle Coal Field: Centreline Data	
	Ditton Geotechnical Services Pty Ltd		Scale:	NTS	Figure No: 10d



Proposed LW34

Approved LW25 - 32

Artefact Scatter or Individual Find

Open Camp Site

Scarred Tree

Grinding grooves

Water supply

Rock Shelters or Stone Arrangements

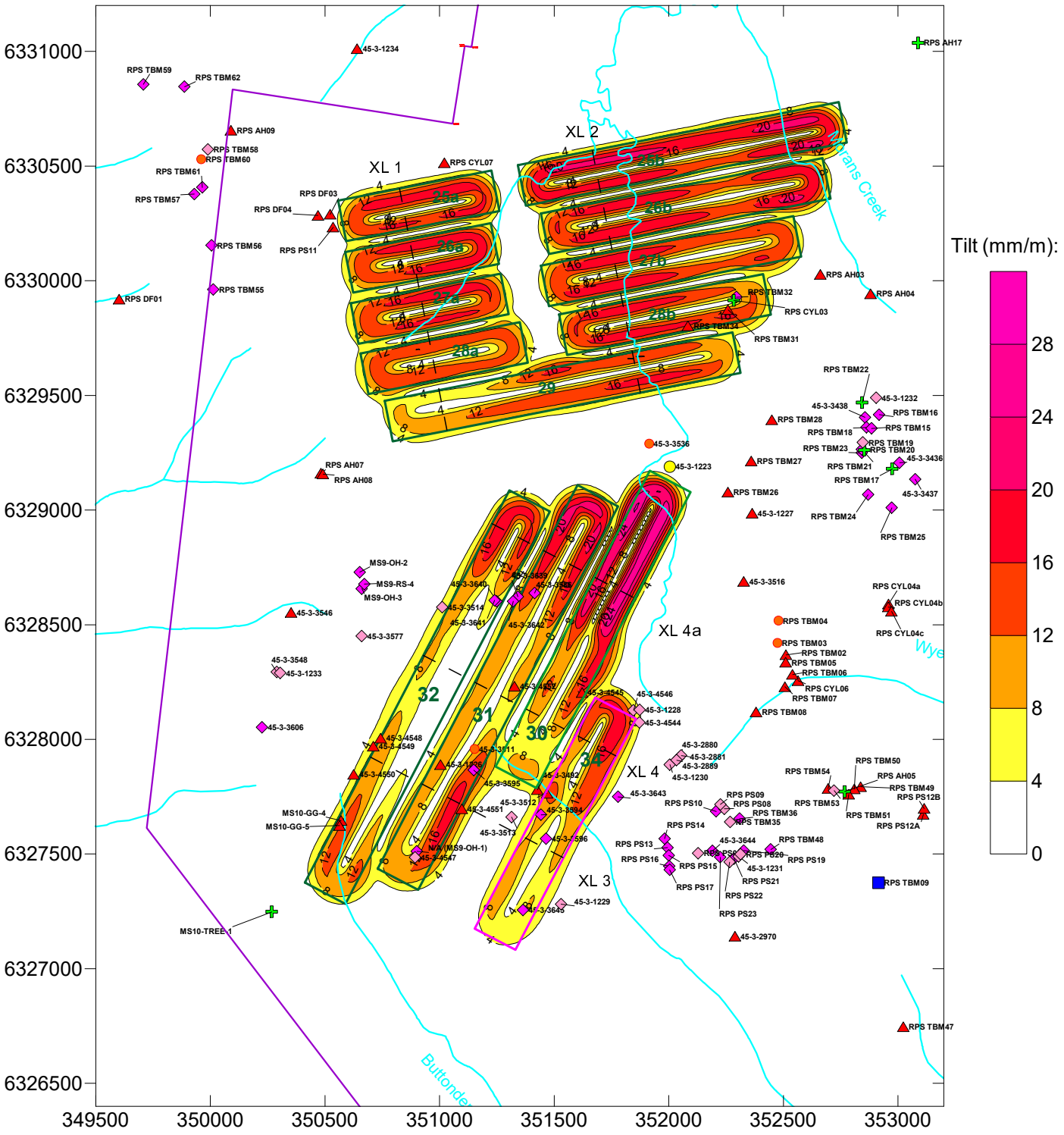
Rock Shelters with Art and/or PADs

Mining Lease Boundary

Creeks

Prediction Lines

DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-001/14	
	Drawn:	S.Ditton			
	Date:	16.06.21	Title:	Predicted U95%CL Subsidence Contours and Aboriginal Artefact Sites above Proposed Longwalls 30 to 32 & 34 at the Mandalong Mine	
Ditton Geotechnical Services Pty Ltd			Scale:	1:25,000 (A4)	Figure No: 11a



Proposed LW34

Approved LW25 - 32

Artefact Scatter or Individual Find

Open Camp Site

Scarred Tree

Grinding grooves

Water supply

Rock Shelters or Stone Arrangements

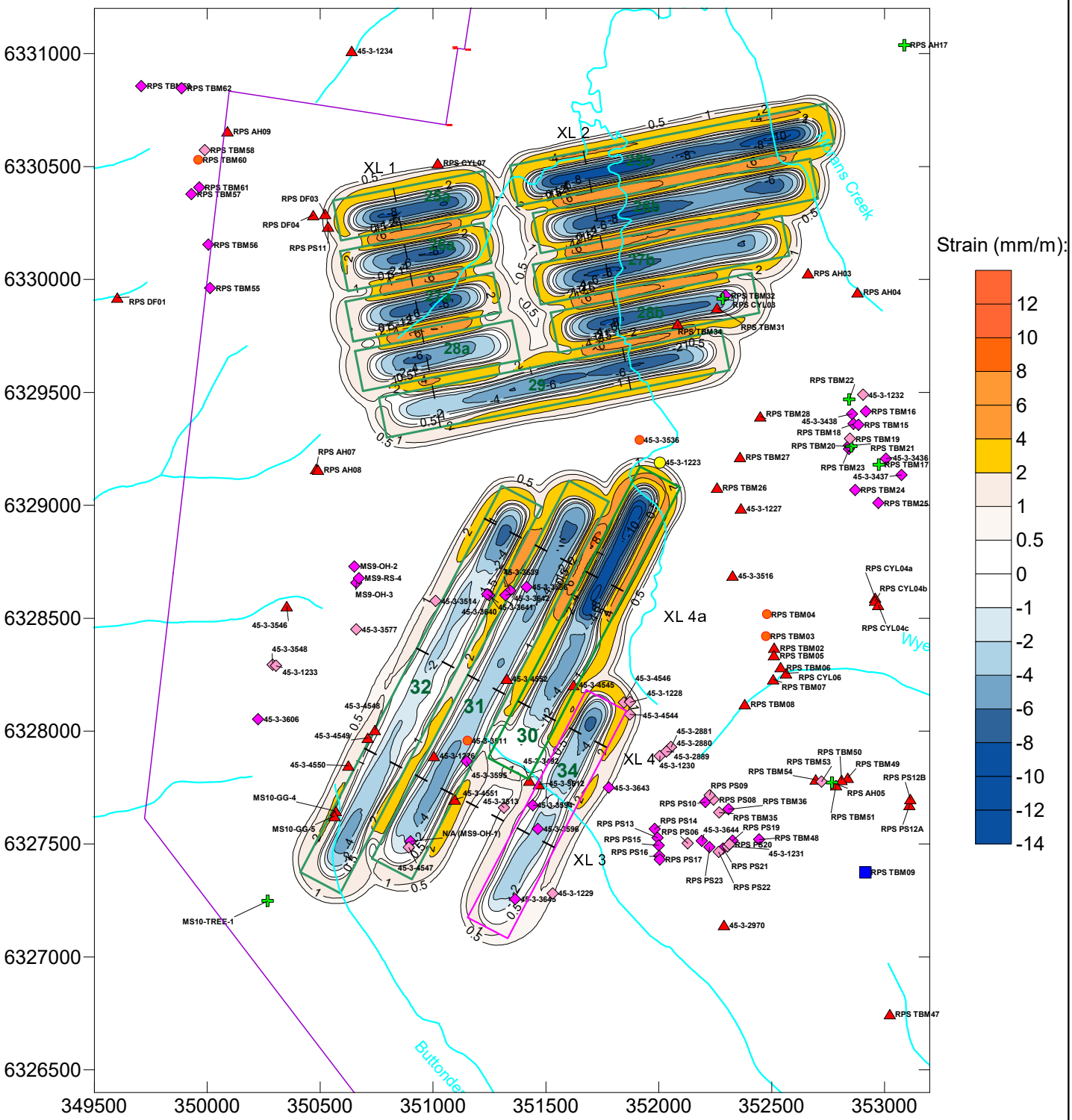
Rock Shelters with Art and/or PADs

Mining Lease Boundary

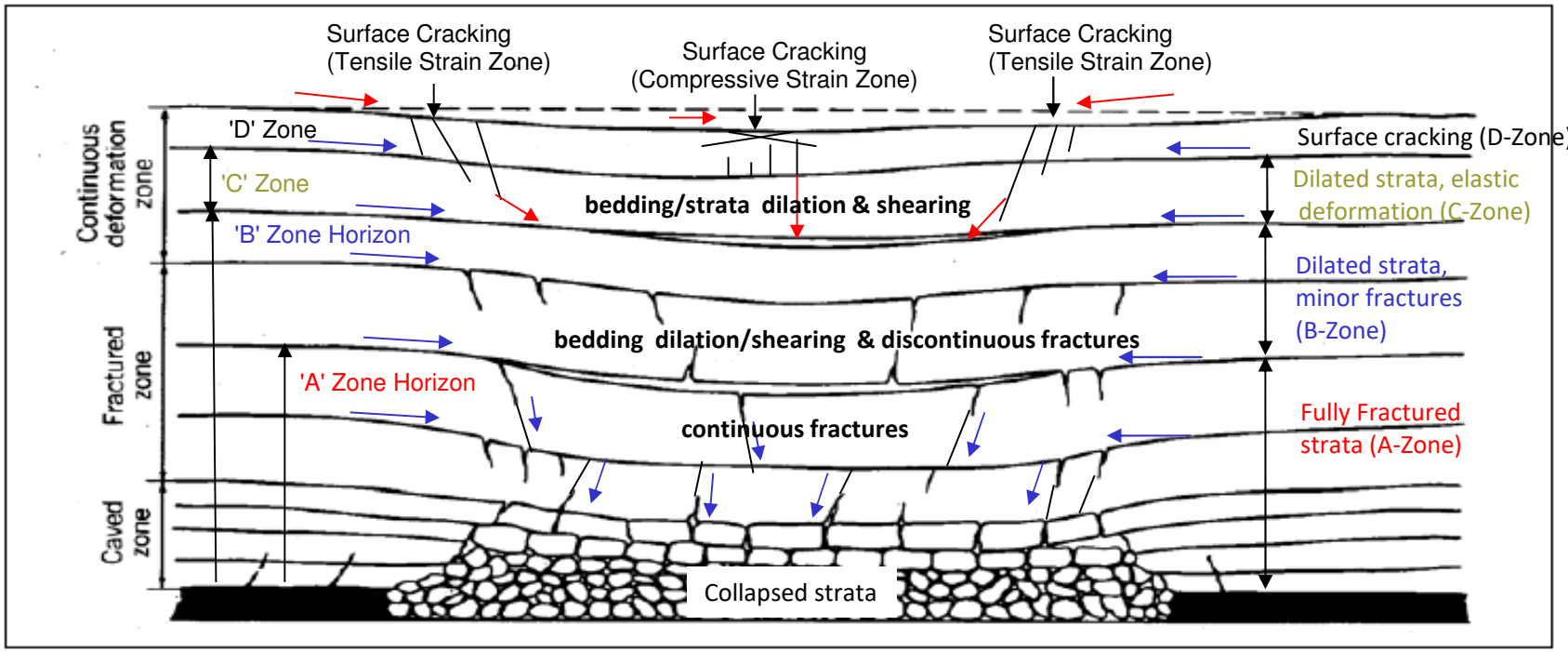
Creeks

Prediction Lines

DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-001/14	
	Drawn:	S.Ditton			
	Date:	01.09.20	Title:	Predicted U95%CL Tilt Contours and Aboriginal Artefact Sites above Proposed Longwalls 30 to 33 (Mod 10) in the Mandalong Southern Extension Area	
Ditton Geotechnical Services Pty Ltd			Scale:	1:25,000 (A4)	Figure No: 11b



DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-001/14	
	Drawn:	S.Ditton			
	Date:	15.06.21	Title:	Predicted U95%CL Horizontal Strain Contours & Aboriginal Artefact Sites above Proposed Longwalls 30 to 32 & 34 (Mod 10) at the Mandalong Mine	
Ditton Geotechnical Services Pty Ltd			Scale:	1:25,000 (A4)	Figure No: 11c



Zones in the Overburden According to Peng and Chiang (1984)

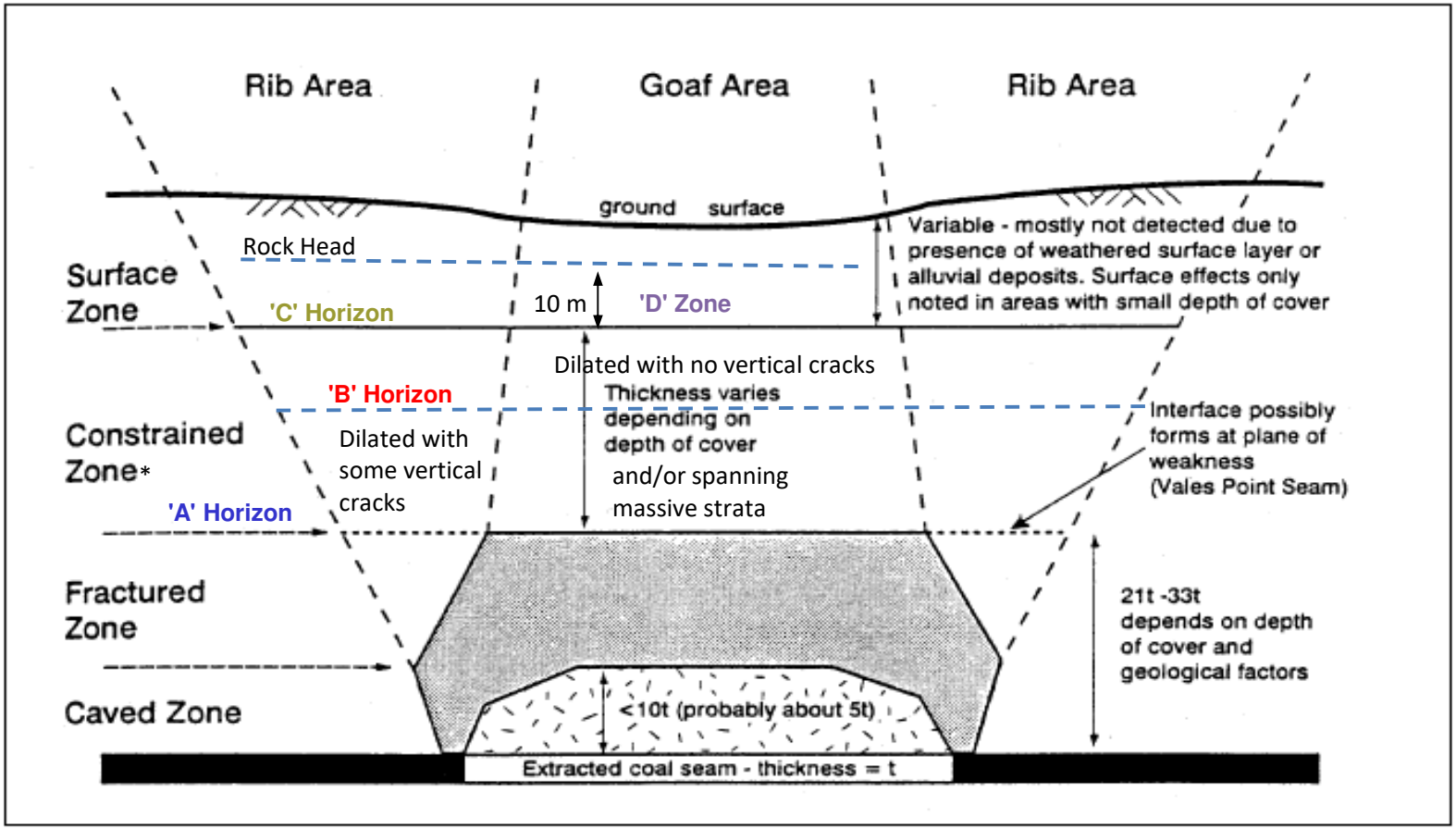
Key

'A' Horizon - Zone of Continuous Crack Connection to Workings (**Whittaker and Reddish,1989**)

'B" Horizon - Zone Of Discontinuous Crack Connection to Workings (**Whittaker and Reddish, 1989**)

→ Surface water flow path → Sub-surface water flow path

DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong MAN-001/14	
	Drawn:	S.Ditton			
	Date:	15.07.21	Title:	Schematic Model of Overburden Fracture Zones Above Longwall Panels	
	Ditton Geotechnical Services Pty Ltd		Scale:	NTS	Figure No: 12a



Zones in the Overburden according to Forster (1995)

* - Constrained Zone generally means B-Zone, but may include C-Zone , depending on W/H ratio and geology

DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong	
	Drawn:	S.Ditton		MAN-001/14	
	Date:	15.07.21	Title:	Schematic Model of Overburden Fracture Zones in **Forster, 1995** Model	
	Ditton Geotechnical Services Pty Ltd			(based on Piezometric Data Above High Extraction Panels in the Newcastle Coalfield)	
			Scale:	NTS	Figure No: 12b

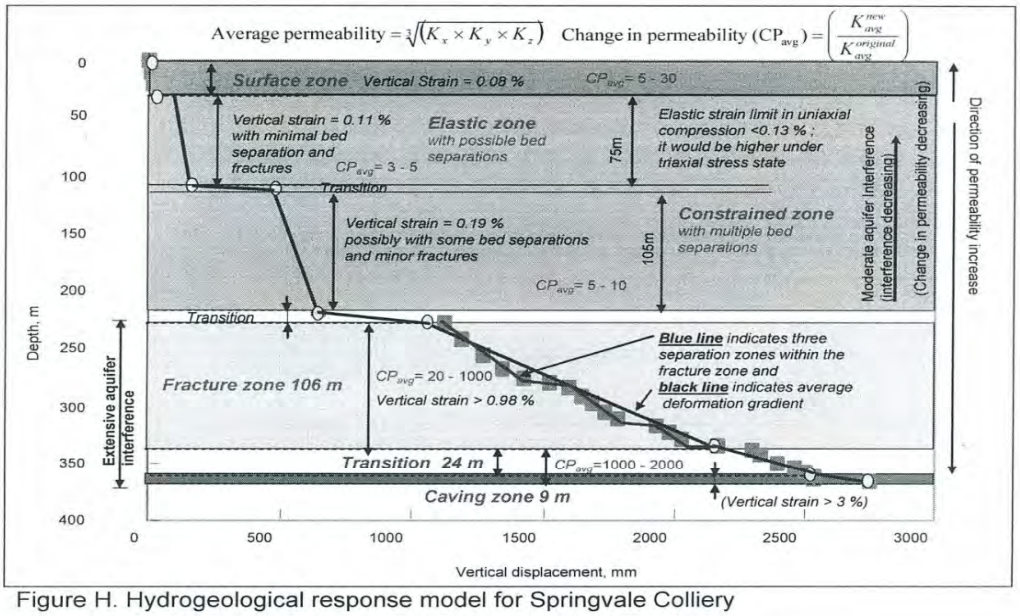


Figure H. Hydrogeological response model for Springvale Colliery

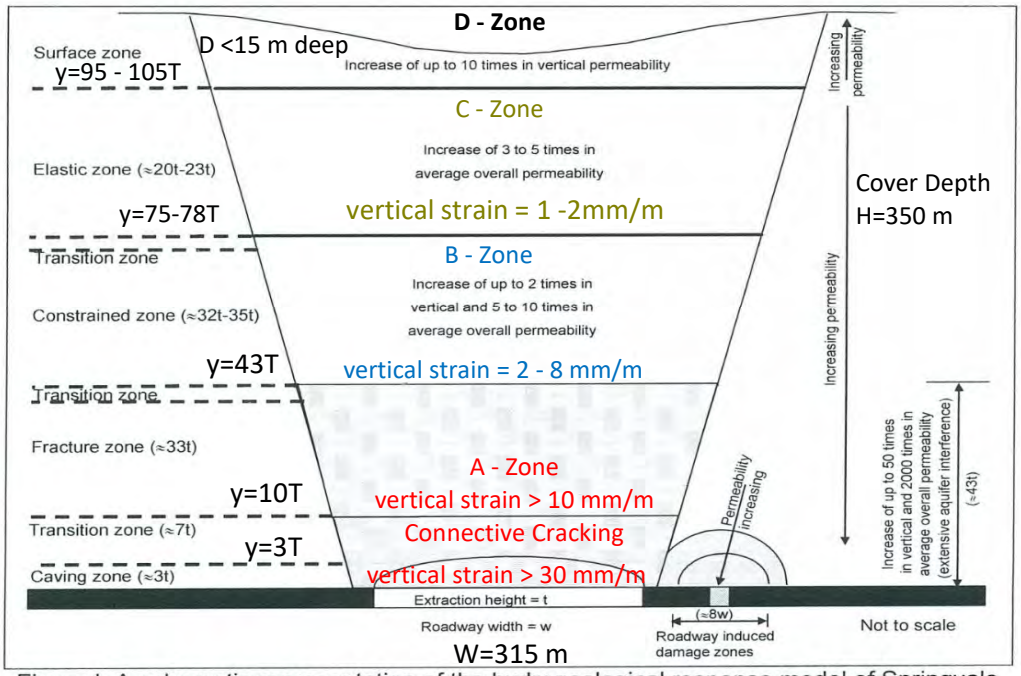
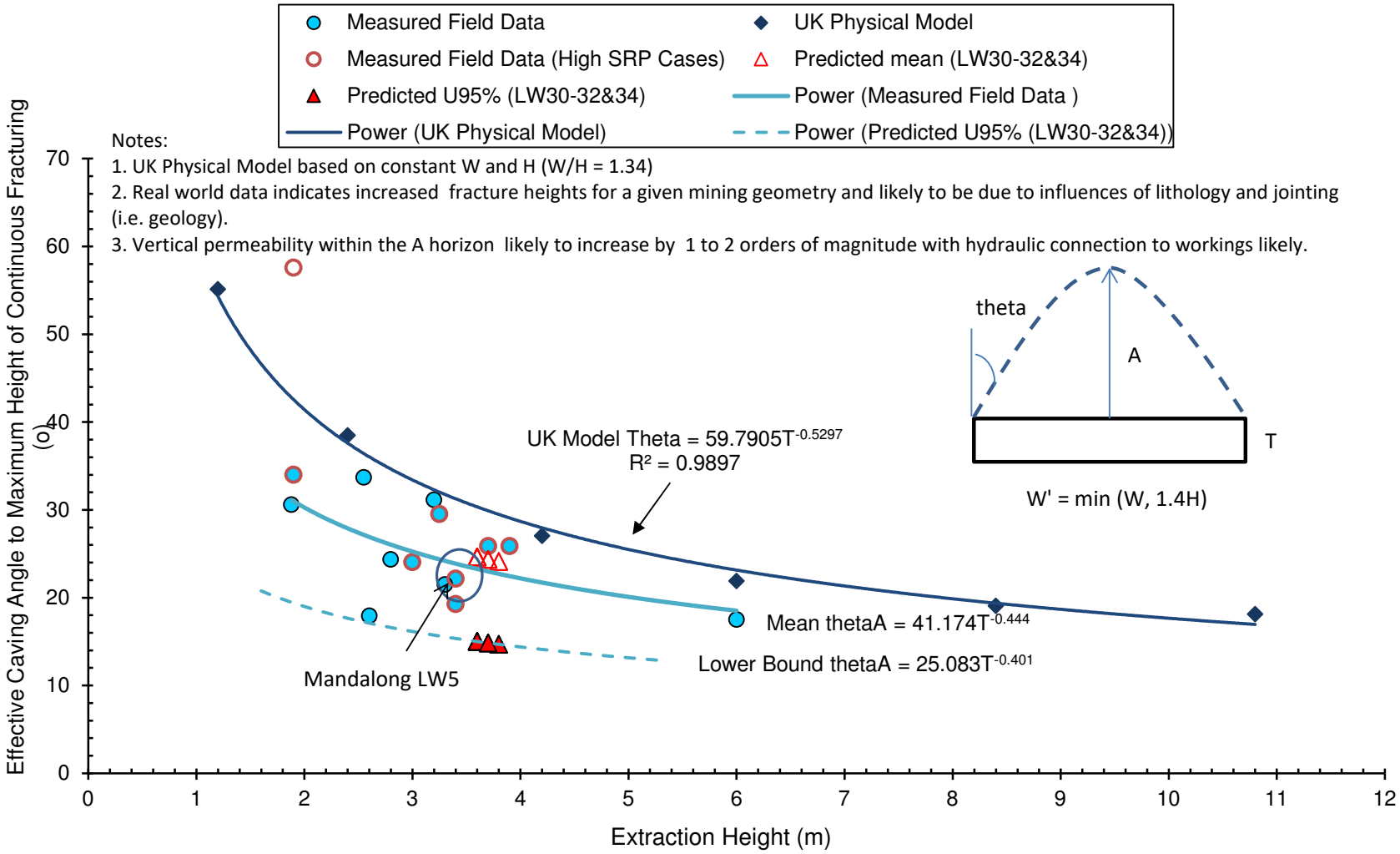
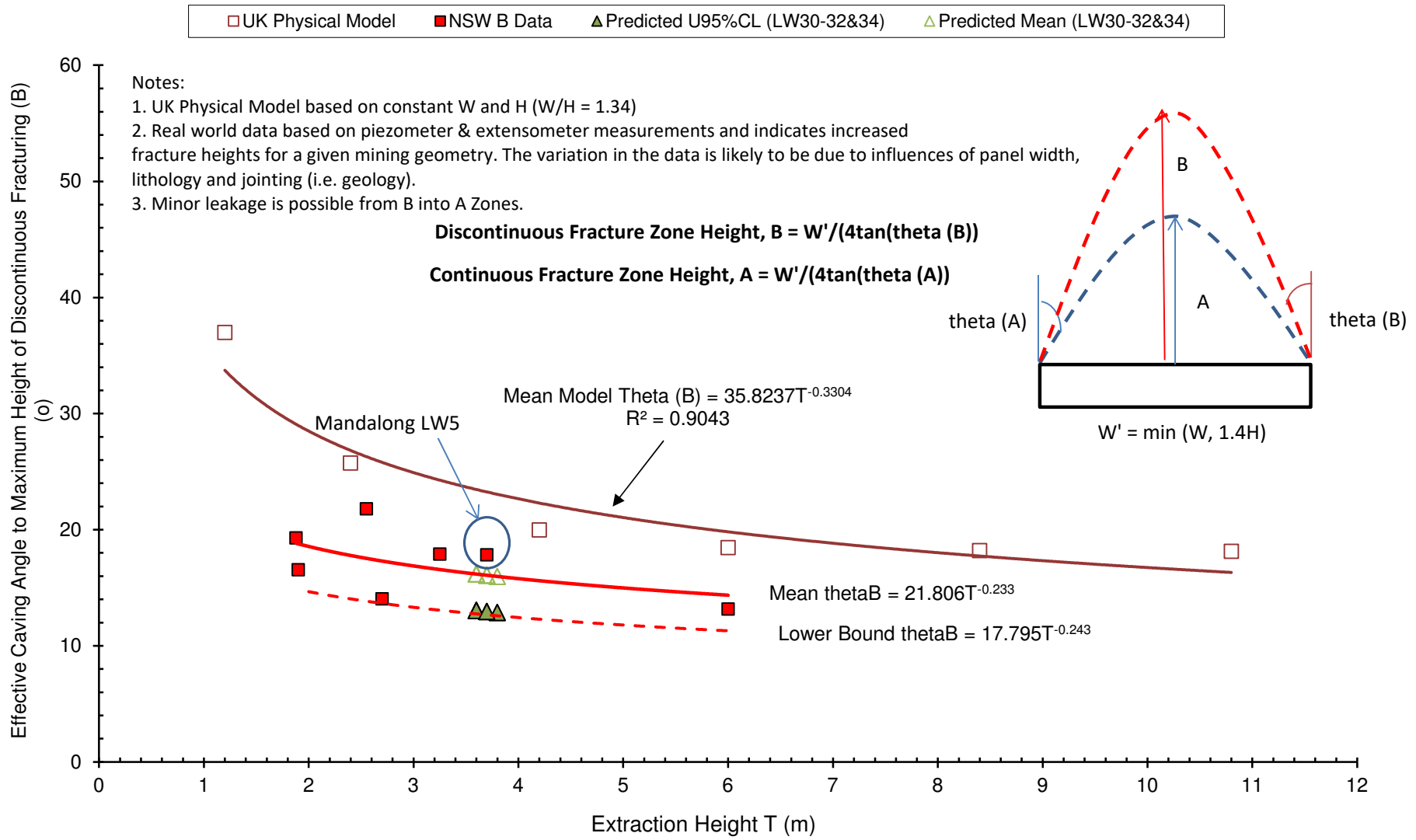


Figure I. A schematic representation of the hydrogeological response model of Springvale Colliery

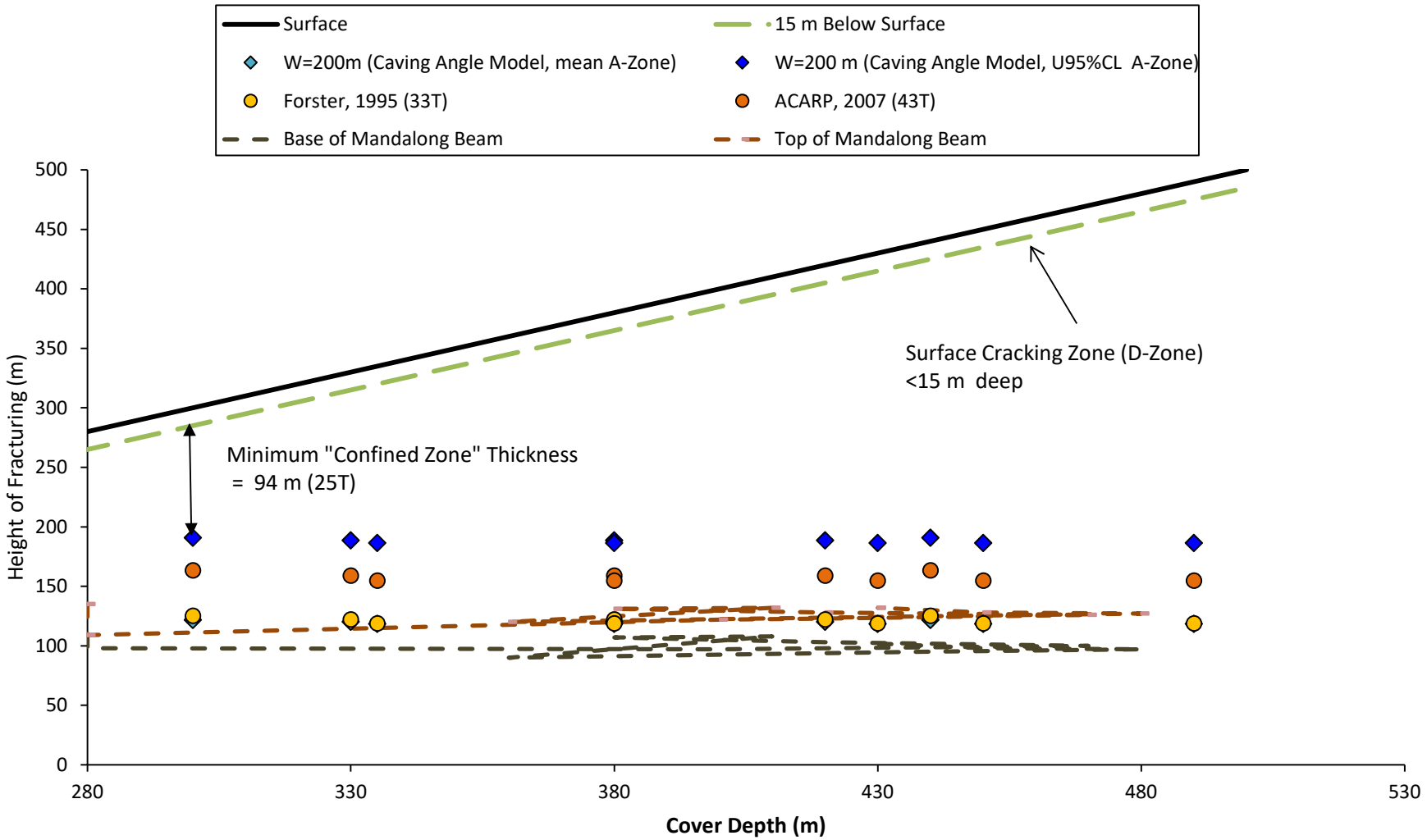
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong	
	Drawn:	S.Ditton		MAN-001/14	
	Date:	15.07.21	Title:	Schematic Model of Overburden Fracture Zones in **ACARP, 2007** Model	
	Ditton Geotechnical Services Pty Ltd		Scale:		Figure No: 12c



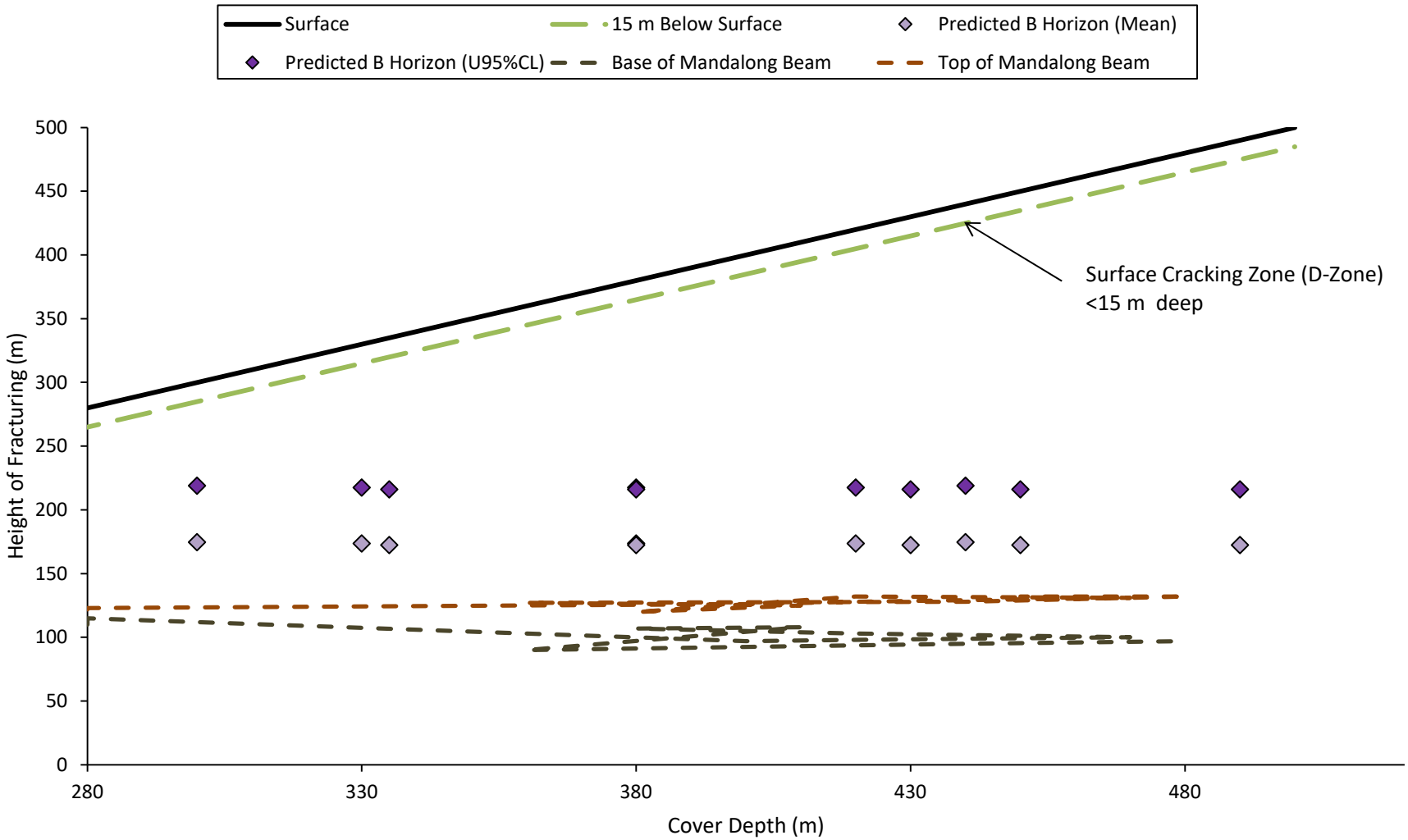
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong	
	Drawn:	S.Ditton		MAN-001/14	
	Date:	15.07.21	Title:	A-Zone Sub-Surface Fracture Height Prediction Model based on Caving Angles and Mining Heights (adapted from **Whittaker & Reddish, 1990**)	
	Ditton Geotechnical Services Pty Ltd		Scale:	NTS	Figure No: 13a



DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong	
	Drawn:	S.Ditton		MAN-001/14	
	Date:	15.07.21	Title:	B-Zone Sub-Surface Fracture Height Prediction Model based on Caving Angles and Mining Heights (adapted from **Whittaker & Reddish, 1990**)	
	Ditton Geotechnical Services Pty Ltd		Scale:	NTS	Figure No: 13b

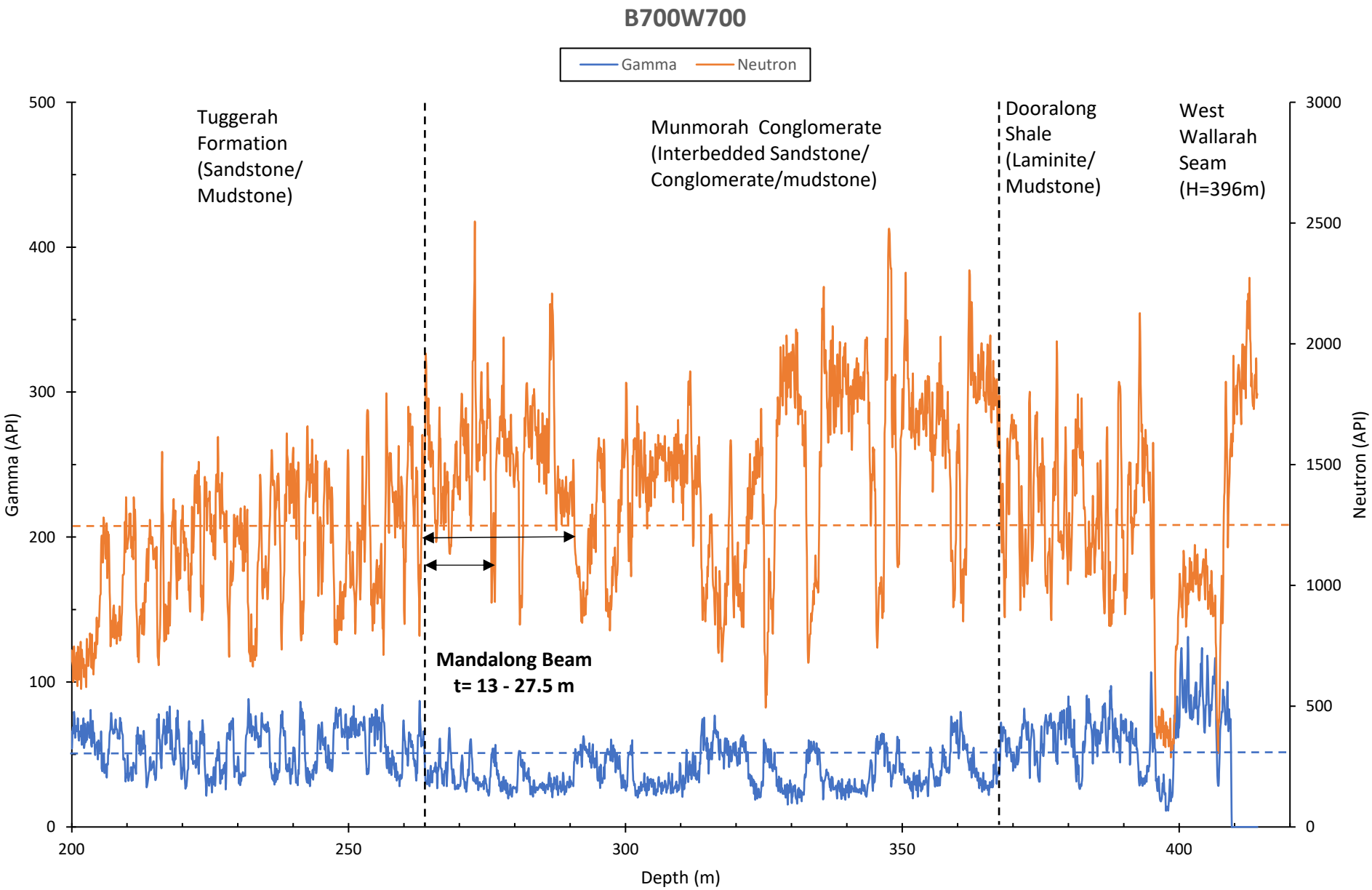


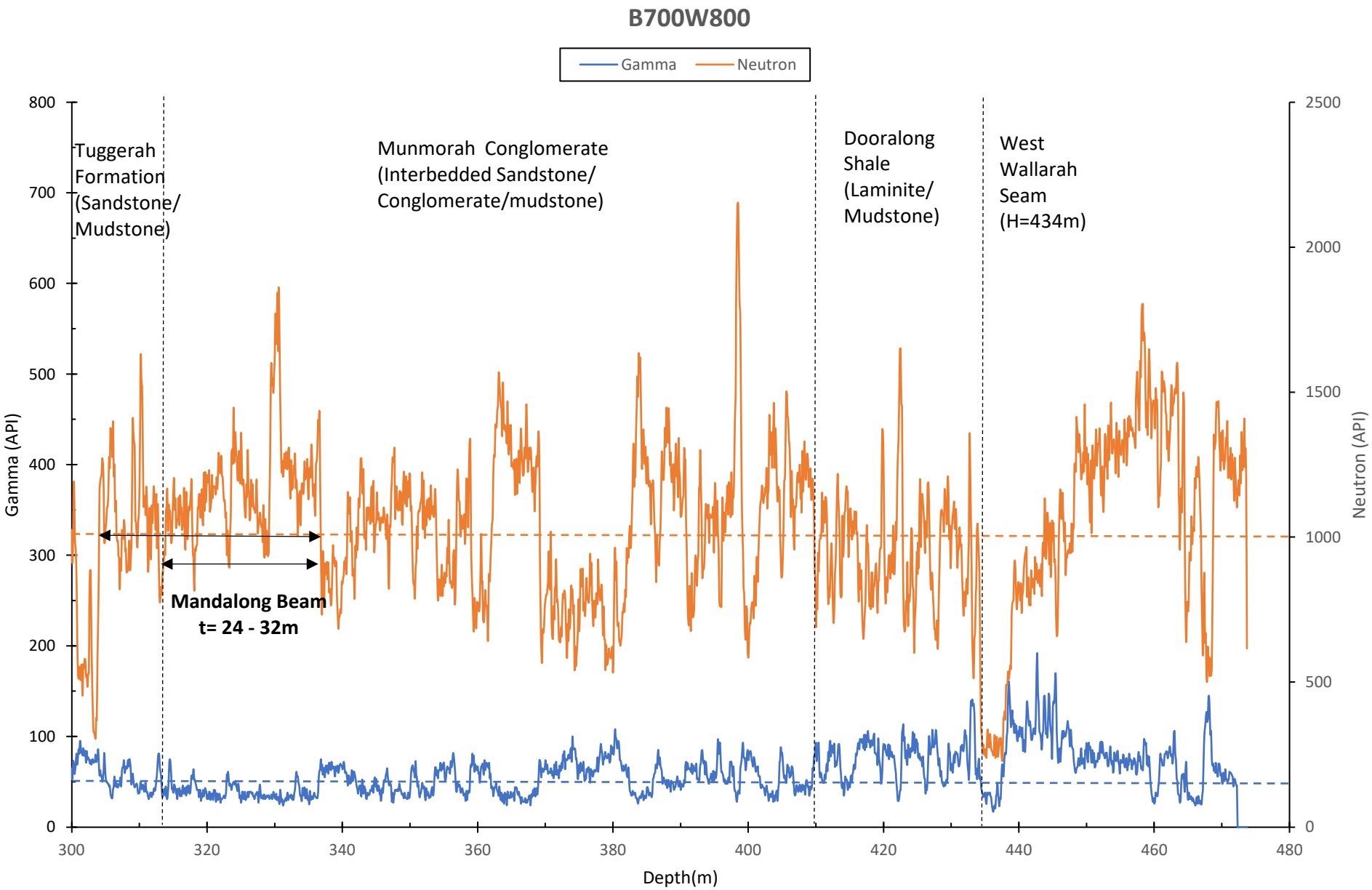
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong	
	Drawn:	S.Ditton		MAN-001/14	
	Date:	15.07.21	Title:	Continuous Sub-Surface Fracture Heights and Confined Zone Thickness above the Proposed 200 m Wide LWs 30 to 32 & 34 at the Mandalong Mine	
	Ditton Geotechnical Services Pty Ltd		Scale:	NTS	Figure No: 14a

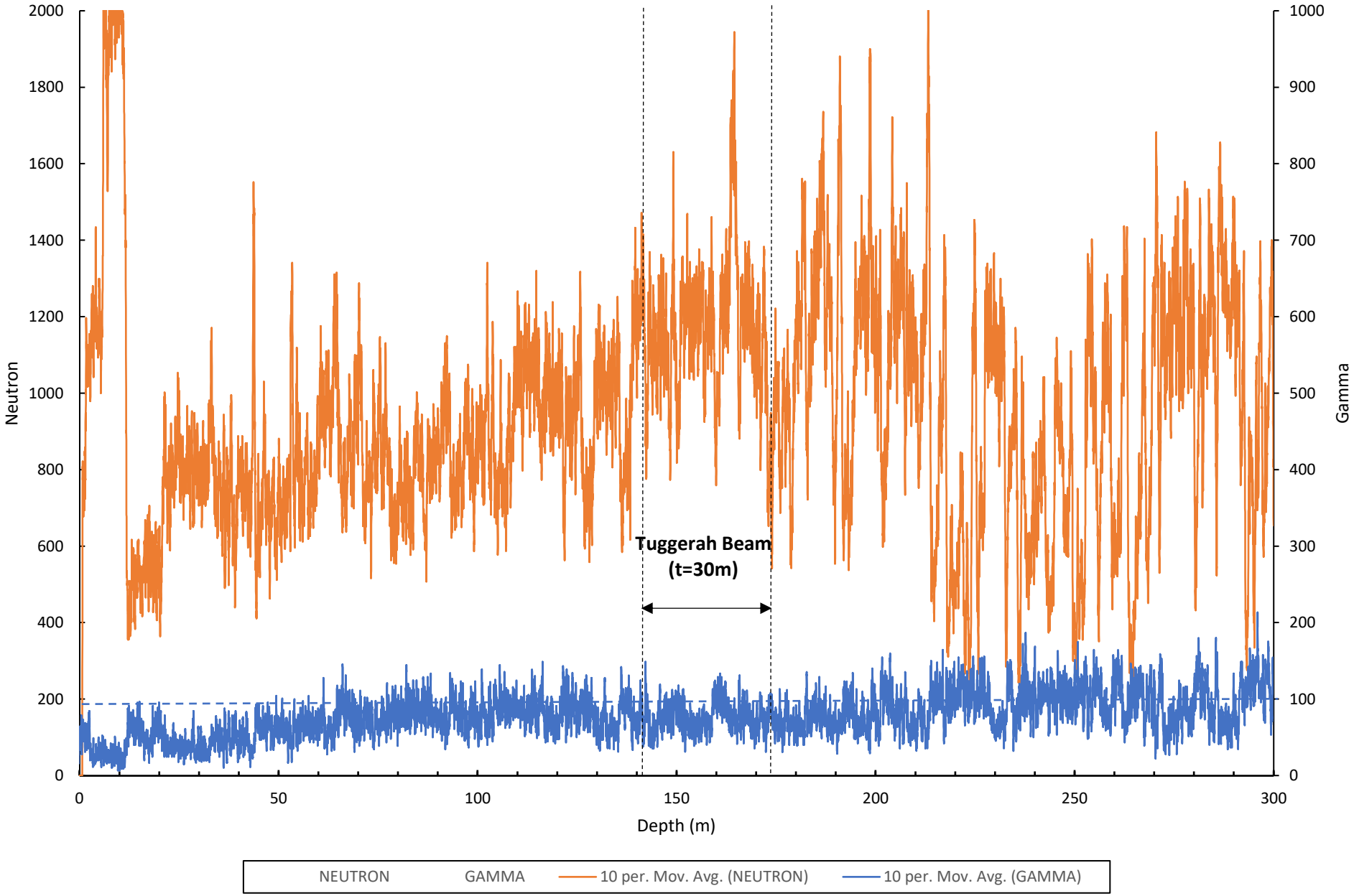


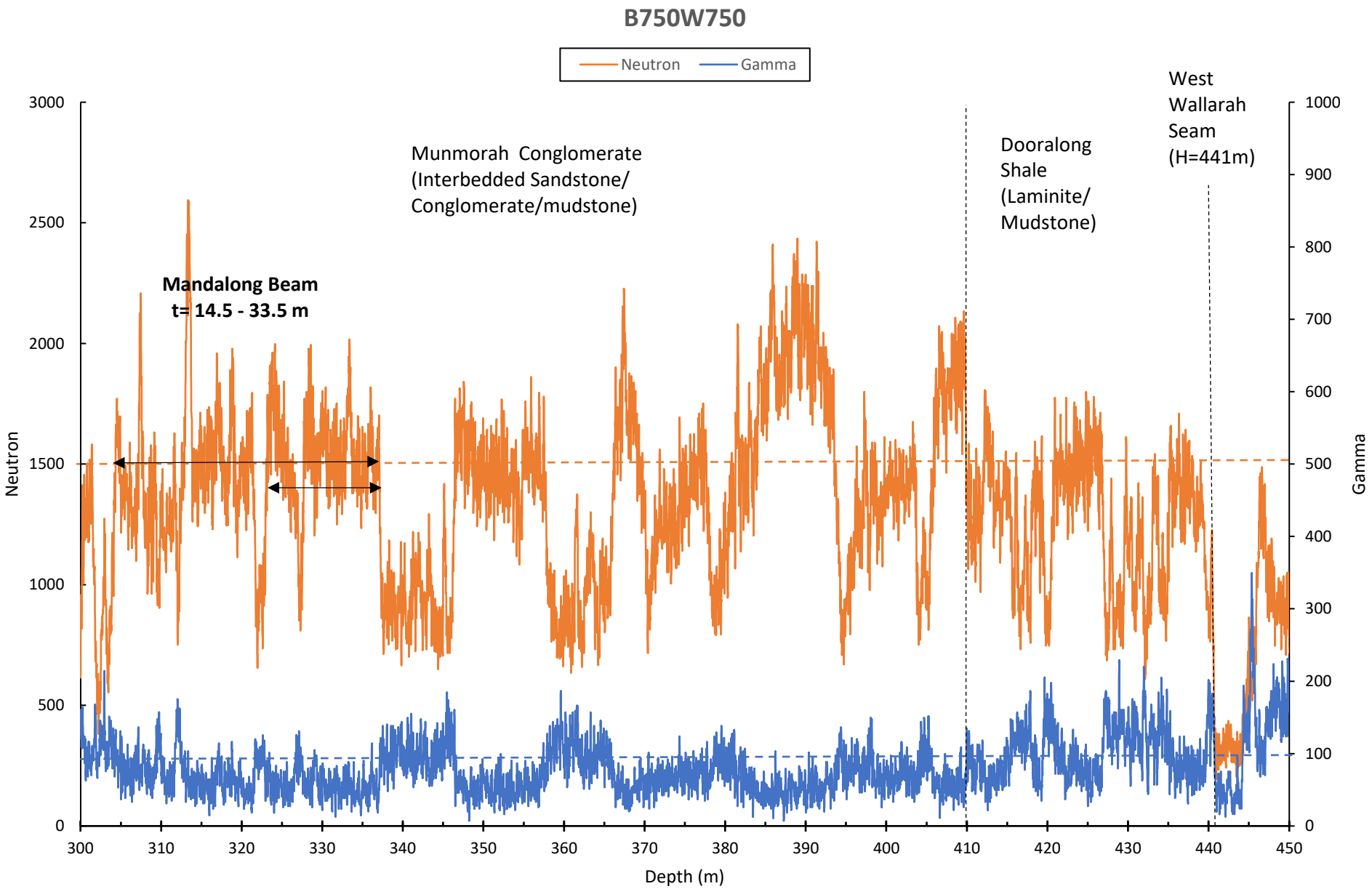
DgS	Engineer:	S.Ditton	Client:	Centennial Mandalong	
	Drawn:	S.Ditton		MAN-001/14	
	Date:	15.07.21	Title:	Discontinuous Sub-Surface Fracture Heights (B-Zone) above the Proposed 200 m Wide LW30 to 32 & 34 at the Mandalong Mine	
	Ditton Geotechnical Services Pty Ltd		Scale:	NTS	Figure No: 14b

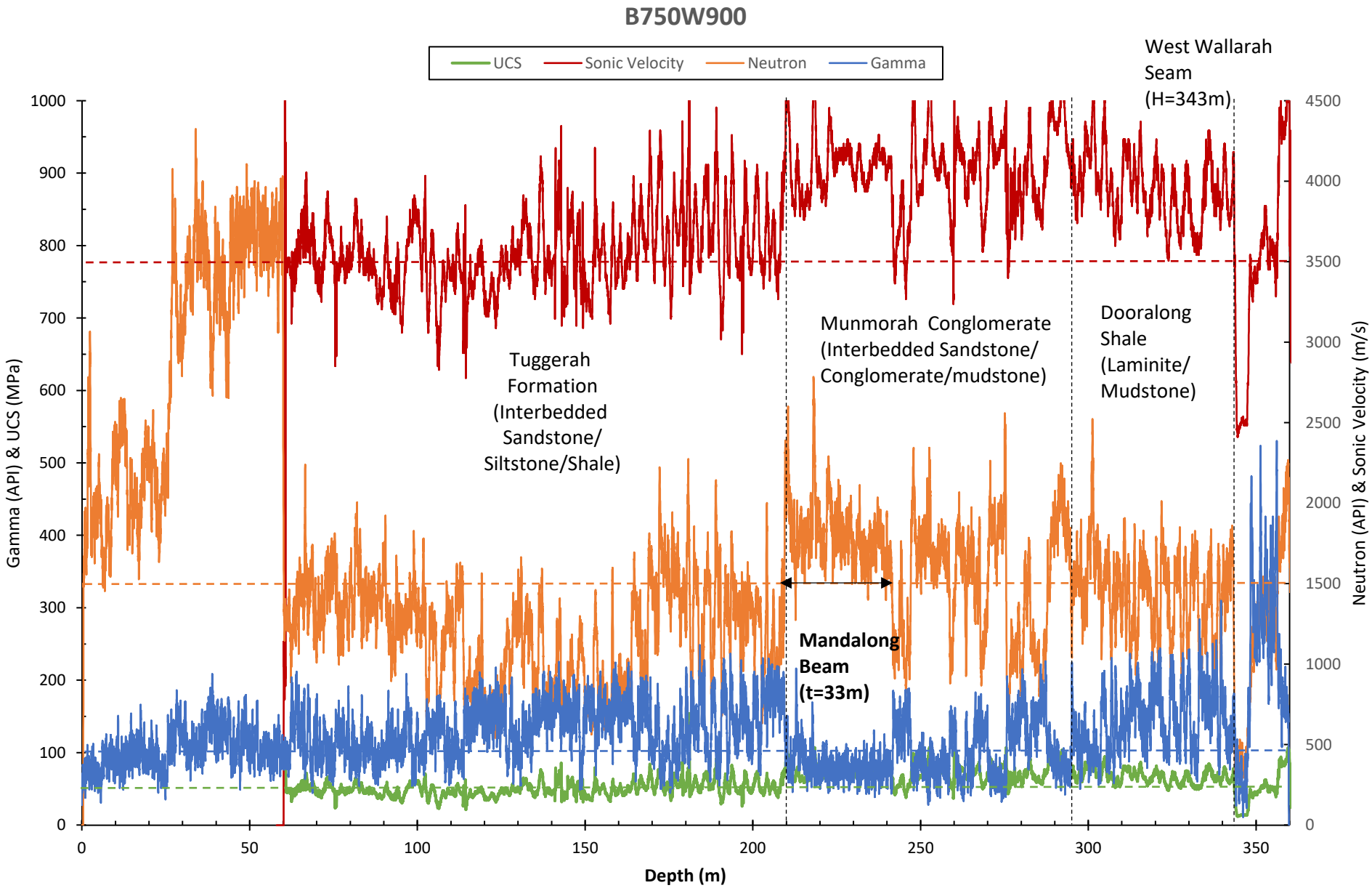
Appendix A - Mandalong Beam Thickness Review Summary

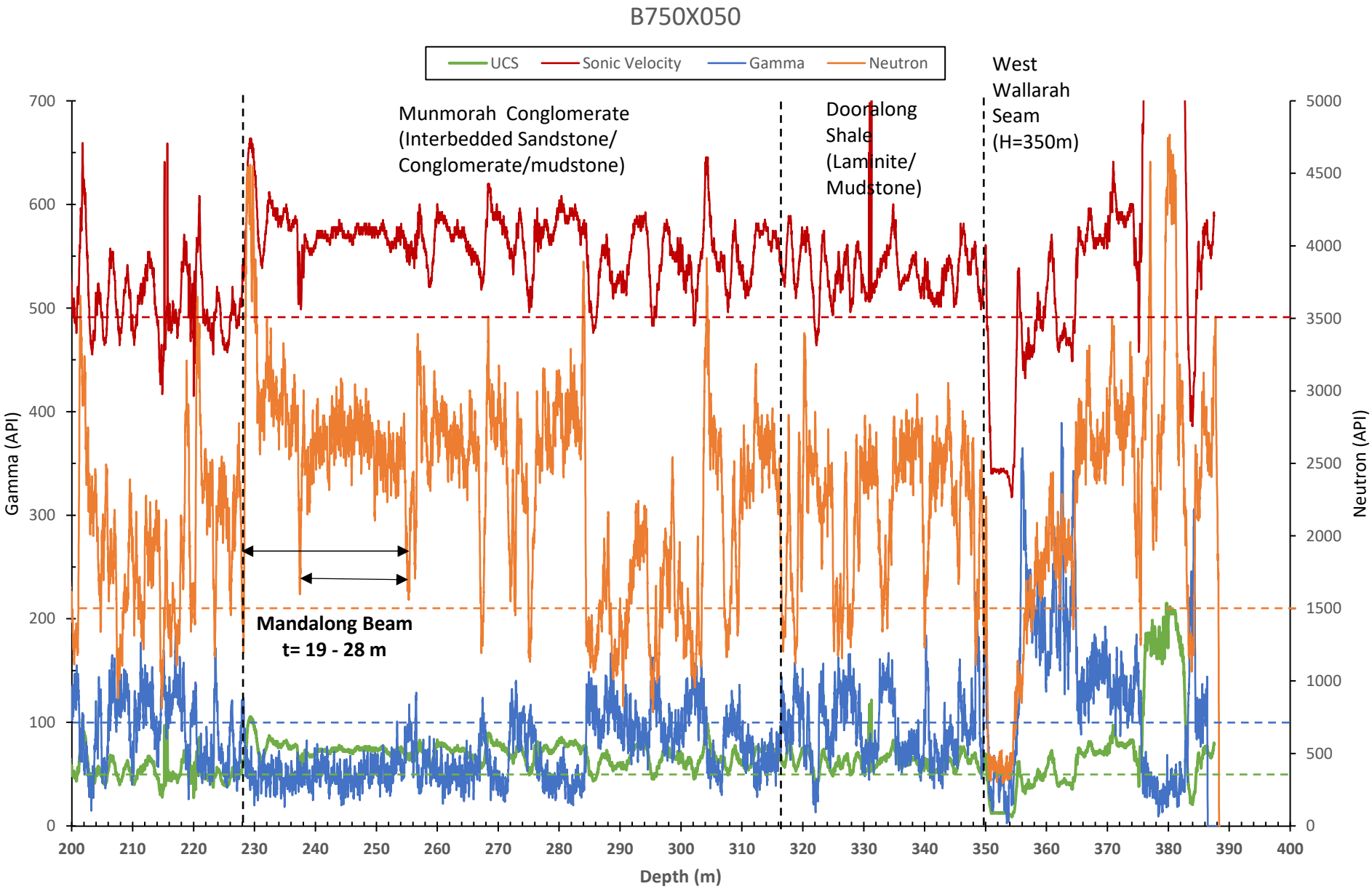

B700W700
Gamma
Neutron
Tuggerah Formation (Sandstone/ Mudstone)
Munmorah Conglomerate (Interbedded Sandstone/ Conglomerate/mudstone)
Dooralong Shale (Laminite/ Mudstone)
West Wallarah Seam (H=396m)
Mandalong Beam
t= 13 - 27.5 m
Gamma (API)
Neutron (API)
Depth (m)
0
100
200
300
400
500
0
500
1000
1500
2000
2500
3000
200
250
300
350
400

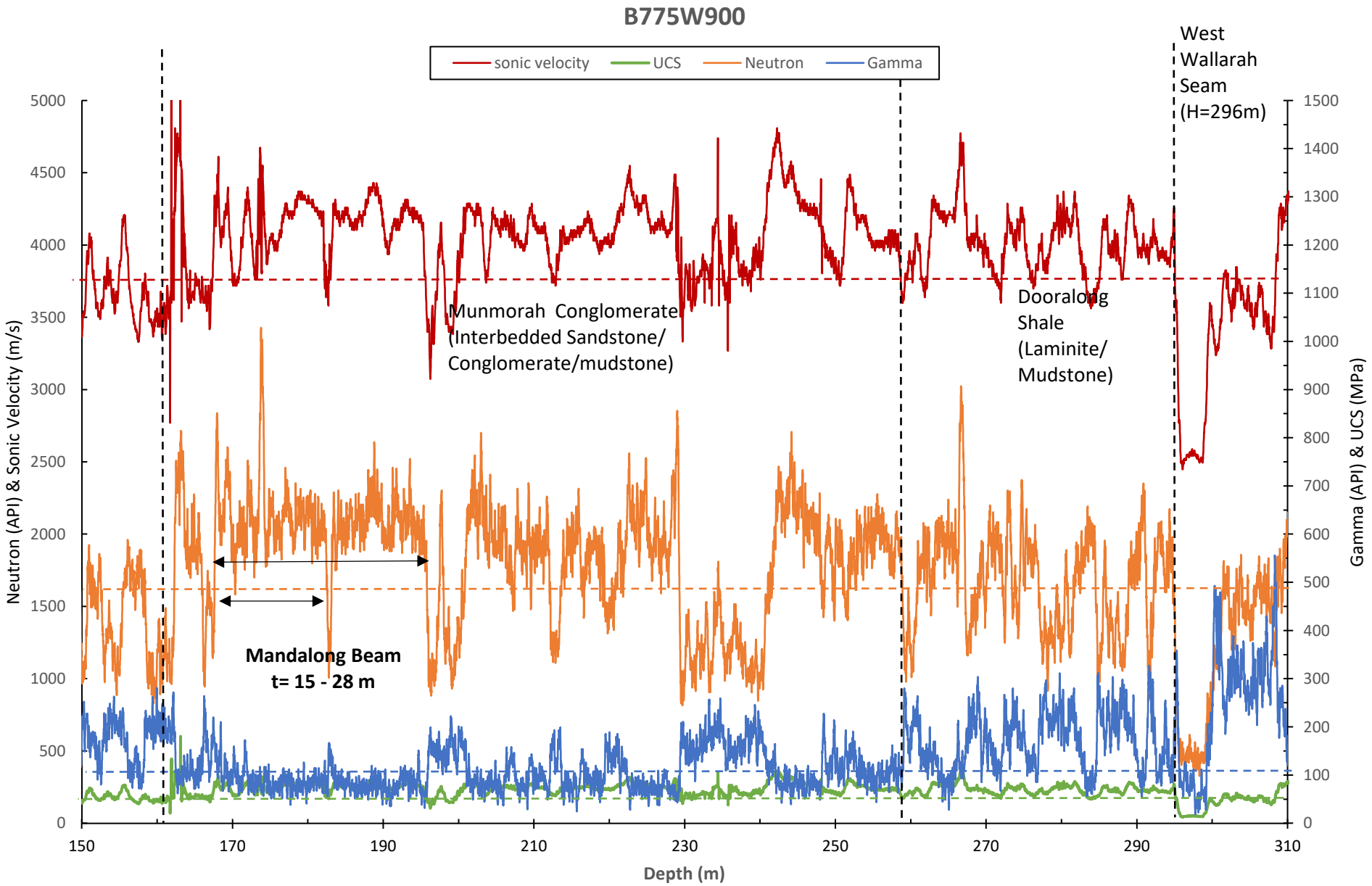

B700W800
Gamma
Neutron
Tuggerah Formation (Sandstone/ Mudstone)
Munmorah Conglomerate (Interbedded Sandstone/ Conglomerate/mudstone)
Dooralong Shale (Laminite/ Mudstone)
West Wallarah Seam (H=434m)
Mandalong Beam t= 24 - 32m
Gamma (API)
Neutron (API)
Depth(m)
800
700
600
500
400
300
200
100
0
2500
2000
1500
1000
500
0
300
320
340
360
380
400
420
440
460
480

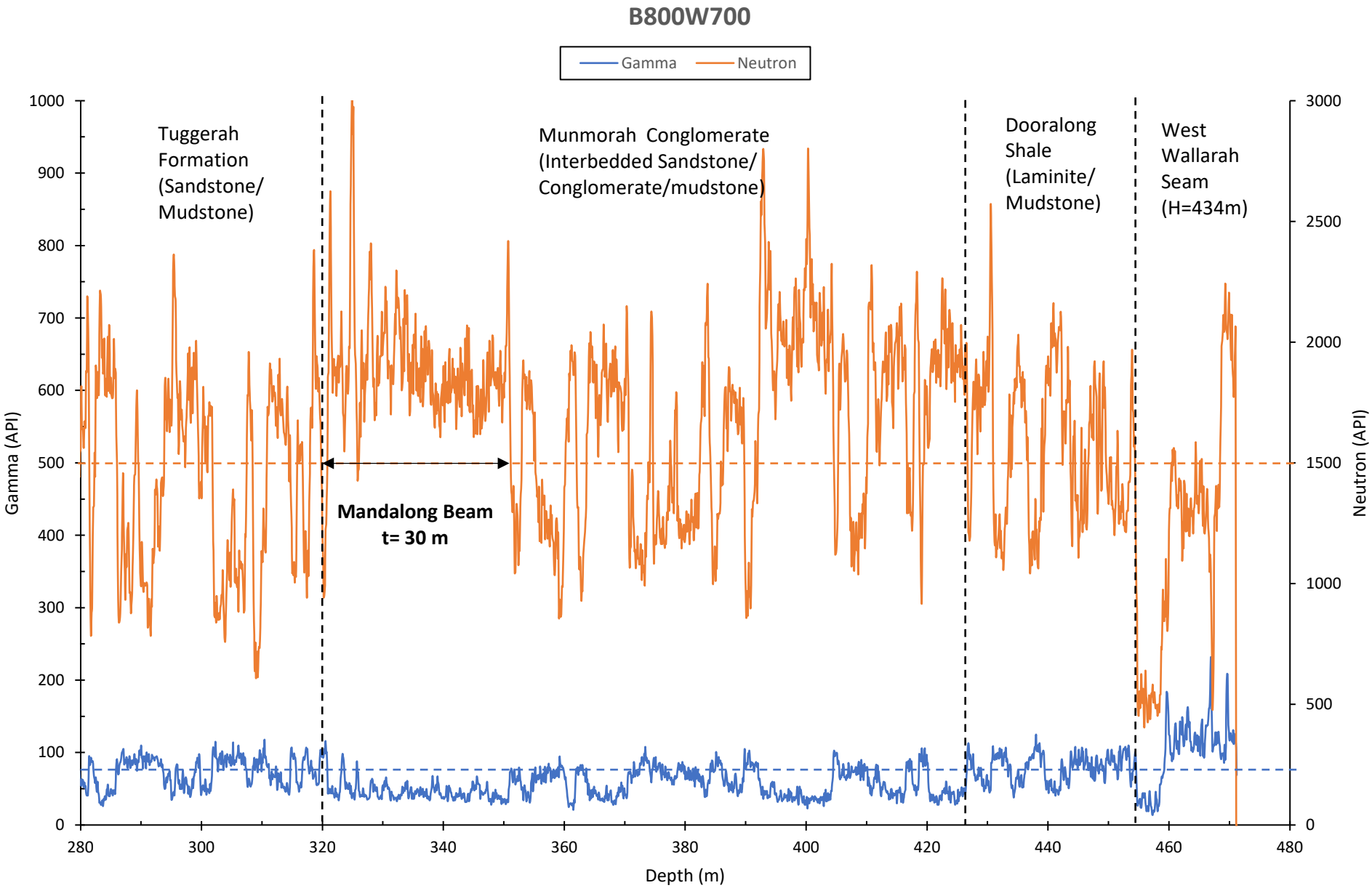

Neutron
Gamma
Depth (m)
Tuggerah Beam
(t=30m)
NEUTRON
GAMMA
10 per. Mov. Avg. (NEUTRON)
10 per. Mov. Avg. (GAMMA)


B750W750
Neutron
Gamma
Munmorah Conglomerate
(Interbedded Sandstone/
Conglomerate/mudstone)
Dooralong
Shale
(Laminite/
Mudstone)
West
Wallarah
Seam
(H=441m)
Mandalong Beam
t= 14.5 - 33.5 m
Neutron
Gamma
Depth (m)
3000
2500
2000
1500
1000
500
0
1000
900
800
700
600
500
400
300
200
100
0
300
310
320
330
340
350
360
370
380
390
400
410
420
430
440
450


B750W900
UCS
Sonic Velocity
Neutron
Gamma
West Wallarah Seam (H=343m)
Tuggerah Formation (Interbedded Sandstone/ Siltstone/Shale)
Munmorah Conglomerate (Interbedded Sandstone/ Conglomerate/mudstone)
Dooralong Shale (Laminite/ Mudstone)
Mandalong Beam (t=33m)
Gamma (API) & UCS (MPa)
Neutron (API) & Sonic Velocity (m/s)
Depth (m)
0
50
100
150
200
250
300
350
100
200
300
400
500
600
700
800
900
1000
500
1000
1500
2000
2500
3000
3500
4000
4500


B750X050
UCS
Sonic Velocity
Gamma
Neutron
Munmorah Conglomerate
(Interbedded Sandstone/
Conglomerate/mudstone)
Dooralong
Shale
(Laminite/
Mudstone)
West
Wallarah
Seam
(H=350m)
Mandalong Beam
t= 19 - 28 m
Gamma (API)
Neutron (API)
Depth (m)
0
100
200
300
400
500
600
700
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
200
210
220
230
240
250
260
270
280
290
300
310
320
330
340
350
360
370
380
390
400


B775W900
sonic velocity
UCS
Neutron
Gamma
West Wallarah Seam (H=296m)
Munmorah Conglomerate (Interbedded Sandstone/ Conglomerate/mudstone)
Dooralong Shale (Laminite/ Mudstone)
Mandalong Beam t= 15 - 28 m
Neutron (API) & Sonic Velocity (m/s)
Gamma (API) & UCS (MPa)
Depth (m)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
150
170
190
210
230
250
270
290
310


B800W700
Gamma
Neutron
Tuggerah Formation (Sandstone/ Mudstone)
Munmorah Conglomerate (Interbedded Sandstone/ Conglomerate/mudstone)
Dooralong Shale (Laminite/ Mudstone)
West Wallarah Seam (H=434m)
Mandalong Beam t= 30 m
Gamma (API)
Neutron (API)
Depth (m)
1000
900
800
700
600
500
400
300
200
100
0
3000
2500
2000
1500
1000
500
0
280
300
320
340
360
380
400
420
440
460
480

Coal Operations Australia Limited
Wyong Areas Coal Joint Venture

Hole Name : B800W800 Easting : 337771.100 m
Total Depth : 492.200 m
Project : Northing : 1328020.600 m
Cased to : 0.000 m
The Wyong Areas Coal Joint Venture Collar RL : 192.800 m
Standing W.L. : 0.000 m

Depth of Weath : 0.000 m
Parish : Sonic Log : Sonic
Portion : Caliper : Caliper
Hole Type : Cored Resistivity : Resistivity
Diameter : HQ Long Space Dens. : Long Spaced Density
Logged by : P.DOYLE Short Spaced Dens. : Short Spaced Density
Geomechanically Logged Dipmeter : Dip
Core Photographed Neutron : Neutron
Drilled by : Paterick & Zeija Natural Gamma : Natural Gamma
Commenced : 140998 Gamma Gamma : N
Completed : 091098

Lithology	Description	Thick (m)	Depth (m)	Recov Thick	Strat Ply	WS No.	Sample	Discontinuities	Remarks
CLAY	Lightbrown, very soft, Unconsolidated. Drilling commenced 14/09/98. Logged by Peter Doyle.	1.900	1.900	0.000	TER	30			
SANDSTONE	brown, coarse to very coarse grai-ned, moderately hard, weathered. Depth adjusted by -0.1m to agree with geophysics.	10.000	11.900	0.000	TER	30			
SANDSTONE	Lightbrown, medium to coarse grained, moderately hard, weathered.	2.000	13.900	0.000	TER	30			
CONGLOMERATE	Lightbrown,	4.000	17.900	0.000	TER	20			

		pebble sized clasts, moderately hard, weathered.						
SANDSTONE		Lightbrown, medium grained, moderately hard, weathered.	2.000	19.900	0.000	TER	20	
MUDSTONE		Darkbrown, sandy, moderately hard, weathered.	4.000	23.900	0.000	TER	20	
SANDSTONE		brown, medium to coarse grained, moderately hard, weathered.	4.000	27.900	0.000	TER	20	
CONGLOMERATE		brown, pebble sized clasts, moderately hard, weathered.	2.000	29.900	0.000	TER	20	
SANDSTONE			3.800	33.700	0.000	TER	20	
SANDSTONE		brown, coarse to very coarse grained, moderately hard, weathered.	2.200	35.900	0.000	TER	10	
SANDSTONE		brown, medium grained, moderately hard, weathered.	4.000	39.900	0.000	TER	10	
SANDSTONE		brown, fine to medium grained, hard, weathered.	8.000	47.900	0.000	PAT	70	
SANDSTONE		brown, medium to coarse grained, hard, weathered.	2.000	49.900	0.000	PAT	70	
SANDSTONE			0.900	50.800	0.000	PAT	70	
SANDSTONE		brown, fine to medium grained, hard, weathered.	5.099	55.899	0.000	PAT	60	
Depth of Weathering			0.001	55.900	0.000	PAT	60	
		Base of weathering at approx. 56.000m.						
SHALE	50%		3.700	59.600	0.000	PAT	60	
SANDSTONE	50%							
			3.700	59.600	0.000			

Lithology		Description	Thick (m)	Depth (m)	Recov Thick	Strat	WS Sample No.	Discontinuities	Remarks
SHALE	50%	green-grey,	2.300	61.900	0.000	PAT	50		

		moderately hard,					
SANDSTONE	50%	grey, medium grained, hard,					
			2.300	61.900	0.000		
SHALE	50%	grey, moderately hard,	4.000	65.900	0.000	PAT	50
SANDSTONE	50%	brown, medium grained, hard,					
			4.000	65.900	0.000		
		Preferentially weathered along joint planes.					
MUDSTONE		Mottledbrown, moderately hard,	8.000	73.900	0.000	PAT	50
SILTSTONE		Darkgrey, moderately hard,	2.000	75.900	0.000	PAT	50
SANDSTONE		Darkgrey, fine to very fine grained, hard,	4.000	79.900	0.000	PAT	40
SILTSTONE		Darkgrey, moderately hard,	2.000	81.900	0.000	PAT	40
MUDSTONE		Mottledbrown, moderately hard,	4.000	85.900	0.000	PAT	40
SHALE		grey, sandy, moderately hard,	2.000	87.900	0.000	PAT	40
MUDSTONE			8.400	96.300	0.000	PAT	40
MUDSTONE		Mottledbrown, moderately hard, Occasional sandy phases.	5.600	101.900	0.000	PAT	30
SHALE		Darkgrey, sandy, moderately hard,	4.000	105.900	0.000	PAT	30
MUDSTONE			4.970	110.870	0.000	PAT	30
MUDSTONE		Darkbrown, moderately hard,	9.030	119.900	0.000	PAT	20
MUDSTONE		Mottledbrown, moderately hard,	4.000	123.900	0.000	PAT	20
MUDSTONE		Mottledbrown, moderately hard,	4.000	127.900	0.000	PAT	20
SHALE			2.310	130.210	0.000	PAT	20
SHALE		grey, moderately hard,	9.690	139.900	0.000	PAT	10
MUDSTONE	50%	Mottledred, moderately hard,	8.000	147.900	0.000	UGG	94
SANDSTONE	50%	grey, fine to very fine grained, hard,					
			8.000	147.900	0.000		
SANDSTONE		grey, fine to medium grained, hard,	6.000	153.900	0.000	UGG	93
SHALE		Mottledred, moderately hard,	2.000	155.900	0.000	UGG	92

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Lithology		Description	Thick (m)	Depth (m)	Recov Thick	Strat	WS Sample No.	Discontinuities	Remarks
SANDSTONE		grey, fine to very fine grained, hard,	4.000	159.900	0.000	UGG	92		
MUDSTONE	50%		4.650	164.550	0.000	UGG	92		
SANDSTONE	50%								
			4.650	164.550	0.000				
MUDSTONE	50%	Mottledred, moderately hard,	5.350	169.900	0.000	UGG	91		
SANDSTONE	50%	grey, fine to very fine grained, hard,							
			5.350	169.900	0.000				
SANDSTONE			8.140	178.040	0.000	UGG	91		
SANDSTONE		Lightgrey, fine to very fine grained, hard,	1.860	179.900	0.000	UGG	90		
MUDSTONE	30%	Mottledgreen, moderately hard,	2.000	181.900	0.000	UGG	90		
SANDSTONE	70%	Lightgrey, fine to very fine grained, hard,							
			2.000	181.900	0.000				
SANDSTONE		Darkgrey, Silty. very fine grained, hard,	8.000	189.900	0.000	UGG	90		
SANDSTONE			13.840	203.740	0.000	UGG	90		
SANDSTONE		Lightgrey, Shaly in parts. fine to very fine grained, hard,	8.160	211.900	0.000	UGG	80		
MUDSTONE	20%		2.930	214.830	0.000	UGG	80		
SANDSTONE	80%								
			2.930	214.830	0.000				
MUDSTONE	20%		7.750	222.580	0.000	UGG	70		
SANDSTONE	80%								
			7.750	222.580	0.000				
MUDSTONE	20%	Mottledbrown, moderately hard,	5.320	227.900	0.000	UGG	60		

SANDSTONE	80%	Lightgrey, very fine grained, hard,	5.320	227.900	0.000		
MUDSTONE		Darkbrown, moderately hard,	10.000	237.900	0.000	UGG	60

Lithology		Description	Thick (m)	Depth (m)	Recov Thick	Strat Ply	WS No.	Sample	Discontinuties	Remarks
MUDSTONE	50%	Darkbrown, moderately hard,	12.000	249.900	0.000	UGG	50			
SANDSTONE	50%	Lightgrey, fine to very fine grained, hard,	12.000	249.900	0.000					
MUDSTONE			2.670	252.570	0.000	UGG	50			
MUDSTONE		Darkbrown, moderately hard,	1.330	253.900	0.000	UGG	40			
MUDSTONE	70%	Darkbrown, moderately hard,	10.000	263.900	0.000	UGG	40			
SANDSTONE	30%	grey, fine to medium grained, hard,	10.000	263.900	0.000					
MUDSTONE		Darkgrey, clayey, moderately hard,	2.000	265.900	0.000	UGG	40			
MUDSTONE	50%	Darkbrown, moderately hard,	6.000	271.900	0.000	UGG	40			
SANDSTONE	50%	grey, fine grained, hard,	6.000	271.900	0.000					
SANDSTONE		Lightgrey, fine to medium grained, hard,	2.000	273.900	0.000	UGG	40			
SHALE	50%	Darkgreen, moderately hard,	2.000	275.900	0.000	UGG	40			
SANDSTONE	50%	grey, fine grained, hard,	2.000	275.900	0.000					
SHALE	50%	Darkgrey, muddy, moderately hard,	6.000	281.900	0.000	UGG	40			
SANDSTONE	50%	Lightbrown,								

		fine to medium grained, hard,					
			6.000	281.900	0.000		
SANDSTONE		Lightgrey, medium grained, hard,	4.000	285.900	0.000	UGG	30
SANDSTONE		Lightgrey, coarse to very coarse grained, hard,	6.000	291.900	0.000	UGG	30
SHALE	50%		2.930	294.830	0.000	UGG	30
SANDSTONE	50%						
			2.930	294.830	0.000		
SHALE	50%	Darkgrey, moderately hard,	3.070	297.900	0.000	UGG	20
SANDSTONE	50%	Lightgrey, fine to medium grained, hard,					

Lithology		Description	Thick (m)	Depth (m)	Recov Thick	Strat	WS Sample No.	Discontinuities	Remarks
			3.070	297.900	0.000				
SANDSTONE			3.610	301.510	0.000	UGG	20		
SANDSTONE		Lightgrey, medium to coarse grained, hard,	4.390	305.900	0.000	UGG	10		
SHALE	50%	Darkgrey, moderately hard,	4.000	309.900	0.000	UGG	10		
SANDSTONE	50%	Lightgrey, medium grained, hard,							
			4.000	309.900	0.000				
SHALE			5.900	315.800	0.000	UGG	10		
SHALE		Darkgrey, moderately hard,	4.100	319.900	0.000	MUN	96		
MUDSTONE	20%		1.640	321.540	0.000	MUN	96		
SANDSTONE	80%								
			1.640	321.540	0.000				
MUDSTONE	20%		2.880	324.420	0.000	MUN	95		
SANDSTONE	80%								
			2.880	324.420	0.000				
MUDSTONE	20%	Mottledgreen, moderately hard,	1.480	325.900	0.000	MUN	94		

Lithology		Description	Thick (m)	Depth (m)	Recov Thick	Strat	WS Ply	Sample No.	Discontinuities	Remarks
SANDSTONE	80%	Lightgrey, medium grained, hard,								
			1.480	325.900	0.000					
		Shaly.								
SANDSTONE			3.060	328.960	0.000	MUN	94			
SANDSTONE		Lightgrey, medium to coarse grained, hard, Occasional pebbly bands.	2.940	331.900	0.000	MUN	93			
SHALE	50%		3.330	335.230	0.000	MUN	93			
SANDSTONE	50%									
			3.330	335.230	0.000					
SHALE	50%		4.940	340.170	0.000	MUN	92			
SANDSTONE	50%									
			4.940	340.170	0.000					
SHALE	50%		7.350	347.520	0.000	MUN	91			
SANDSTONE	50%									
			7.350	347.520	0.000					
SHALE	50%	Darkgrey, moderately hard,	6.380	353.900	0.000	MUN	90			
SANDSTONE	50%	Darkgrey, fine to medium grained, hard,								
			6.380	353.900	0.000					

Lithology		Description	Thick (m)	Depth (m)	Recov Thick	Strat	WS Ply	Sample No.	Discontinuities	Remarks
SANDSTONE		Darkgrey, fine grained, hard,	4.000	357.900	0.000	MUN	90			
SHALE	50%		0.840	358.740	0.000	MUN	90			
SANDSTONE	50%									
			0.840	358.740	0.000					
SHALE	50%	Darkgrey, moderately hard,	2.860	361.600	0.000	MUN	80			
SANDSTONE	50%	Darkgrey, fine to medium grained,								

hard,
2.860 361.600 0.000
Base of open holing at 361.700m. End of chip samples.

MUDSTONE 1.220 362.820 0.000 MUN 80

MUDSTONE Darkgreen, moderately hard, 4.600 367.420 4.600 MUN 70

Bedding plane partings:

Fracture count: 100.

RQD = 000%.

Bedding planes too numerous to count. Core ground in parts. Badly broken in
parts. Shrinkage cracks throughout. Silty in parts, particularly at base.
Occasional sandy phases near top.

SANDSTONE 80% grey, 2.870 370.290 2.870 MUN 70
Fining up.
medium to coarse grained,
hard,

CONGLOMERATE 20% multi-coloured,
pebble sized clasts, hard,
centimetre bedded,
decimetre bedded, 2.870 370.290 2.870

Bedding plane partings:

Fracture count: 2.

RQD = 100%.

Occasional granular phases.
Geotech sample at 368.000m. Crossbedded in parts. Occasional muddy clasts.

CONGLOMERATE multi-coloured, 0.610 370.900 0.610 MUN 70

Bedding plane partings:
pebble sized clasts, hard,

Fracture count: 1.

RQD = 100%.

SANDSTONE grey, 1.840 372.740 1.840 MUN 70

RQD = 100%.
medium to coarse grained,
hard,
Geotech sample at 372.500m. Occasional granular phases. Pebbly bands common.

MUDSTONE Darkgreen, moderately hard, 0.470 373.210 0.470 MUN 60

Bedding plane partings:

Fracture count: 11.

RQD = 000%.

Shrinkage cracks throughout. Sandy particles weakly

disseminated through
centre. Sideritic nodules common near middle.

Lithology	Description	Remarks	Thick (m)	Depth (m)	Recov Thick	Strat Ply	WS No.
MUDSTONE	30% Darkgreen, moderately hard,		1.180	374.390	1.180	MUN	60
SANDSTONE	70% Darkgreen, fine to medium grained, hard,		1.180	374.390	1.180		
	Bedding plane partings:						
	Fracture count: 12.						
	RQD = 010%.						
		Shrinkage cracks throughout. Silty near base. Occasional disturbed bedding. Diffuse at boundaries.					
SANDSTONE	grey,		0.850	375.240	0.850	MUN	60
	Bedding plane partings:						
	Fracture count: 4.						
	RQD = 100%.						
		Slightly muddy throughout. Silty bands near middle.					
SILTSTONE	Darkgrey, muddy, moderately hard,		0.740	375.980	0.000	MUN	60
	Bedding plane partings:						
	Fracture count: 7.						
	RQD = 020%.						
		Thinly interbedded muds, silts and sands throughout. Tends to laminite in parts. Occasional disturbed bedding and bioturbation near base. Large siderite clasts near middle distorting bedding. Mudstone					
MUDSTONE	Darkgreen, moderately hard,		0.490	376.470	0.490	MUN	60

Bedding plane partings:

Fracture count: 11.

RQD = 000%.

Grades to sandy at base. Shrinkage cracks throughout. Silty in part.

SANDSTONE Darkgrey, fine grained, 0.230 376.700 0.230 MUN 60

RQD = 100%.

hard,
Dominant muddy matrix throughout. Band of muddy rip-up clasts near base.

MUDSTONE Darkbrown, moderately soft, 0.120 376.820 0.120 MUN 60

Bedding plane partings:

Fracture count: 4.

RQD = 000%.

Slightly sandy. Broken.

SANDSTONE Darkgrey, medium grained, 0.320 377.140 0.320 MUN 60

RQD = 100%.

hard,
Muddy matrix and small angular clasts throughout. Mud flow deposit.

MUDSTONE Darkgrey, moderately soft, 1.040 378.180 1.040 MUN 60

Bedding plane partings:

Fracture count: 21.

RQD = 000%.

Silty in parts near base. Small sideritic pellets common near middle. Shrinkage
cracks throughout. Core ground and dispersive in parts.

SANDSTONE Lightgrey, fine grained, 0.150 378.330 0.150 MUN 60

RQD = 100%.

hard,
Slightly muddy throughout. Muddy bands near middle.

MUDSTONE Darkgrey, moderately hard, 0.900 379.230 0.900 MUN 60

Bedding plane partings:

Fracture count: 16.

RQD = 000%.

Common.

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Lithology	Description	Thick (m)	Depth (m)	Recov Thick	Strat Ply	WS No.	Sample	Discontinuities	Remarks
	Shrinkage cracks throughout. Silty near middle.								
MUDSTONE	Darkgrey, sideritic, hard,	0.370	379.600	0.370	MUN	60			
	RQD = 000%.								
	Carbonate filled root traces throughout. Slightly sandy throughout. Sideritic pellets common throughout.								
MUDSTONE	Darkgrey, moderately hard,	0.460	380.060	0.460	MUN	60			
	Bedding plane partings:								
	Fracture count: 9.								
	RQD = 000%.								
	Shrinkage cracks throughout. Desiccated.								
SANDSTONE	Darkgrey, fine grained,	1.410	381.470	1.410	MUN	60			
	Bedding plane partings:								
	hard,								
	Fracture count: 7.								
	RQD = 080%.								
	Mudflow deposit. Clasts dominated by pebble sized very angular muddy particles. Unit tends to breccia throughout. Small carbonaceous lenses and clasts common throughout. Geotech sample at 380.100m.								
SANDSTONE 80%	grey, medium to coarse grained, hard,	1.240	382.710	1.240	MUN	60			
CONGLOMERATE 20%	multi-coloured, pebble sized clasts, hard, decimetre bedded,	1.240	382.710	1.240					
	RQD = 100%.								
	Erosional basal contact.								
MUDSTONE	Darkgrey, moderately hard,	0.020	382.730	0.020	MUN	60			
	RQD = 000%.								Lenticular
CONGLOMERATE	multi-coloured,	5.370	388.100	5.370	MUN	60			
	Bedding plane partings:								
	pebble sized clasts, hard,								
	Fracture count: 7.								
	RQD = 100%.								
	Occasional matrix supported sandy phases. Occasional								

granular phases. Erosional
basal contact. Geotech sample at 384.600m.

SILTSTONE	Darkgrey, moderately hard,	0.330	388.430	0.330	MUN	50

Bedding plane partings:

Fracture count: 4.

RQD = 050%.

Large sideritic lenses near base. Sandy band near middle.

SANDSTONE	Lightgrey,	0.200	388.630	0.200	MUN	50

RQD = 100%.

fine to medium grained,
hard,
Erosional basal contact.

SILTSTONE	Darkgrey, muddy, moderately	0.270	388.900	0.270	MUN	50

Bedding plane partings:
hard,
Fracture count: 3.

RQD = 000%.

Occasional disturbed bedding.

SANDSTONE	grey, medium grained, hard,	0.130	389.030	0.130	MUN	50

RQD = 100%.

Erosional basal contact. Large sideritic lense near middle.
Sporadic pebbles
near middle.

MUDSTONE	Darkgrey, silty, moderately	0.070	389.100	0.070	MUN	50

Bedding plane partings:
hard,
Fracture count: 2.

RQD = 000%.

Lithology	Description	Thick (m)	Depth (m)	Recov Thick	Strat Ply	WS No.	Sample	Discontinuities	Remarks
CONGLOMERATE	multi-coloured,	0.250	389.350	0.250	MUN	50			

Bedding plane partings:
pebble sized clasts, hard,
Fracture count: 1.

RQD = 100%.

SANDSTONE	grey,	0.660	390.010	0.660	MUN	50

RQD = 100%.

medium to coarse grained,
hard,
Fining up. Granules and pebbles common near base.

CONGLOMERATE	multi-coloured,	1.520	391.530	1.520	MUN	50

Bedding plane partings:
granule sized clasts, hard,
Fracture count: 4.

RQD = 100%.

Erosional basal contact. Occasional pebbly phases.

MUDSTONE	grey, silty,	0.440	391.970	0.440	MUN	40

Bedding plane partings:
moderately hard,
Fracture count: 8.

RQD = 000%.

Shrinkage cracks throughout.

LAMINITE	Darkgrey, sandy, moderately	0.510	392.480	0.510	MUN	40

Bedding plane partings:
hard,
dipping 0 degrees,

Fracture count: 3.

RQD = 070%.

Sandy layers fining up.

MUDSTONE	30% Darkgrey, moderately hard,	0.300	392.780	0.300	MUN	40
SANDSTONE	70% grey, medium to coarse grained, hard,	0.300	392.780	0.300		

Bedding plane partings:

Fracture count: 2.

RQD = 070%.

Fining up. Granule lag at base.
Erosional basal contact. Muds mostly at middle, and appear lenticular.

MUDSTONE	Darkgreen, moderately hard,	2.520	395.300	2.520	MUN	40

Bedding plane partings:

Fracture count: 24.

RQD = 000%.

Shrinkage cracks throughout. Geotech sample at 394.800m.

Sideritic nodules and
carbonate filled root traces common near top.

LAMINITE	50%	Darkgrey, moderately hard,	0.800	396.100	0.800	MUN	40
SANDSTONE	50%	Darkgrey, fine grained, hard,	0.800	396.100	0.800		

Bedding plane partings: Sharp basal con-

Fracture count: 9. tact.

RQD = 040%.

At middle, visible displacement <1cm.

SANDSTONE			1.230	397.330	0.000	MUN	40

Lithology	Description	Thick (m)	Depth (m)	Recov Thick	Strat Ply	WS No.	Sample	Discontinuties	Remarks
SANDSTONE	Lightgrey,	2.800	400.130	2.800	MUN	30			

Bedding plane partings:
coarse to very coarse grai-
Fracture count: 3.
ned, hard, crossbedded,
RQD = 100%.
Pebbles and granules common throughout. Occasional carbonaceous wisps.
Carbonaceous laminae parting near base. Large muddy clast near middle.

SANDSTONE	Darkgrey, medium grained,	0.530	400.660	0.530	MUN	30	
MUDSTONE	grey, silty,	0.080	400.740	0.080	MUN	20	
SANDSTONE	grey,	0.110	400.850	0.110	MUN	20	

RQD = 100%.
Erosional basal contact. Fining up. Granule lag at base.
Bedding plane partings:
moderately hard,
Fracture count: 3.

RQD = 000%.
RQD = 100%.

fine to medium grained,
hard,
Occasional carbonaceous wisps.

MUDSTONE Darkgrey, sandy, moderately 0.910 401.760 0.910 MUN 20

Bedding plane partings:
hard,
Fracture count: 8.

RQD = 030%.

Planar joint: At middle.

dipping 80 degrees,

Fracture count: 1.

Occasional shrinkage cracks throughout. Root traces and sand filled mud cracks
common near base. Sandy band at base.

SANDSTONE Lightgrey, medium grained, 0.440 402.200 0.440 MUN 20

Planar joint:
hard,
very rough surface,

dipping 70 degrees,

Fracture count: 1.

RQD = 050%.
Erosional basal contact.

MUDSTONE Darkgrey, moderately hard, 1.910 404.110 1.910 MUN 20

Bedding plane partings:

Fracture count: 22.

RQD = 000%.

Planar joint: slickensided

surface,

dipping 70 degrees,

Fracture count: 1.

Occasional sandy phases. Tends to laminite in parts. Shrinkage cracks
throughout. Occasional disturbed bedding and root traces near top.
Striated joint plane near middle.

Some slickensided, some infilled with lutite.
SANDSTONE grey, coarse to very coarse 2.660 406.770 2.660 MUN 10
Bedding plane partings:
grained, hard, crossbedded,
Fracture count: 2.

RQD = 090%.

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Sharp basal contact. Occasional wispy muddy lenses near base.

MUDSTONE Darkgrey, silty, moderately 0.020 408.750 0.020 MUN 10
Bedding plane partings:
hard,
Fracture count: 3.

RQD = 000%.

SANDSTONE grey, coarse to very coarse 1.990 410.740 1.990 MUN 10
Bedding plane partings:
grained, hard, crossbedded,
Fracture count: 2.

RQD = 100%.

Occasional granular phases, with sporadic pebbles near middle.

SANDSTONE Lightgrey, 0.640 411.380 0.640 MUN 10
Planar joint:
very coarse grained, hard,
very rough surface,
faulted,
dipping 60 degrees,

Fracture count: 3.

RQD = 030%.

Granular phases common throughout, grades to paraconglomerate in parts.

Displacement approximately 2cm.

SANDSTONE grey, medium grained, hard, 0.360 411.740 0.360 MUN 10
Bedding plane partings:

Fracture count: 3.

RQD = 000%.

Near middle.

Brecciated near base.

SANDSTONE grey, 0.670 412.410 0.670 MUN 10
Bedding plane partings: Sharp basal con-
medium to coarse grained,
Fracture count: 6. tact.
hard, crossbedded,
RQD = 080%.

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Fracture count: 1.

Silty laminae at base.
MUDSTONE Darkgrey, sandy, moderately 0.270 413.250 0.270 DOR 80
Bedding plane partings:
hard, jointed,
Fracture count: 5.

RQD = 000%.

Thin breccia at top. Slumping and mixing evident throughout. Disturbed bedding
and root traces common. Shrinkage cracks throughout.
MUDSTONE 40% Darkgrey, moderately hard, 0.600 413.850 0.600 DOR 80

SANDSTONE 60% grey,
fine to medium grained,
hard,
0.600 413.850 0.600
Bedding plane partings:

Fracture count: 6.

RQD = 030%.

Shrinkage cracks throughout.
Occasional disturbed bedding.
MUDSTONE Darkgrey, moderately hard, 1.040 414.890 1.040 DOR 80
Bedding plane partings:

Fracture count: 21.

RQD = 000%.
Geotech sample at 414.500m. Shrinkage cracks throughout. Occasional disturbed
bedding. Diffuse basal contact.

Lithology	Description	Thick (m)	Depth (m)	Recov Thick	Strat Ply	WS Sample No.	Discontinuties	Remarks

SANDSTONE		Lightgrey,	0.540	415.430	0.540	DOR	80
	RQD = 100%.						
		fine to very fine grained,					
		hard,					
		Occasional muddy phases near base.					
SANDSTONE		Lightgrey, medium to coarse	1.940	417.370	1.940	DOR	80
	Bedding plane partings:						
		grained, hard, crossbedded,					
	Fracture count: 1.						
	RQD = 100%.						
		Occasional carbonaceous wisps. Fining up. Sparsely disseminated granules near					
		middle. Erosional basal contact.					
LAMINITE		Darkgrey, moderately hard,	1.390	418.760	1.390	DOR	70
	Bedding plane partings:						
	Fracture count: 16.						
	RQD = 040%.						
		Shrinkage cracks in muddy bands common. Occasional disturbed bedding. Sideritic					
		nodules near top.					
SANDSTONE		Darkgrey, fine to very fine	0.390	419.150	0.390	DOR	70
	RQD = 100%.						
		grained, hard,					
		Geotech sample at 419.100m. Slightly muddy throughout.					
MUDSTONE		Darkgrey, moderately hard,	0.450	419.600	0.450	DOR	70
	Bedding plane partings:						
	Fracture count: 11.						
	RQD = 000%.						
		Shrinkage cracks throughout. Occasional sandy phases near middle.					
MUDSTONE	50%	Darkgrey, moderately hard,	1.620	421.220	1.620	DOR	70
SANDSTONE	50%	grey,					
		fine to medium grained,					
		hard,					
		decimetre bedded,	1.620	421.220	1.620		
	Bedding plane partings:						
	Fracture count: 9.						
	RQD = 030%.						
		Shrinkage cracks throughout. Occasional disturbed bedding.					
SANDSTONE		grey, fine grained, hard,	0.330	421.550	0.330	DOR	70
	RQD = 100%.						
		Slightly muddy throughout. Diffuse bedding throughout.					
LAMINITE		Darkgrey, moderately hard,	0.600	422.150	0.600	DOR	70

Bedding plane partings:

Fracture count: 4.

RQD = 060%.

Occasional disturbed bedding with diffuse contacts.

SANDSTONE grey, 1.130 423.280 1.130 DOR 70

Bedding plane partings:

fine to medium grained,

Fracture count: 4.

hard, crossbedded,

RQD = 090%.

Occasional disturbed bedding. Muddy rip-up clasts common near middle.

Occasional silty laminae.

LAMINITE Darkgrey, sandy, moderately 0.620 423.900 0.620 DOR 60

Bedding plane partings:

hard,

Fracture count: 9.

RQD = 060%.

Shrinkage cracks throughout muddy bands. Occasional disturbed bedding.

Lithology	Description	Thick (m)	Depth (m)	Recov Thick	Strat Ply	WS Sample No.	Discontinuties	Remarks
SANDSTONE	grey, fine to medium grained, hard, crossbedded,	0.220	424.120	0.220	DOR	60	Planar joint: very rough surface, dipping 60 degrees, Fracture count: 1. RQD = 050%.	Silty laminae define low angle trough crossbedding throughout.
MUDSTONE	Darkgrey, silty, moderately	0.260	424.380	0.260	DOR	60		

Bedding plane partings:
hard,
Fracture count: 5.

RQD = 000%.
Occasional disturbed bedding. Shrinkage cracks throughout.

SANDSTONE		grey, fine grained, hard,	0.290	424.670	0.290	DOR	60

Bedding plane partings:
jointed,
Fracture count: 1.

RQD = 000%.

Occasional muddy phases throughout.

MUDSTONE	70%	Darkgrey, moderately hard,	1.610	426.280	1.610	DOR	60
SANDSTONE	30%	grey, fine to medium grained, hard,					
			1.610	426.280	1.610		

Bedding plane partings:

Fracture count: 21.

RQD = 030%.
Shrinkage cracks throughout.
Diffuse bedding throughout. Occasional disturbed bedding.
Geotech sample at
425.500m.

SANDSTONE		Lightgrey, coarse grained,	1.700	427.980	1.700	DOR	60

Bedding plane partings:
hard, crossbedded,
Fracture count: 4.

RQD = 080%.

Silty and carbonaceous laminae define low angle trough crossbedding throughout.

SANDSTONE		Lightgrey,	0.770	428.750	0.770	DOR	60

Planar joint:
coarse to very coarse grai-
very rough surface,
ned, hard, broken,
dipping 70 degrees,

Fracture count: 5.

RQD = 000%.
Core badly broken and friable throughout. Occasional carbonaceous laminae.

CORE-LOSS			0.320	429.070	0.000	DOR	60

Drillers block at 430.20m. Drilled 6.00m. Recovered 5.62m.

SANDSTONE Lightgrey, 1.040 430.110 1.040 DOR 60
Bedding plane partings:
very coarse grained, hard,
Fracture count: 2.

RQD = 080%.
Occasional carbonaceous laminae partings. Erosional basal contact.

SANDSTONE Darkgrey, 1.210 431.320 1.210 DOR 50
Cross bedding partings:
fine to medium grained,
Fracture count: 6.
hard, crossbedded,
RQD = 080%.
Silty carbonaceous laminae define low angle trough crossbedding throughout.
Occasional carbonaceous wisps throughout. Diffuse bedding in parts.

Lithology	Description	Thick (m)	Depth (m)	Recov Thick	Strat Ply	WS Sample No.	Discontinuities	Remarks
SANDSTONE	Lightgrey,	0.220	431.540	0.220	DOR	50		

Bedding plane partings:
coarse to very coarse grai-
Fracture count: 1.
ned, hard, crossbedded,
RQD = 000%.

At base.
Carbonaceous laminae common throughout.

SANDSTONE Lightgrey, medium grained, 0.860 432.400 0.860 DOR 50
Planar joint:
hard, crossbedded,
very rough surface,

dipping 60 degrees,

Fracture count: 2.

RQD = 070%.

Occasional carbonaceous laminae.
SANDSTONE Darkgrey, fine grained, 0.450 432.850 0.450 DOR 50
Bedding plane partings:
hard, millimetre bedded,
Fracture count: 3.

RQD = 070%.

Carbonacous laminae abundant throughout.
SANDSTONE grey, 1.370 434.220 1.370 DOR 50
Bedding plane partings:
fine to medium grained,
Fracture count: 3.
hard, millimetre bedded,
RQD = 100%.
Geotech samples at 433.800m and 434.200m. Silty laminae define low angle trough
crossbedding near middle and base.
SANDSTONE Lightgrey, medium grained, 1.880 436.100 1.880 DOR 45
Bedding plane partings:
hard, crossbedded,
Fracture count: 3.

RQD = 100%.

At base.
Occasional carbonaceous wisps. Occasional silty laminae. Occasional muddy
rip-up clasts.
MUDSTONE Darkgrey, silty, moderately 0.080 436.180 0.080 DOR 45
Moderate discing: FractureFissile.
hard,
count: 0.

RQD = 000%.
SANDSTONE Lightgrey, medium grained, 0.770 436.950 0.770 DOR 45
Bedding plane partings:
hard, crossbedded,
Fracture count: 1.

RQD = 100%.
Geotech samples at 436.600m and 436.800m. Erosional basal contact. Occasional
carbonaceous wisps throughout.
COAL Bright 00%, 0.019 436.969 0.019 WGN C4
101858
COAL Bright 1 00%, 0.010 436.979 0.010 WGN C4
101858 Crushed.
COAL Bright 10%, 0.078 437.057 0.078 WGN C4
101858
Fusainous lenses common near middle.

COAL	Bright 30%,	0.012	437.069	0.012	WGN	C4 101858
	Planar joint: dipping 60 degrees, Fracture count: 1.					
COAL	Bright 10%,	0.099	437.168	0.099	WGN	C4 101858
	Planar joint: dipping 60 degrees, Fracture count: 1.					
COAL	Bright 40%,	0.030	437.198	0.030	WGN	C4 101858

Lithology	Description	Thick (m)	Depth (m)	Recov Thick	Strat Ply	WS No.	Sample	Discontinuties	Remarks
	Sideritic nodules common throughout.								
COAL	Bright 10%,	0.099	437.297	0.099	WGN	C4 101858			
	Sideritic nodules common throughout.								
COAL	Bright 20%,	0.039	437.336	0.039	WGN	C4 101858			
COAL	Bright 40%,	0.062	437.398	0.062	WGN	C4 101858			
	Sideritic nodules common throughout.								
COAL	Bright 70%,	0.040	437.438	0.040	WGN	C4 101858			
COAL	Bright 1 00%,	0.008	437.446	0.008	WGN	C4 101858			
CLAYSTONE	grey, tuffaceous, Pelletal. moderately hard,	0.004	437.450	0.004	WGN	D1 101859			
COAL	Bright 10%,	0.069	437.519	0.069	WGN	D2 101859			
	Fusainous lenses common near middle.								
COAL	Bright 80%,	0.015	437.534	0.015	WGN	D2 101859			
	Large sideritic nodules common throughout.								
COAL	Bright 10%,	0.018	437.552	0.018	WGN	D2 101859			

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COAL                Bright 50%,                  0.029 437.581  0.029  WGN  D2
 101859 Planar joint:

        dipping 50 degrees,

        Fracture count: 1.
COAL                Bright 20%,                  0.064 437.645  0.064  WGN  D2
 101859 Planar joint:

        dipping 60 degrees,

        Fracture count: 1.
COAL                Bright 1 00%,                0.008 437.653  0.008  WGN  D2
 101859
CLAYSTONE           brown, tuffaceous,           0.002 437.655  0.002  WGN  D2
 101859
                    moderately hard,
COAL                Bright 10%,                  0.078 437.733  0.078  WGN  D2
 101859
CLAYSTONE           Darkbrown, tuffaceous,       0.003 437.736  0.003  WGN  D2
 101859
                    moderately hard,
COAL                Bright 20%,                  0.041 437.777  0.041  WGN  D2
 101859
                    Sideritic nodules common near base.
COAL                Bright 10%,                  0.090 437.867  0.090  WGN  D2
 101859
COAL                Bright 30%,                  0.025 437.892  0.025  WGN  D2
 101859
                    Occasional sideritic nodules.
COAL                Bright 10%,                  0.024 437.916  0.024  WGN  D2
 101859
COAL                Bright 40%,                  0.036 437.952  0.036  WGN  D2
 101859
COAL                Bright 10%,                  0.042 437.994  0.042  WGN  D2
 101859
COAL                Bright 30%,                  0.014 438.008  0.014  WGN  D2
 101859
                    Occasional sideritic nodules.
CLAYSTONE           Darkgrey, tuffaceous,        0.002 438.010  0.002  WGN  D2
 101859
                    moderately hard,
COAL                Bright 30%,                  0.088 438.098  0.088  WGN  D2
 101859
                    Sporadic sideritic nodules throughout.
COAL                Bright 00%,                  0.016 438.114  0.016  WGN  E2
 101860
COAL                Bright 30%,                  0.039 438.153  0.039  WGN  E2
 101860
COAL                Bright 00%,                  0.019 438.172  0.019  WGN  E2
 101860
COAL                Bright 20%,                  0.037 438.209  0.037  WGN  E2
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101860						
COAL	Bright 40%,	0.030	438.239	0.030	WGN	E2
101860						
	Sideritic nodules common throughout.					
COAL	Bright 1 00%,	0.022	438.261	0.022	WGN	E2
101860						

Lithology	Description	Thick (m)	Depth (m)	Recov Thick	Strat Ply	WS No.	Sample	Discontinuties	Remarks
	Sideritic nodules common throughout.								
COAL	Bright 10%,	0.030	438.291	0.030	WGN	E2			
101860									
COAL	Bright 20%,	0.037	438.328	0.037	WGN	E2			
101860									
CLAYSTONE	Darkbrown, tuffaceous,	0.003	438.331	0.003	WGN	E2			
101860									
	moderately hard,								
COAL	Bright 00%,	0.045	438.376	0.045	WGN	E2			
101860									
COAL	Bright 10%,	0.071	438.447	0.071	WGN	E2			
101860									
COAL	Bright 00%,	0.155	438.602	0.155	WGN	E2			
101860									
COAL	Bright 20%,	0.038	438.640	0.038	WGN	F2			
101861									
COAL	Bright 10%,	0.029	438.669	0.029	WGN	F2			
101861									
COAL	Bright 50%,	0.034	438.703	0.034	WGN	F2			
101861									
COAL	Bright 20%,	0.102	438.805	0.102	WGN	F2			
101861									
COAL	Bright 1 00%,	0.008	438.813	0.008	WGN	F2			
101861									
COAL	Bright 10%,	0.057	438.870	0.057	WGN	F2			
101861									
	Fusainous lenses common near top.								
COAL	Bright 40%,	0.046	438.916	0.046	WGN	F2			
101861									
	Occasional sideritic nodules.								
COAL	Bright 90%,	0.047	438.963	0.047	WGN	F2			
101861									

CLAYSTONE	grey, tuffaceous,	0.005	438.968	0.005	WGN	F2
101861						
	moderately hard,					
COAL	Bright 00%,	0.018	438.986	0.018	WGN	F2
101861	Planar joint:					
	dipping 90 degrees,					
	Fracture count: 1.					
COAL	Bright 10%,	0.087	439.073	0.087	WGN	F2
101861	Planar joint:					
	dipping 90 degrees,					
	Fracture count: 1.					
COAL	Bright 20%,	0.079	439.152	0.079	WGN	F2
101861	Planar joint:					
	dipping 90 degrees,					
	Fracture count: 1.					
COAL	Bright 1 00%,	0.018	439.170	0.018	WGN	F2
101861						
COAL	Bright 40%,	0.048	439.218	0.048	WGN	F2
101861						
COAL	Bright 10%,	0.083	439.301	0.083	WGN	F4
101862						
COAL	Bright 20%,	0.026	439.327	0.026	WGN	F4
101862						
COAL	Bright 00%,	0.037	439.364	0.037	WGN	F4
101862						
COAL	Bright 10%,	0.075	439.439	0.075	WGN	F4
101862						
COAL	Bright 30%,	0.025	439.464	0.025	WGN	F4
101862						
COAL	Bright 80%,	0.034	439.498	0.034	WGN	F4
101862						
	Carbonate common on cleat.					
COAL	Bright 00%,	0.006	439.504	0.006	WGN	F4
101862						
COAL	Bright 60%,	0.033	439.537	0.033	WGN	F4
101862						
	Fusainous lenses common near base.					
COAL	Bright 20%,	0.031	439.568	0.031	WGN	G2
101863						
COAL	Bright 10%,	0.025	439.593	0.025	WGN	G2
101863						
COAL	Bright 30%,	0.032	439.625	0.032	WGN	G2
101863						
COAL	Bright 20%,	0.040	439.665	0.040	WGN	G2
101863						
COAL	Bright 10%,	0.049	439.714	0.049	WGN	G2

101863						
COAL	Bright 30%,	0.037	439.751	0.037	WGN	G2
101863						

Lithology	Description	Thick (m)	Depth (m)	Recov Thick	Strat	WS Sample No.	Discontinuties	Remarks
CLAYSTONE	Darkgrey, tuffaceous,	0.005	439.756	0.005	WGN	G2		
101863								
	moderately hard,							
COAL	Bright 30%,	0.025	439.781	0.025	WGN	G2		
101863								
CLAYSTONE	Darkbrown, tuffaceous,	0.002	439.783	0.002	WGN	G2		
101863								
	moderately hard,							
COAL	Bright 10%,	0.025	439.808	0.025	WGN	G2		
101863								
COAL	Bright 20%,	0.028	439.836	0.028	WGN	G2		
101863								
COAL	Bright 70%,	0.070	439.906	0.070	WGN	G2		
101863								
	Carbonate common on cleat.							
CLAYSTONE	Darkbrown, tuffaceous,	0.003	439.909	0.003	WGN	H1		
101864								
	moderately hard,							
COAL	Bright 00%,	0.025	439.934	0.025	WGN	H2		
101864								
COAL	Bright 1 00%,	0.015	439.949	0.015	WGN	H2		
101864								
COAL	Bright 10%,	0.039	439.988	0.039	WGN	H2		
101864								
	Carbonate common on cleat.							
COAL	Bright 70%,	0.094	440.082	0.094	WGN	H2		
101864								
	Prolific carbonate on cleat.							
CLAYSTONE	brown, tuffaceous,	0.001	440.083	0.001	WGN	H2		
101864								
	moderately hard,							
COAL	Bright 30%,	0.027	440.110	0.027	WGN	H2		
101864								
COAL	Bright 80%,	0.049	440.159	0.049	WGN	H2		

101864						
COAL	Bright 10%,	0.013	440.172	0.013	WGN	H2
101864						
COAL	Bright 1 00%,	0.015	440.187	0.015	WGN	H2
101864						
COAL	Bright 00%,	0.011	440.198	0.011	WGN	H2
101864						
COAL	Bright 60%,	0.046	440.244	0.046	WGN	H2
101864						
	Fusainous lenses common near base.					
CLAYSTONE	Darkbrown, tuffaceous,	0.004	440.248	0.004	WGN	H2
101864						
	moderately hard,					
	lenticular,					
COAL	Bright 60%,	0.029	440.277	0.029	WGN	H2
101864						
CLAYSTONE	Darkbrown, tuffaceous,	0.006	440.283	0.006	WGN	H2
101864						
	moderately hard,					
	Slightly carbonaceous throughout.					
COAL	Bright 60%,	0.032	440.315	0.032	WGN	H2
101864						
COAL	Bright 00%,	0.016	440.331	0.016	WGN	H2
101864						
COAL	Bright 70%,	0.028	440.359	0.028	WGN	H2
101864						
COAL	Bright 20%,	0.020	440.379	0.020	WGN	H2
101864						
COAL	Bright 50%,	0.015	440.394	0.015	WGN	H2
101864						
	Carbonate laminations throughout.					
COAL	Bright 60%,	0.036	440.430	0.036	WGN	H2
101864						
	Carbonate common on cleat.					
CLAYSTONE		1.090	441.520	0.000	AWT	90
CLAYSTONE		1.450	442.970	0.000	AWT	80
CLAYSTONE	grey, sandy,	0.470	443.440	0.470	AWT	70
Bedding plane partings:						
	moderately hard,					
Fracture count: 21.						
	tuffaceous,					
RQD = 070%.						
	Occasional carbonaceous wisps.					
CLAYSTONE		0.390	443.830	0.000	AWT	70

B800W800

Lithology	Description	Thick (m)	Depth (m)	Recov Thick	Strat Ply	WS Sample No.	Discontinuities	Remarks
CLAYSTONE		1.120	444.950	0.000	AWT	60		
CLAYSTONE		1.600	446.550	0.000	AWT	50		
CLAYSTONE		0.910	447.460	0.000	AWT	40		
CLAYSTONE		0.570	448.030	0.000	AWT	30		
CLAYSTONE		0.600	448.630	0.000	AWT	20		
CLAYSTONE	buff, tuffaceous,	0.200	448.830	0.200	AWT	10		
	Bedding plane partings: moderately hard,							
	Fracture count: 36.							
	RQD = 000%.							
	Planar joint:							
	dipping 80 degrees,							
	Fracture count: 9.							
	Carbonate veining and laminae common as thin bands. Occasional sandy phases.							
MUDSTONE	Darkgrey, moderately hard,	0.320	449.150	0.320	ELB			
	Bedding plane partings:							
	Fracture count: 2.							
	RQD = 000%.							
	Occasional sandy phases. Occasional disturbed bedding.							
SANDSTONE	Darkgrey, fine grained,	1.100	450.250	1.100	ELB			
	Bedding plane partings: hard,							
	Fracture count: 6.							
	RQD = 080%.							
	Prolific silty laminae define low angle trough crossbedding throughout. Occasional disturbed bedding.							
SANDSTONE	grey, coarse grained, hard,	4.420	454.670	4.420	ELB			
	Bedding plane partings:							
	Fracture count: 12.							
	RQD = 070%.							

At top.

	Silty and carbonaceous laminae common, some parted. Occasional finer grained					
	bands. Sporadic granule lags.					
SANDSTONE	Darkgrey, fine grained,	0.180	454.850	0.180		ELB
Bedding plane partings:						
	hard,					
Fracture count: 3.						
RQD = 000%.						
	Carbonaceous laminae common.					
SANDSTONE	grey, medium grained, hard,	1.140	455.990	1.140		ELB
Bedding plane partings:						
Fracture count: 2.						
RQD = 090%.						
	Coarsening up. Occasional granular phases.					
SANDSTONE	grey, coarse to very coarse	0.110	456.100	0.110		ELB
RQD = 100%.						
	grained, hard, Erosional basal contact.					
SANDSTONE	Darkgrey,	0.350	456.450	0.350		ELB
Bedding plane partings:						
	fine to medium grained,					
Fracture count: 2.						
	hard,					
RQD = 100%.						
	Carbonaceous laminae common throughout. Coarsening up.					
COAL	Bright 00%,	0.010	456.460	0.010		ELB

Lithology	Description	Thick (m)	Depth (m)	Recov Thick	Strat Ply	WS No.	Sample	Discontinuities	Remarks
SANDSTONE	50% grey,	0.730	457.190	0.730	ELB				
Fracture count: 0.									
	fine to medium grained, hard,								
SANDSTONE	50% grey, coarse to very coarse grained, hard,								

		decimetre bedded,	0.730	457.190	0.730	
	Bedding plane partings:					
	Fracture count: 1.					
	RQD = 100%.					
		Erosional basal contact.				
SANDSTONE		Lightgrey, medium grained,	1.160	458.350	1.160	ELB
	Bedding plane partings:					
		hard,				
	with carbonaceous remains-					
	infill.					
	Fracture count: 3.					
	RQD = 100%.					
		Occasional coaly traces near base. Sharp basal contact.				
SANDSTONE	50%	Lightgrey, medium to coarse grained, hard,	2.590	460.940	2.590	ELB
CONGLOMERATE	50%	Lightmulti-coloured, pebble sized clasts, hard,				
		decimetre bedded,	2.590	460.940	2.590	
	Bedding plane partings:					
	Fracture count: 60.					
	RQD = 100%.					
		Occasional carbonaceous laminae. Slightly heat affected, mobilised carbon				
		infused along bedding plane partings common near base.				
SANDSTONE		grey,	1.770	462.710	1.770	ELB
	Bedding plane partings:					
		fine to medium grained,				
	Fracture count: 6.					
		hard,				
	RQD = 000%.					
		Carbonaceous laminae common throughout. Strong dogtooth spar growths in void				
		created phreatomagmatically near base.				
SANDSTONE		grey,	1.080	463.790	1.080	ELB
	Bedding plane partings:					
		medium to coarse grained,				
	Fracture count: 3.					
		hard,				
	RQD = 100%.					
		Slightly heat affected. Carbonaceous laminae throughout, some localised				
		infusion along joints and bedding planes due to heating.				

COAL Heat alte-red		0.360	464.150	0.360	FAS	IN
	Broken throughout. Carbonate common throughout.					
IGNEOUS	Lightgreen, hard, Intrusive sill. Doleritite. Coaly blebs throughout.	0.080	464.230	0.080	FAS	IN
COAL Heat alte-red		0.110	464.340	0.110	FAS	IN
IGNEOUS	Lightgreen, hard, Carbonate common throughout. Olive colour. Doleritic.	0.340	464.680	0.340	FAS	IN

Lithology	Description	Thick (m)	Depth (m)	Recov Thick	Strat Ply	WS No.	Sample	Discontinuities	Remarks
COAL Heat alte-red		0.090	464.770	0.090	FAS	IN			
IGNEOUS	Lightbrown, hard,	0.030	464.800	0.030	FAS	IN			
COAL Heat alte-red		0.080	464.880	0.080	FAS	IN			
	Igneous lenses near middle.								
IGNEOUS	Lightbrown, hard, lenticular,	0.030	464.910	0.030	FAS	IN			
COAL Heat alte-red		0.420	465.330	0.420	FAS	IN			
	Carbonate veining common throughout.								
IGNEOUS	Darkgreen, hard,	0.020	465.350	0.020	FAS	IN			
COAL Heat alte-red		0.120	465.470	0.120	FAS	IN			
	Igneous blebs throughout.								
IGNEOUS	grey, very hard,	0.170	465.640	0.170	FAS	IN			
COAL Heat alte-red		0.170	465.810	0.170	FAS	IN			
	Wispy carbonate veining common throughout.								
IGNEOUS	grey, very hard,	0.540	466.350	0.540	FAS	IN			
IGNEOUS	green, hard, broken, Carbonate veining strong in parts. Badly broken and weakly structured throughout.	1.730	468.080	1.730	FAS	IN			
COAL Heat alte-red		0.300	468.380	0.300	FAS	IN			
	Wispy carbonate veining common throughout.								
CLAYSTONE	Darkgrey, tuffaceous,	0.020	468.400	0.020	FAS	IN			

	moderately hard, heat altered,					
COAL Heat altered		0.080	468.480	0.080	FAS	IN
	Wispy carbonate veining common throughout.					
CLAYSTONE	Darkgrey, tuffaceous, moderately hard, heat altered,	0.050	468.530	0.050	FAS	IN
COAL Heat altered		0.040	468.570	0.040	FAS	IN
	Wispy carbonate veining common throughout.					
COAL Heat altered		0.140	468.710	0.140	FAS	IN
	Wispy carbonate veining common throughout. Carbonate common on cleat.					
IGNEOUS		0.310	469.020	0.310	FAS	IN
	Badly broken throughout.					
COAL Heat altered		0.020	469.040	0.020	FAS	IN
IGNEOUS		1.120	470.160	1.120	FAS	IN
	Badly broken throughout.					

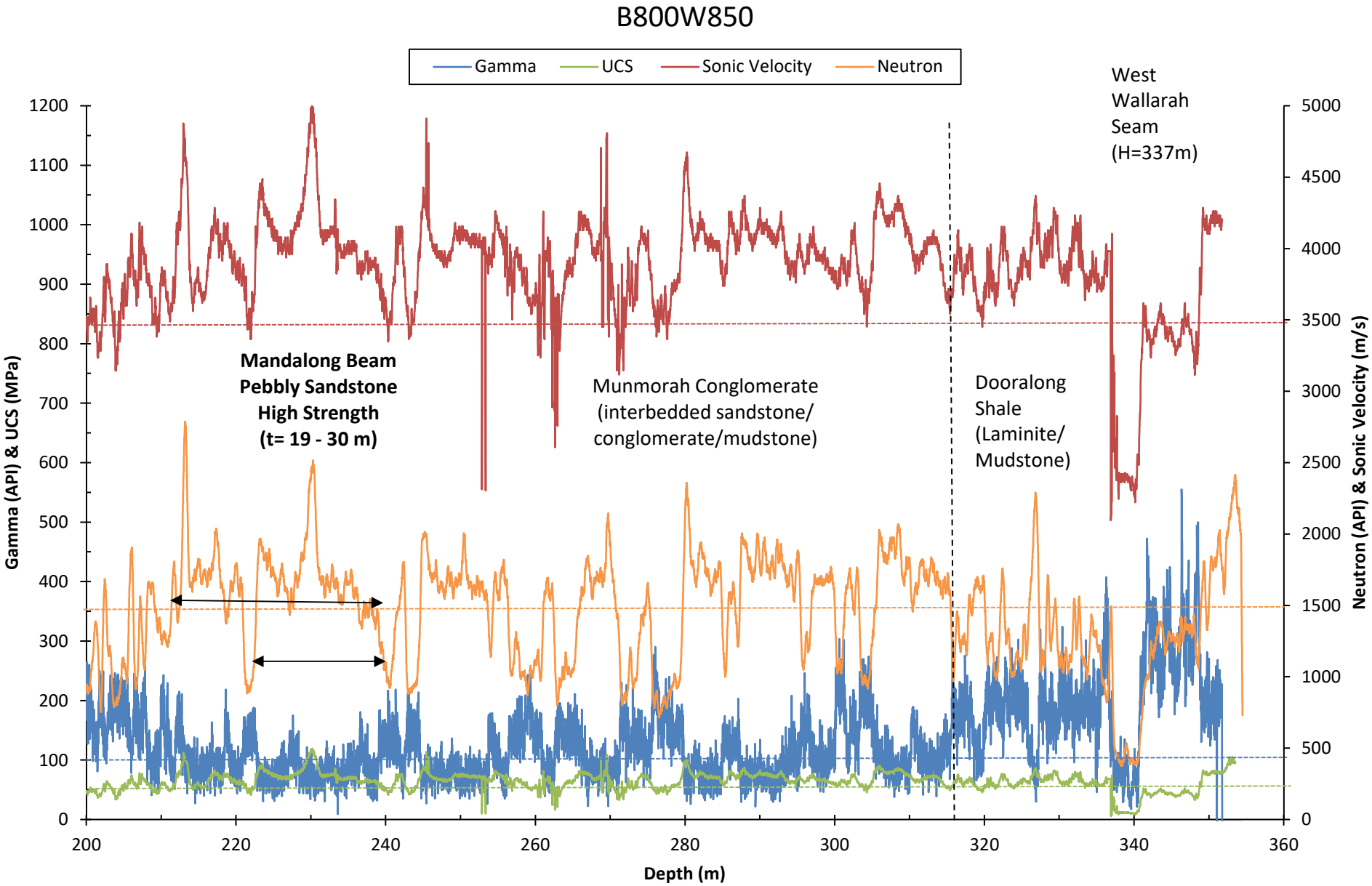
Lithology	Description	Thick (m)	Depth (m)	Recov Thick	Strat Ply	WS Sample No.	Discontinuities	Remarks
COAL Heat altered		0.010	470.170	0.010	FAS	IN		
IGNEOUS	Lightbrown, hard,	0.060	470.230	0.060	FAS	IN		
COAL Heat altered		0.090	470.320	0.090	FAS	IN		
	Wispy carbonate veining common throughout.							
IGNEOUS	green, very hard,	0.540	470.860	0.540	FAS	IN		
COAL Heat altered		0.060	470.920	0.060	FAS	IN		
CLAYSTONE	Darkgrey, tuffaceous, moderately hard, heat altered,	0.130	471.050	0.130				
COAL Heat altered		0.010	471.060	0.010				
CLAYSTONE	Darkgrey, tuffaceous, moderately hard,	0.030	471.090	0.030				

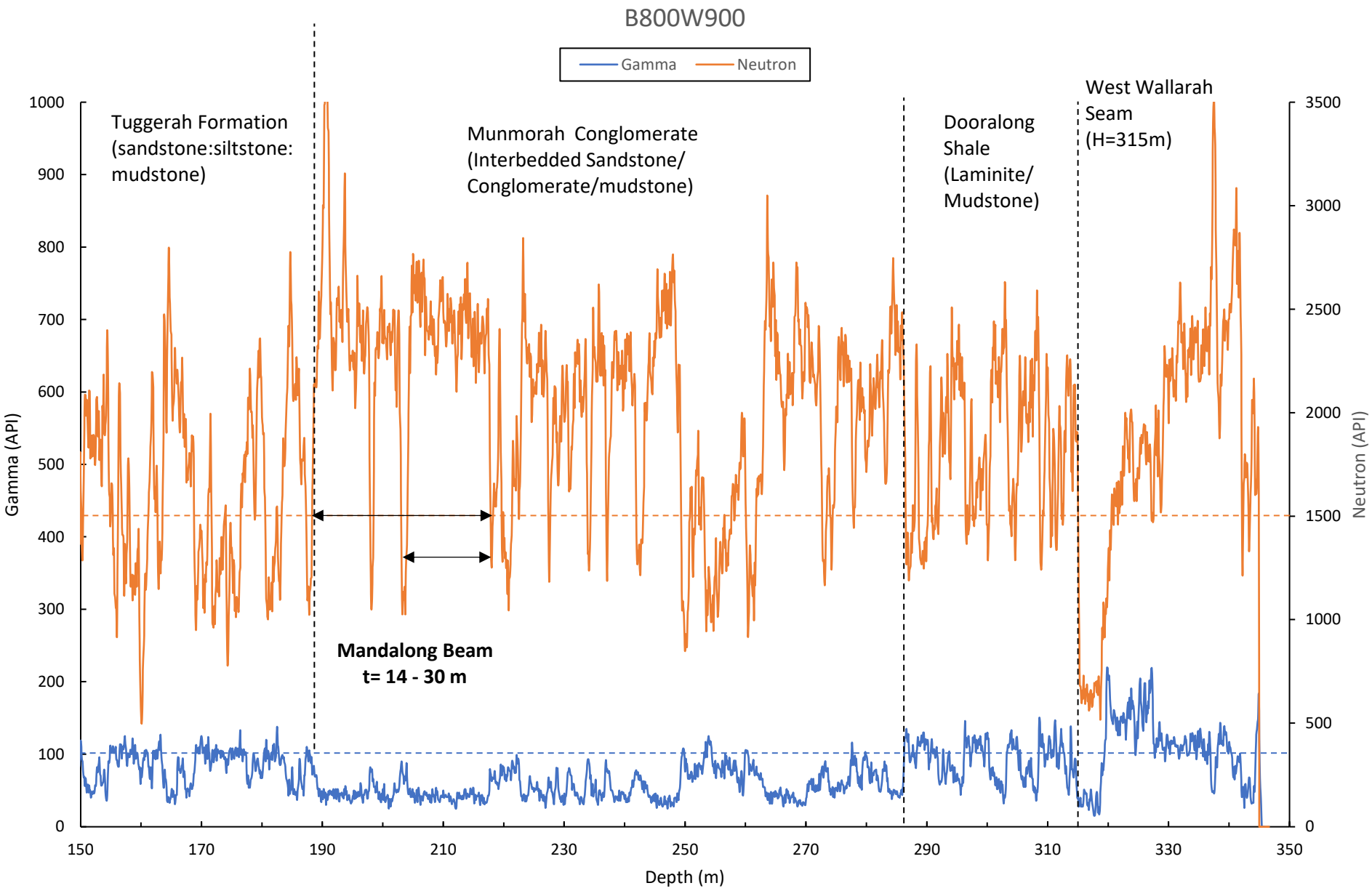
tuffaceous,
SANDSTONE grey, 0.390 471.480 0.390
Bedding plane partings:
fine to medium grained,
Fracture count: 1.
hard,
RQD = 100%.
Slightly heat affected. Occasional carbonaceous wisps and laminae.
SANDSTONE grey, medium grained, hard, 0.620 472.100 0.620
Bedding plane partings:

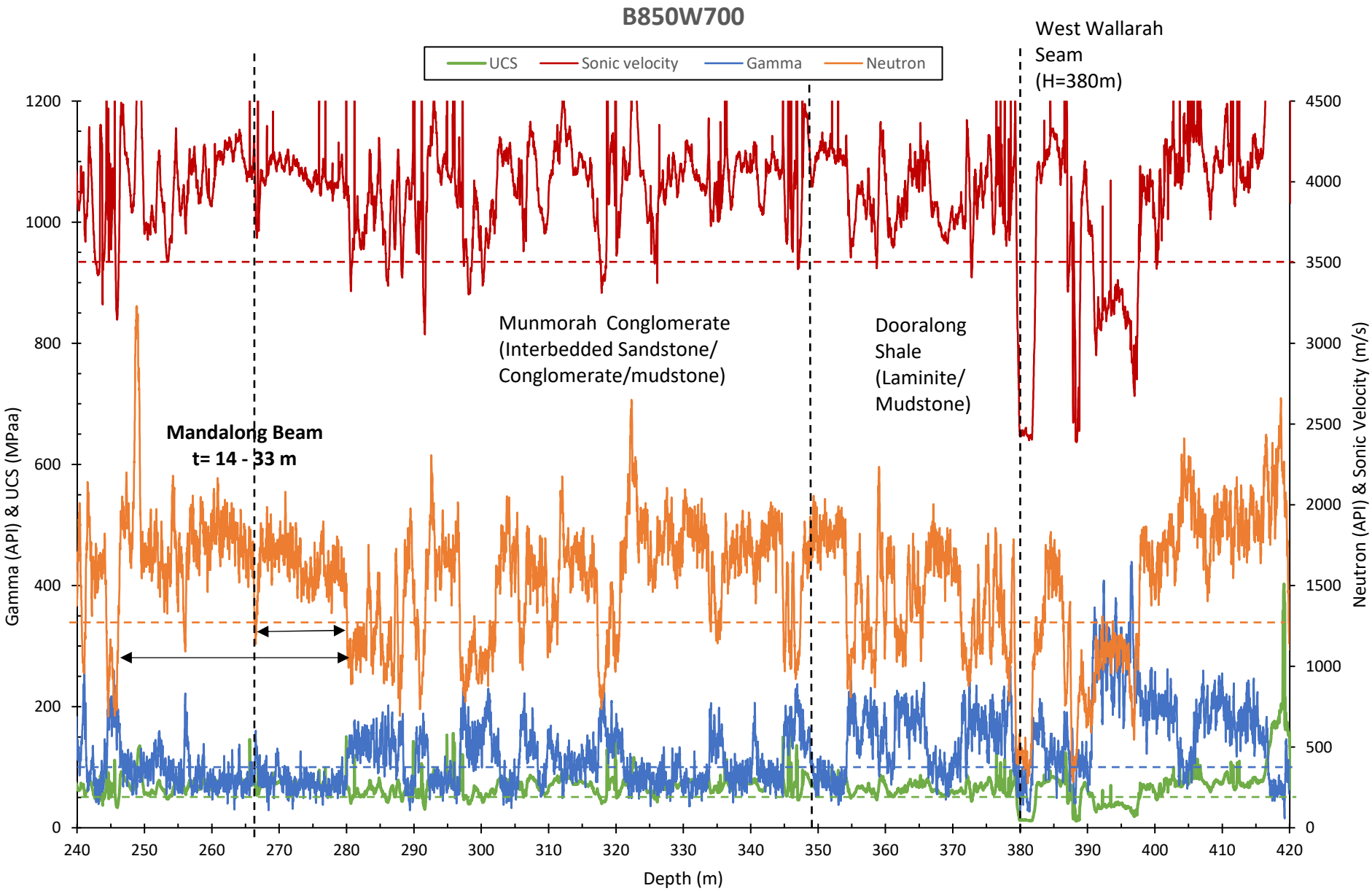
Fracture count: 4.

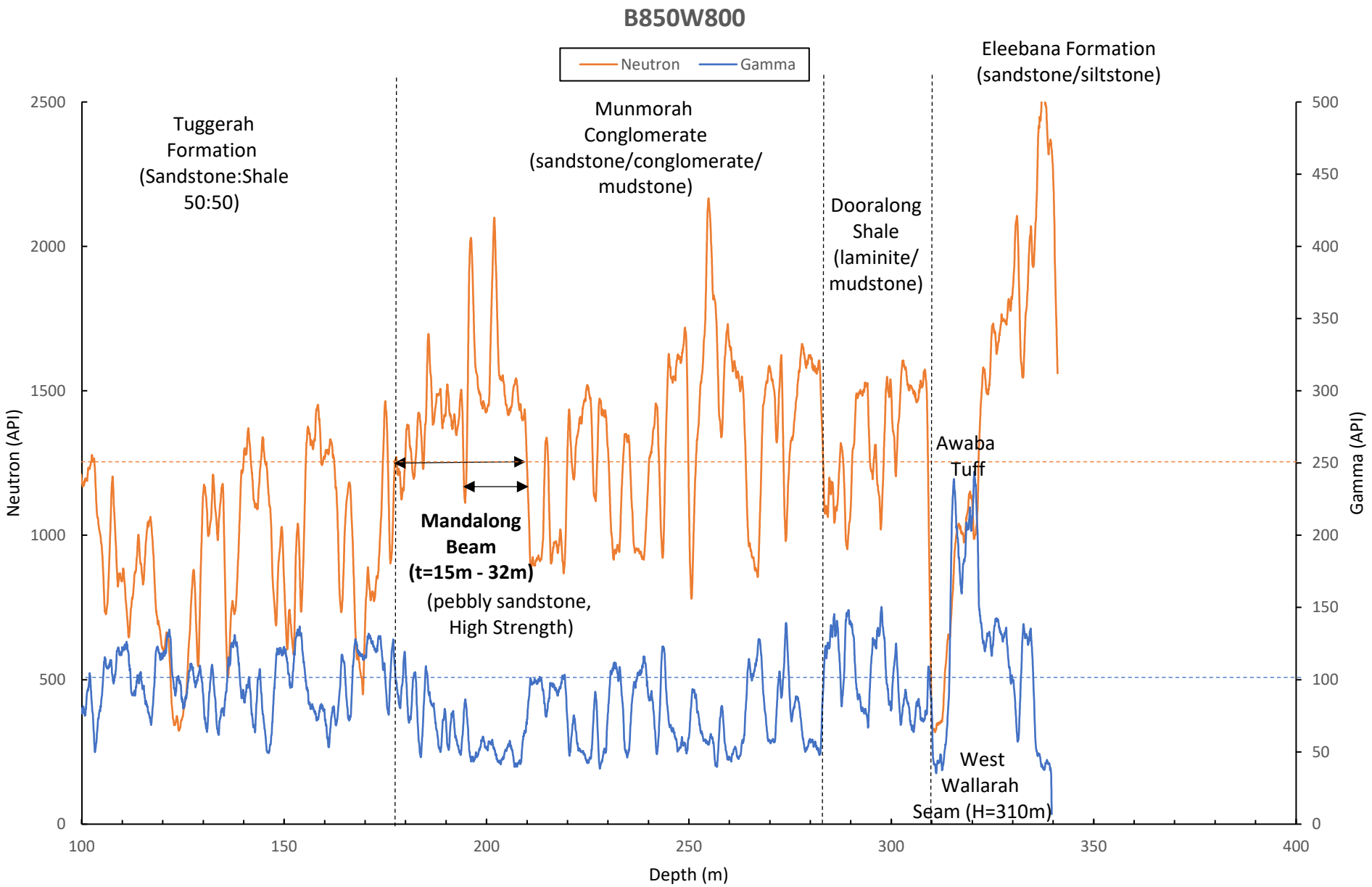
RQD = 100%.
Occasional carbonaceous wisps and vertebraria near top. End of hole. Drillers
T.D.= 472.200m. Drilling finished 06/10/98. Logged by Peter Doyle, completed on
14/10/98.

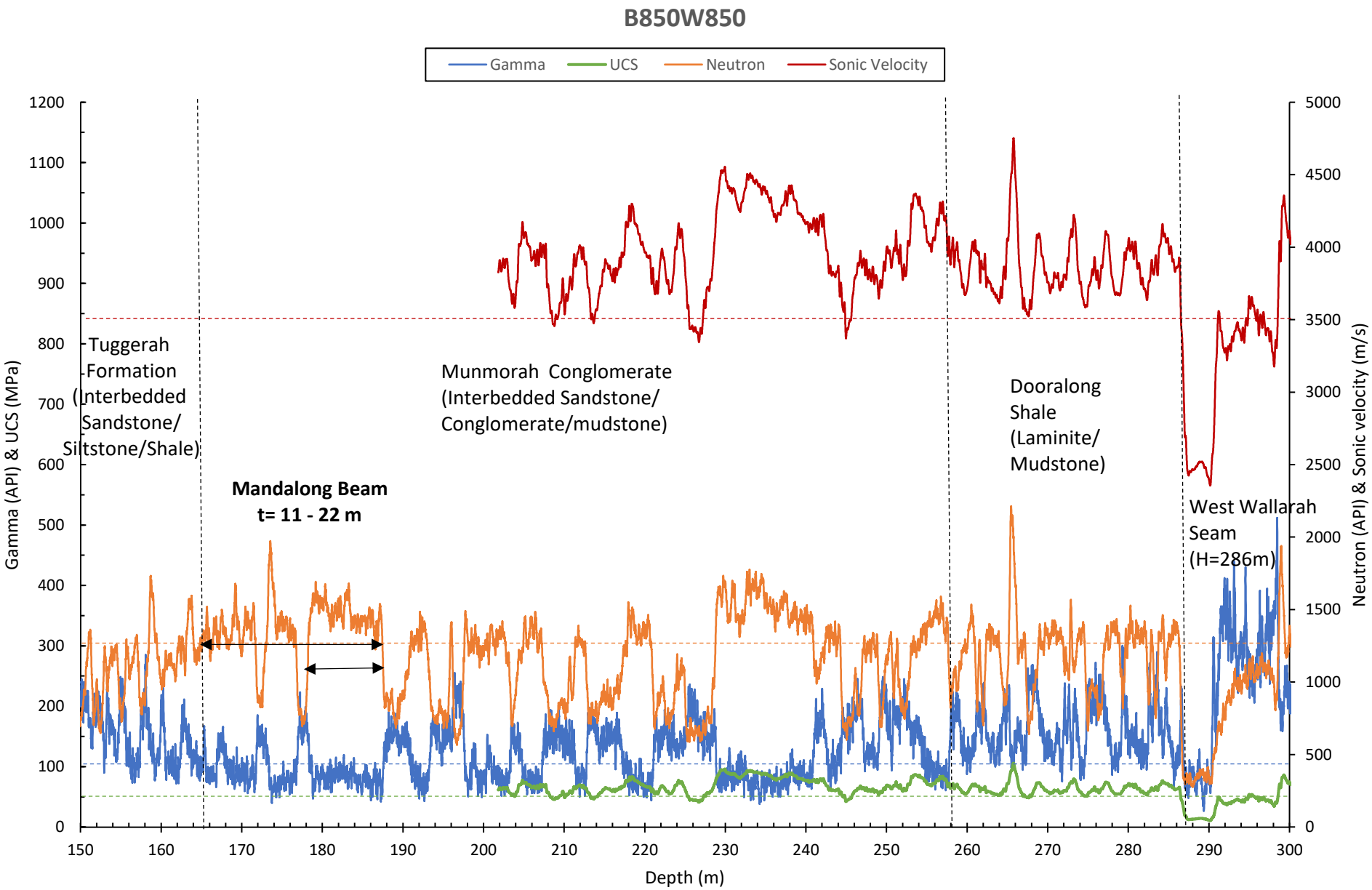
+----------+ +
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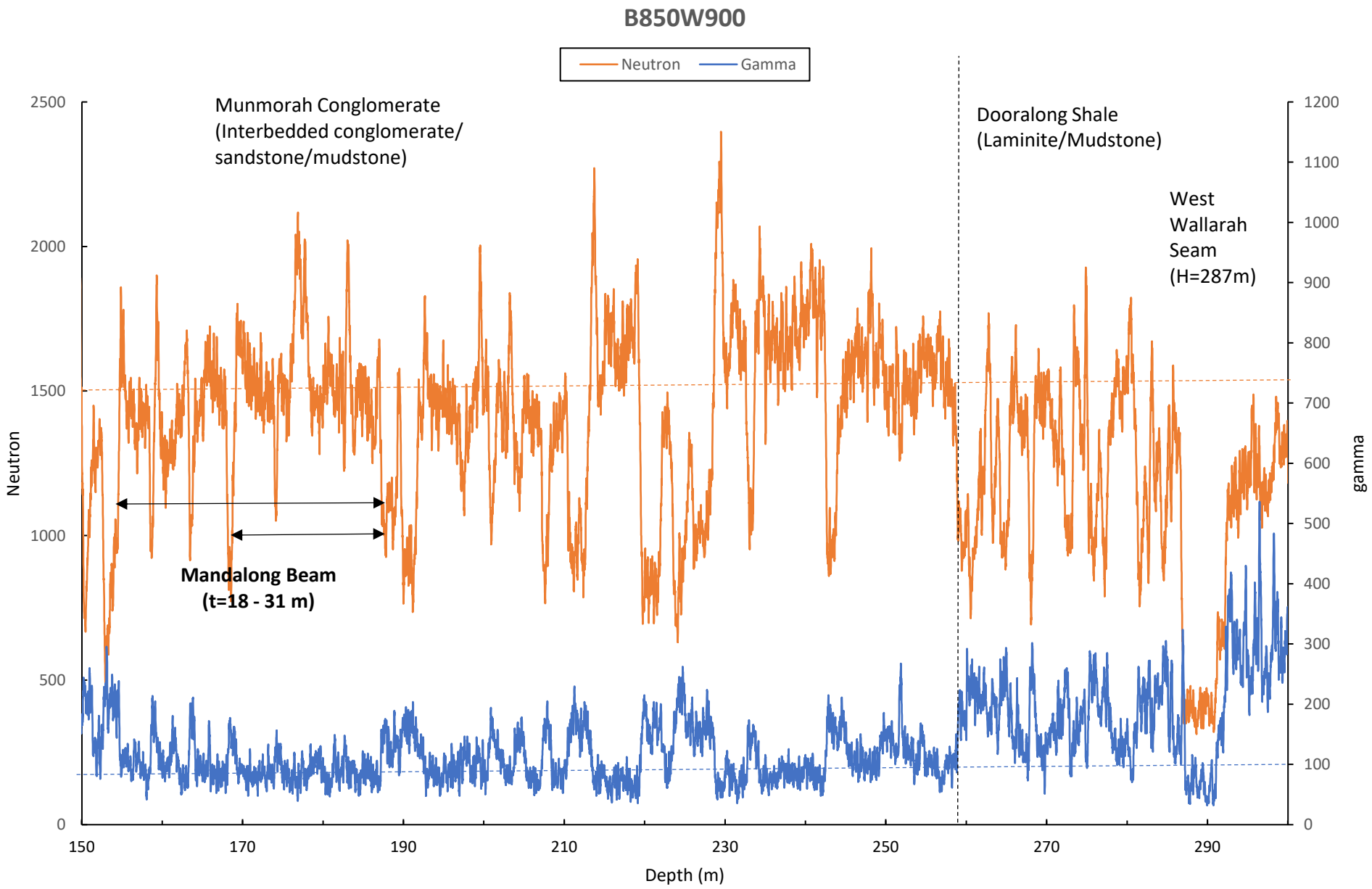

B800W850
Gamma
UCS
Sonic Velocity
Neutron
West Wallarah Seam (H=337m)
Mandalong Beam Pebbly Sandstone High Strength (t= 19 - 30 m)
Munmorah Conglomerate (interbedded sandstone/ conglomerate/mudstone)
Dooralong Shale (Laminite/ Mudstone)
Gamma (API) & UCS (MPa)
Neutron (API) & Sonic Velocity (m/s)
Depth (m)
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
200
220
240
260
280
300
320
340
360

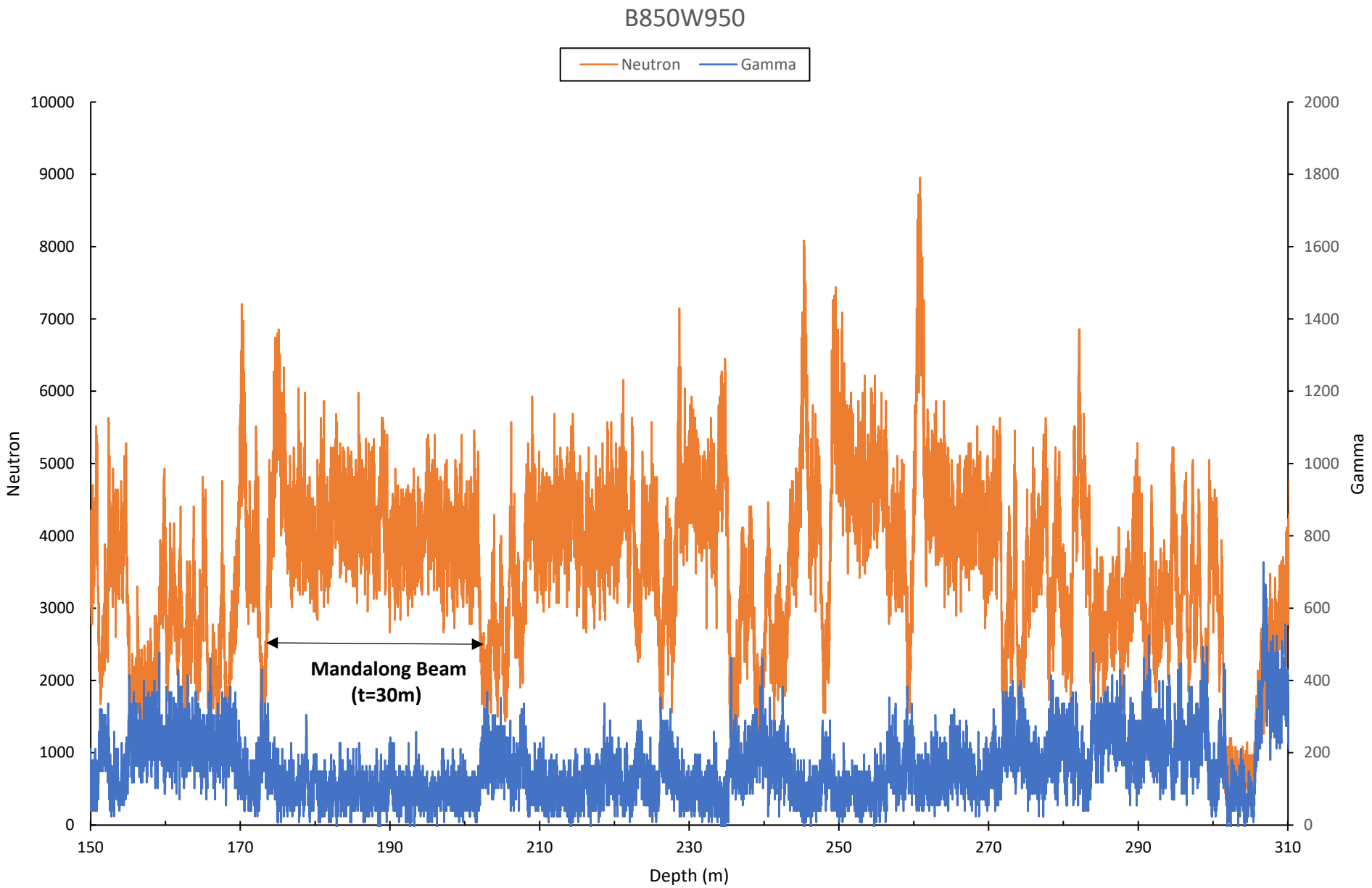

B800W900
Gamma
Neutron
Tuggerah Formation
(sandstone:siltstone:
mudstone)
Munmorah Conglomerate
(Interbedded Sandstone/
Conglomerate/mudstone)
Dooralong
Shale
(Laminite/
Mudstone)
West Wallarah
Seam
(H=315m)
Mandalong Beam
t= 14 - 30 m
Gamma (API)
Neutron (API)
Depth (m)
0
100
200
300
400
500
600
700
800
900
1000
0
500
1000
1500
2000
2500
3000
3500
150
170
190
210
230
250
270
290
310
330
350

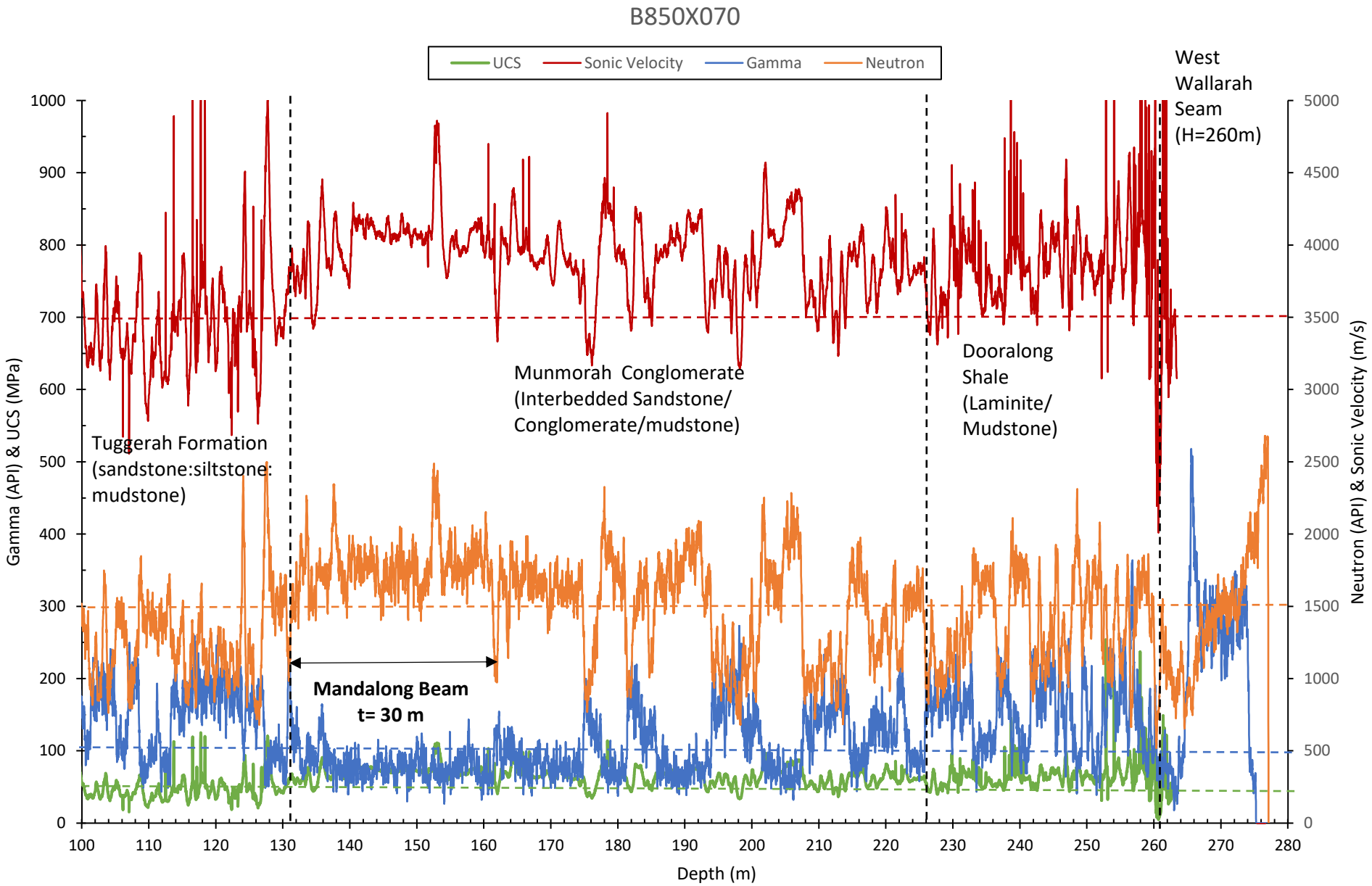

B850W700
UCS
Sonic velocity
Gamma
Neutron
West Wallarah
Seam
(H=380m)
Munmorah Conglomerate
(Interbedded Sandstone/
Conglomerate/mudstone)
Dooralong
Shale
(Laminite/
Mudstone)
Mandalong Beam
t= 14 - 33 m
Gamma (API) & UCS (MPaa)
Neutron (API) & Sonic Velocity (m/s)
Depth (m)
0
200
400
600
800
1000
1200
0
500
1000
1500
2000
2500
3000
3500
4000
4500
240
250
260
270
280
290
300
310
320
330
340
350
360
370
380
390
400
410
420

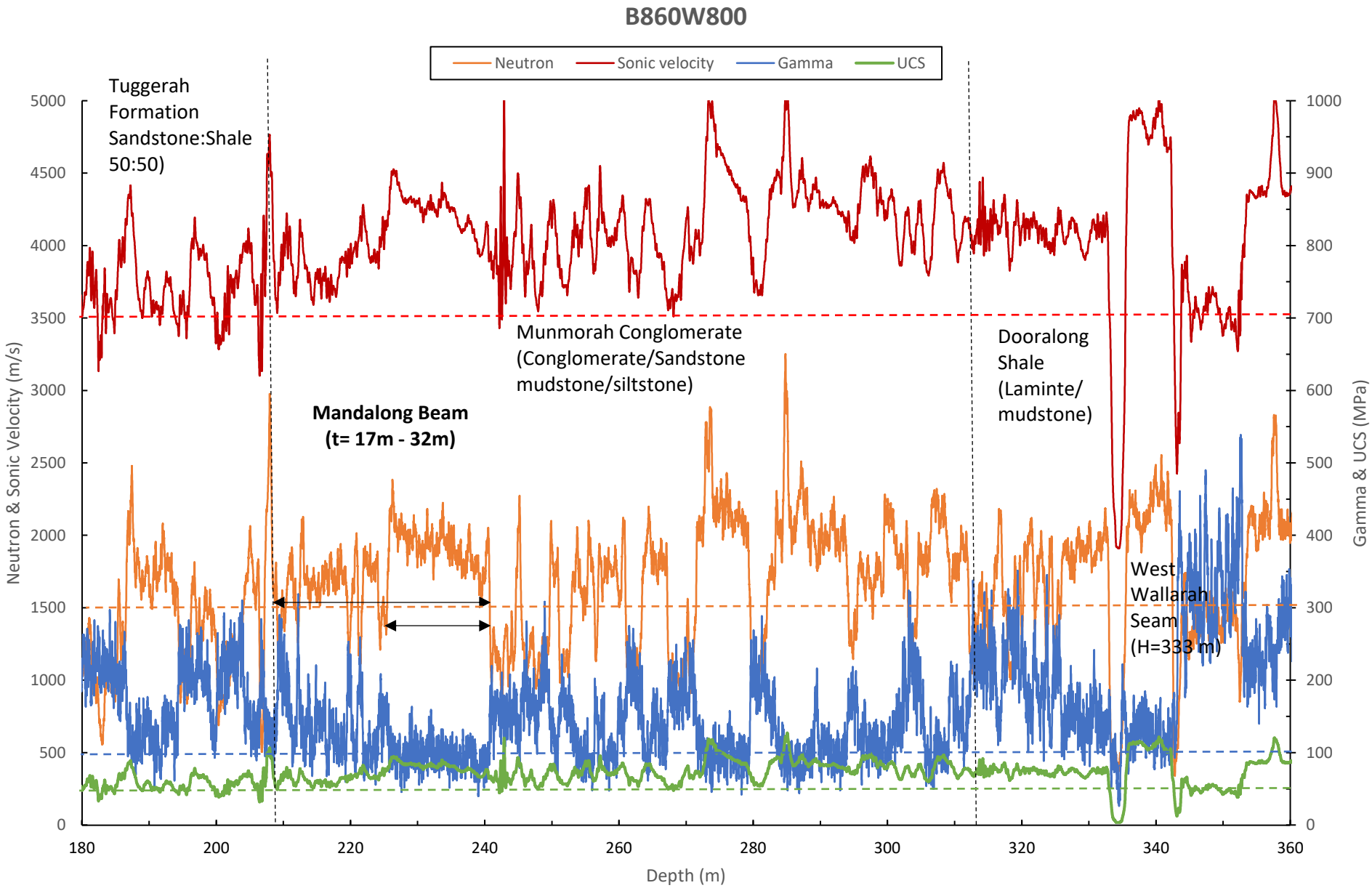

B850W800
Neutron
Gamma
Tuggerah Formation (Sandstone:Shale 50:50)
Munmorah Conglomerate (sandstone/conglomerate/ mudstone)
Dooralong Shale (laminite/ mudstone)
Eleebana Formation (sandstone/siltstone)
Awaba Tuff
Mandalong Beam (t=15m - 32m)
(pebbly sandstone, High Strength)
West Wallarah Seam (H=310m)
Neutron (API)
Gamma (API)
Depth (m)
2500
2000
1500
1000
500
0
500
450
400
350
300
250
200
150
100
50
0
100
150
200
250
300
350
400

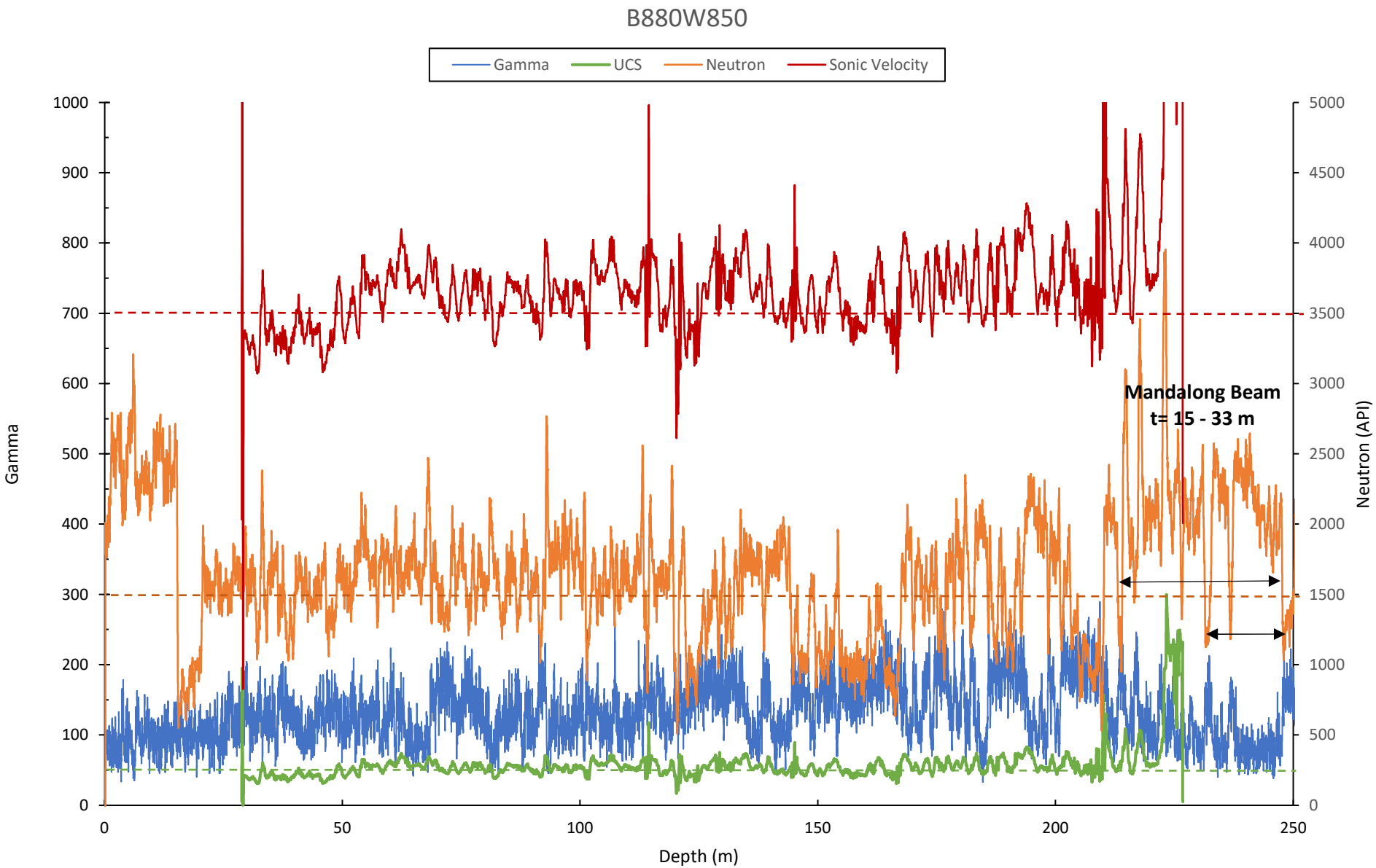

B850W850
Gamma
UCS
Neutron
Sonic Velocity
Gamma (API) & UCS (MPa)
Neutron (API) & Sonic velocity (m/s)
Depth (m)
Tuggerah Formation (Interbedded Sandstone/ Siltstone/Shale)
Munmorah Conglomerate (Interbedded Sandstone/ Conglomerate/mudstone)
Dooralong Shale (Laminite/ Mudstone)
West Wallarah Seam (H=286m)
Mandalong Beam t= 11 - 22 m

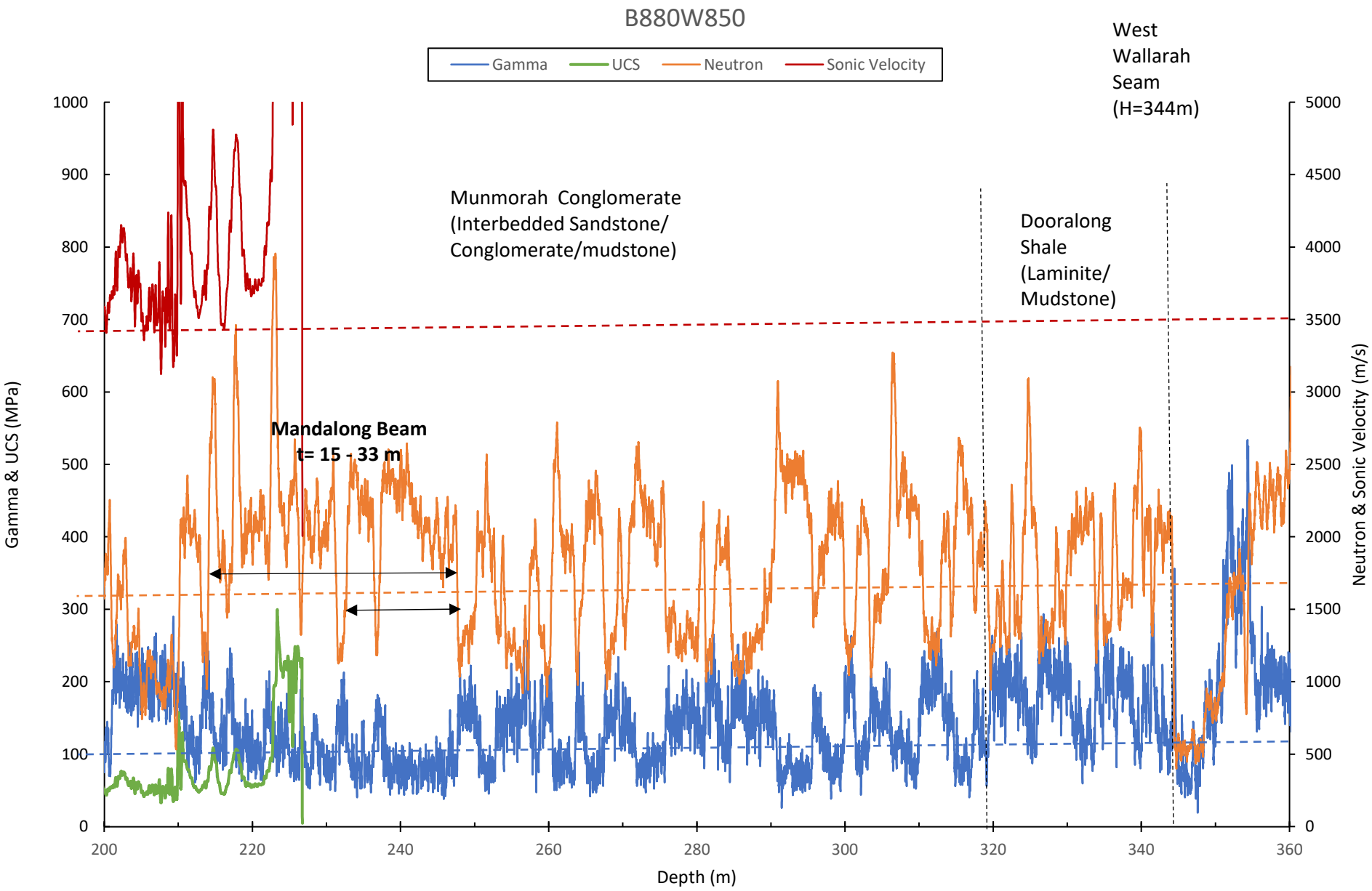

B850W900
Neutron
Gamma
Munmorah Conglomerate
(Interbedded conglomerate/
sandstone/mudstone)
Dooralong Shale
(Laminite/Mudstone)
West
Wallarah
Seam
(H=287m)
Mandalong Beam
(t=18 - 31 m)
Neutron
gamma
Depth (m)
2500
2000
1500
1000
500
0
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
150
170
190
210
230
250
270
290

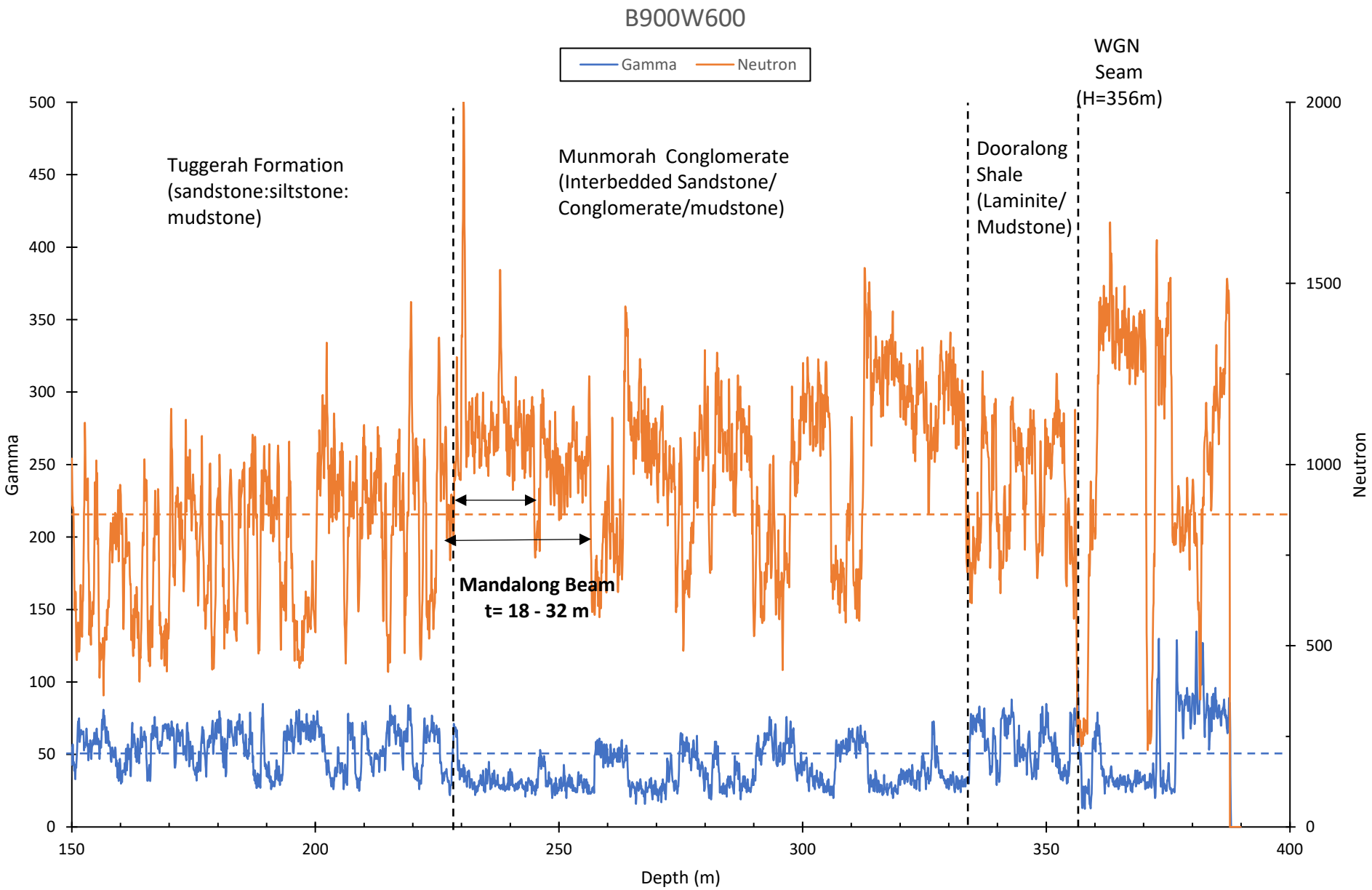

B850W950
Neutron
Gamma
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
2000
1800
1600
1400
1200
1000
800
600
400
200
0
150
170
190
210
230
250
270
290
310
Depth (m)
Mandalong Beam
(t=30m)

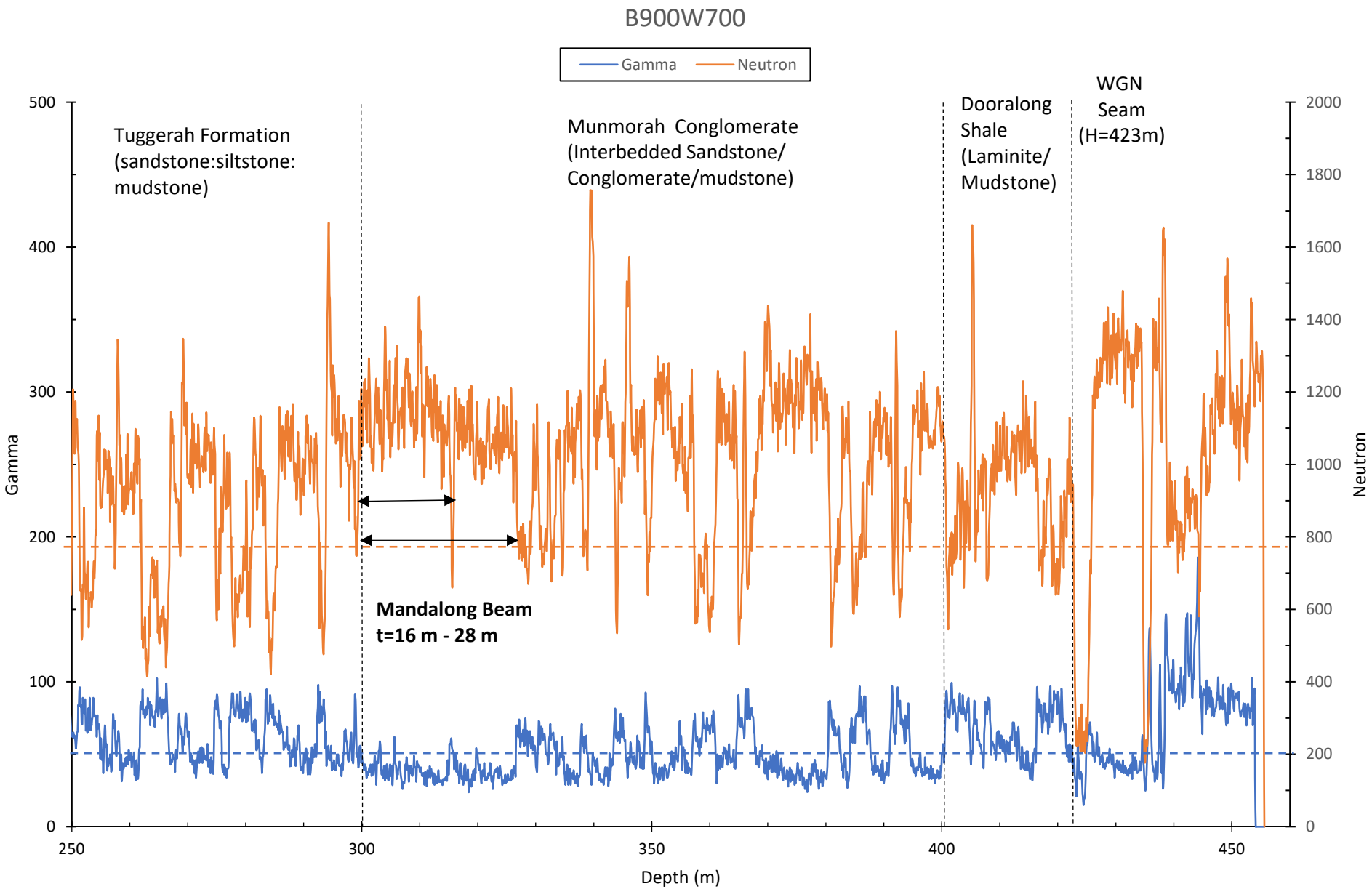

B850X070
UCS
Sonic Velocity
Gamma
Neutron
West Wallarah Seam (H=260m)
Tuggerah Formation (sandstone:siltstone: mudstone)
Munmorah Conglomerate (Interbedded Sandstone/ Conglomerate/mudstone)
Dooralong Shale (Laminite/ Mudstone)
Mandalong Beam t= 30 m
Gamma (API) & UCS (MPa)
Neutron (API) & Sonic Velocity (m/s)
Depth (m)
0
100
200
300
400
500
600
700
800
900
1000
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280

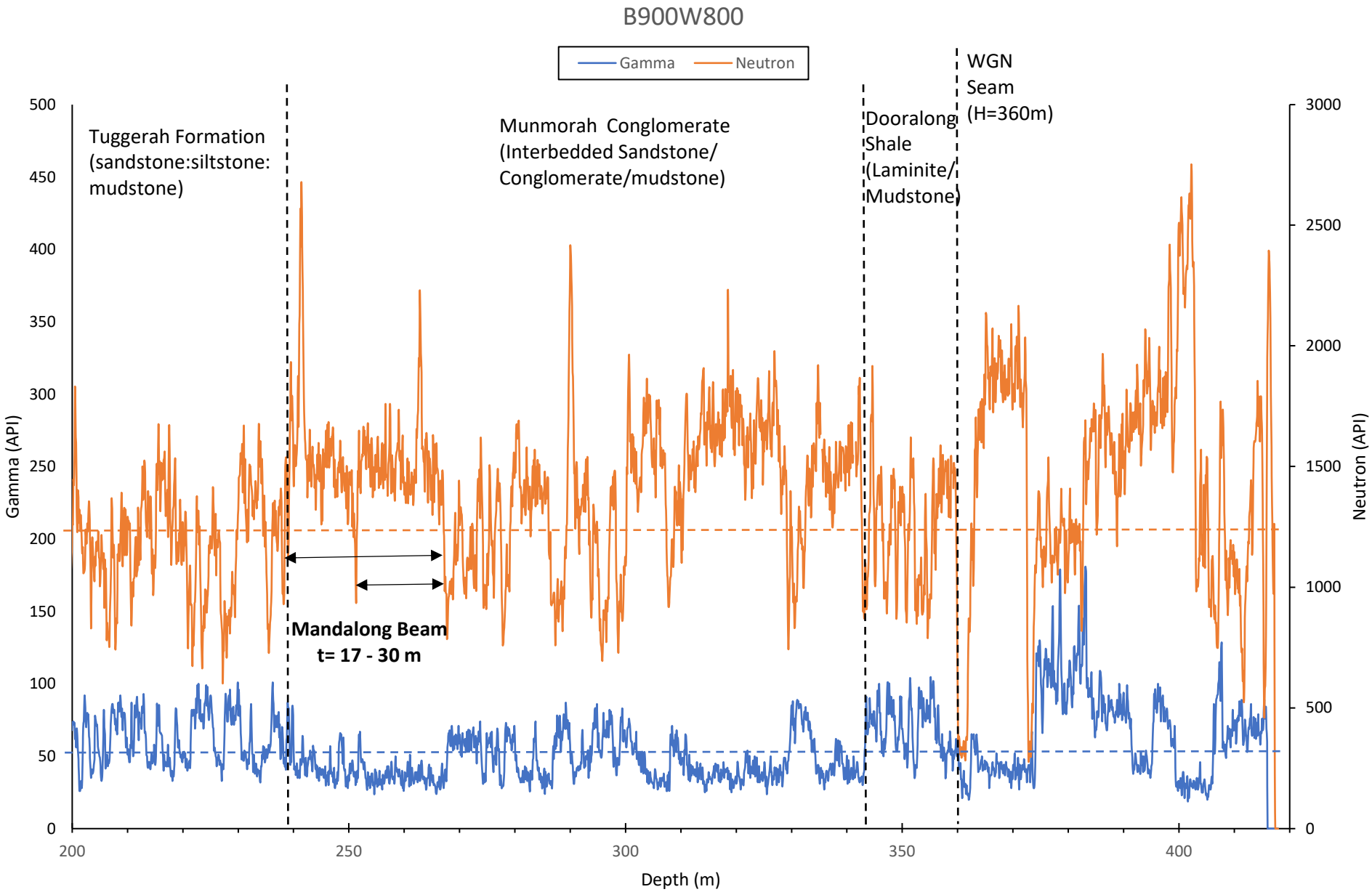

B860W800
Neutron
Sonic velocity
Gamma
UCS
Tuggerah Formation Sandstone:Shale 50:50)
Munmorah Conglomerate (Conglomerate/Sandstone mudstone/siltstone)
Dooralong Shale (Laminte/ mudstone)
Mandalong Beam (t= 17m - 32m)
West Wallarah Seam (H=333 m)
Neutron & Sonic Velocity (m/s)
Gamma & UCS (MPa)
Depth (m)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1000
900
800
700
600
500
400
300
200
100
0
180
200
220
240
260
280
300
320
340
360

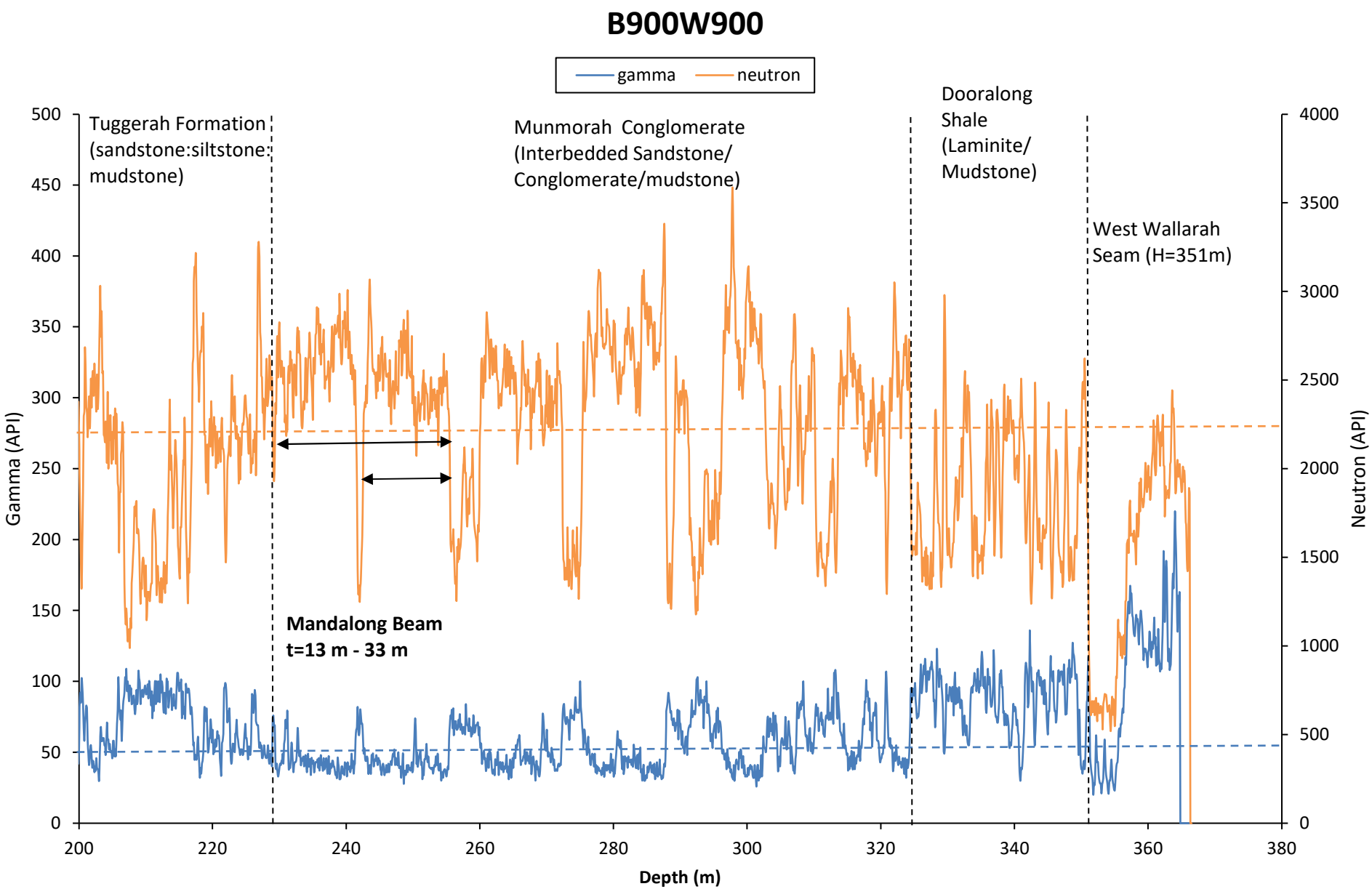

B880W850
Gamma
UCS
Neutron
Sonic Velocity
Mandalong Beam
t= 15 - 33 m
Gamma
Neutron (API)
Depth (m)
0
100
200
300
400
500
600
700
800
900
1000
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
0
50
100
150
200
250

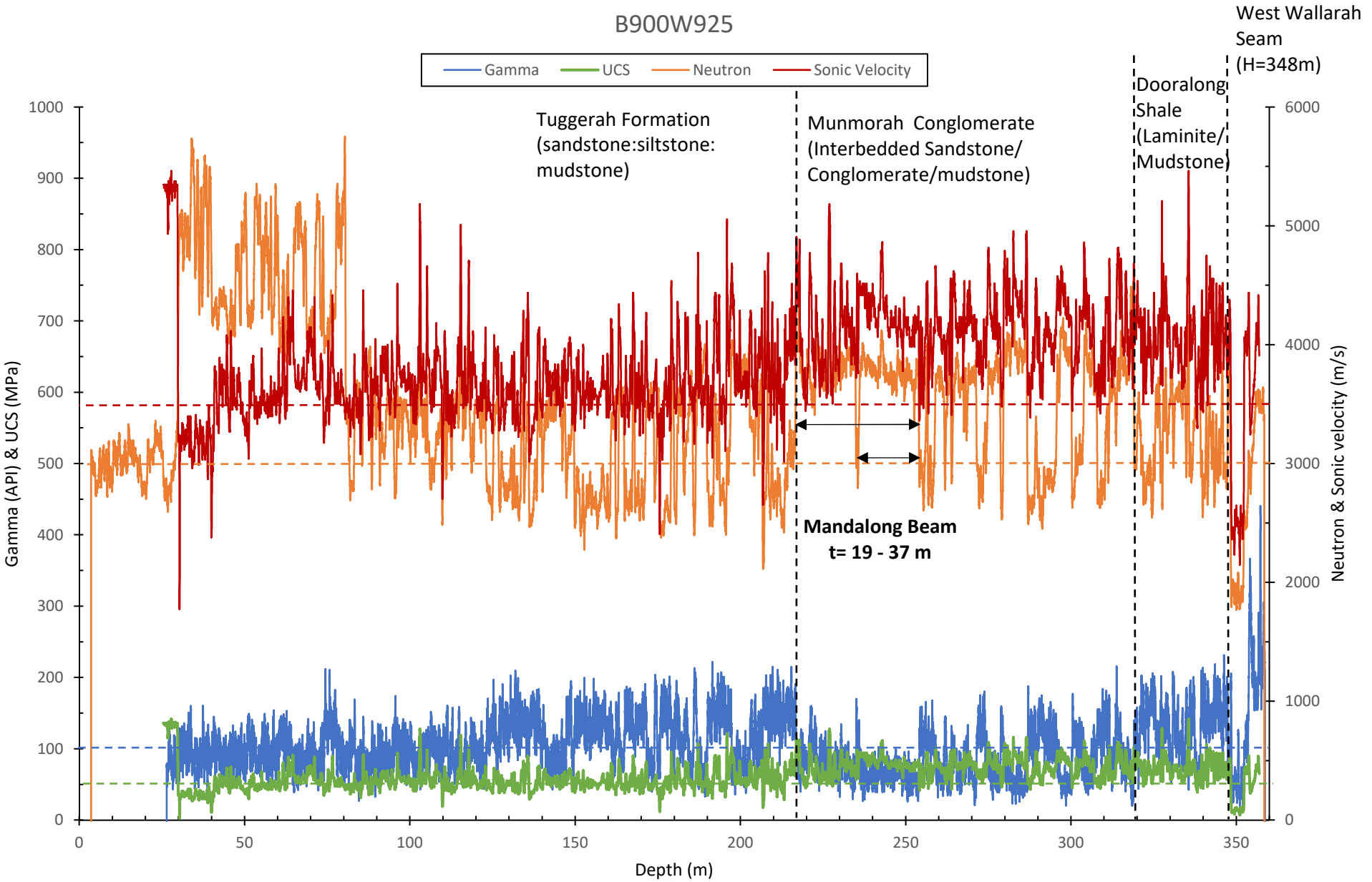

B880W850
Gamma
UCS
Neutron
Sonic Velocity
West
Wallarah
Seam
(H=344m)
Munmorah Conglomerate
(Interbedded Sandstone/
Conglomerate/mudstone)
Dooralong
Shale
(Laminite/
Mudstone)
Mandalong Beam
t= 15 - 33 m
Gamma & UCS (MPa)
Neutron & Sonic Velocity (m/s)
Depth (m)
0
100
200
300
400
500
600
700
800
900
1000
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
200
220
240
260
280
300
320
340
360

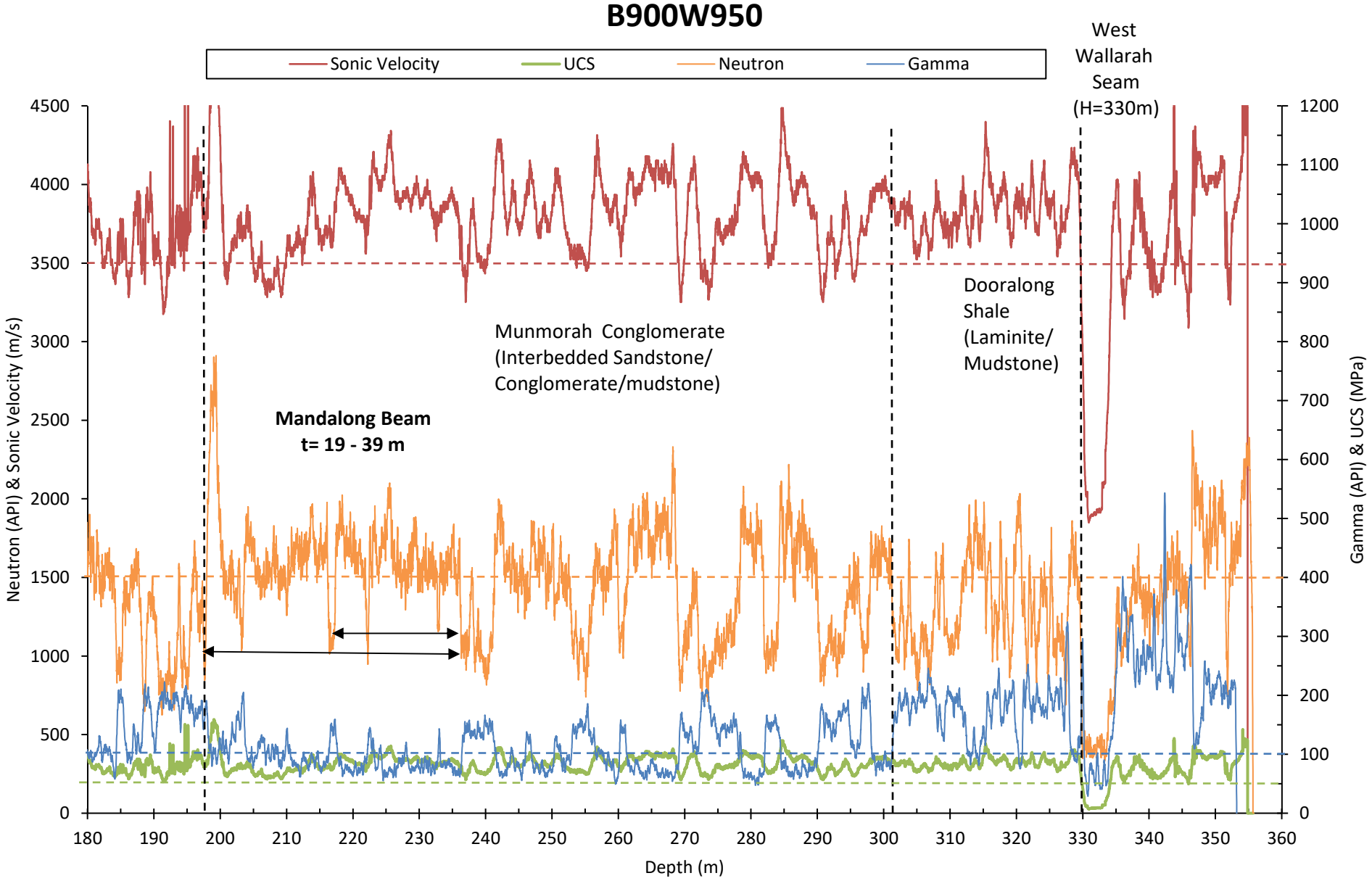

B900W600
Gamma
Neutron
WGN
Seam
(H=356m)
Tuggerah Formation
(sandstone:siltstone:
mudstone)
Munmorah Conglomerate
(Interbedded Sandstone/
Conglomerate/mudstone)
Dooralong
Shale
(Laminite/
Mudstone)
Mandalong Beam
t= 18 - 32 m
Gamma
Neutron
Depth (m)
500
450
400
350
300
250
200
150
100
50
0
2000
1500
1000
500
0
150
200
250
300
350
400

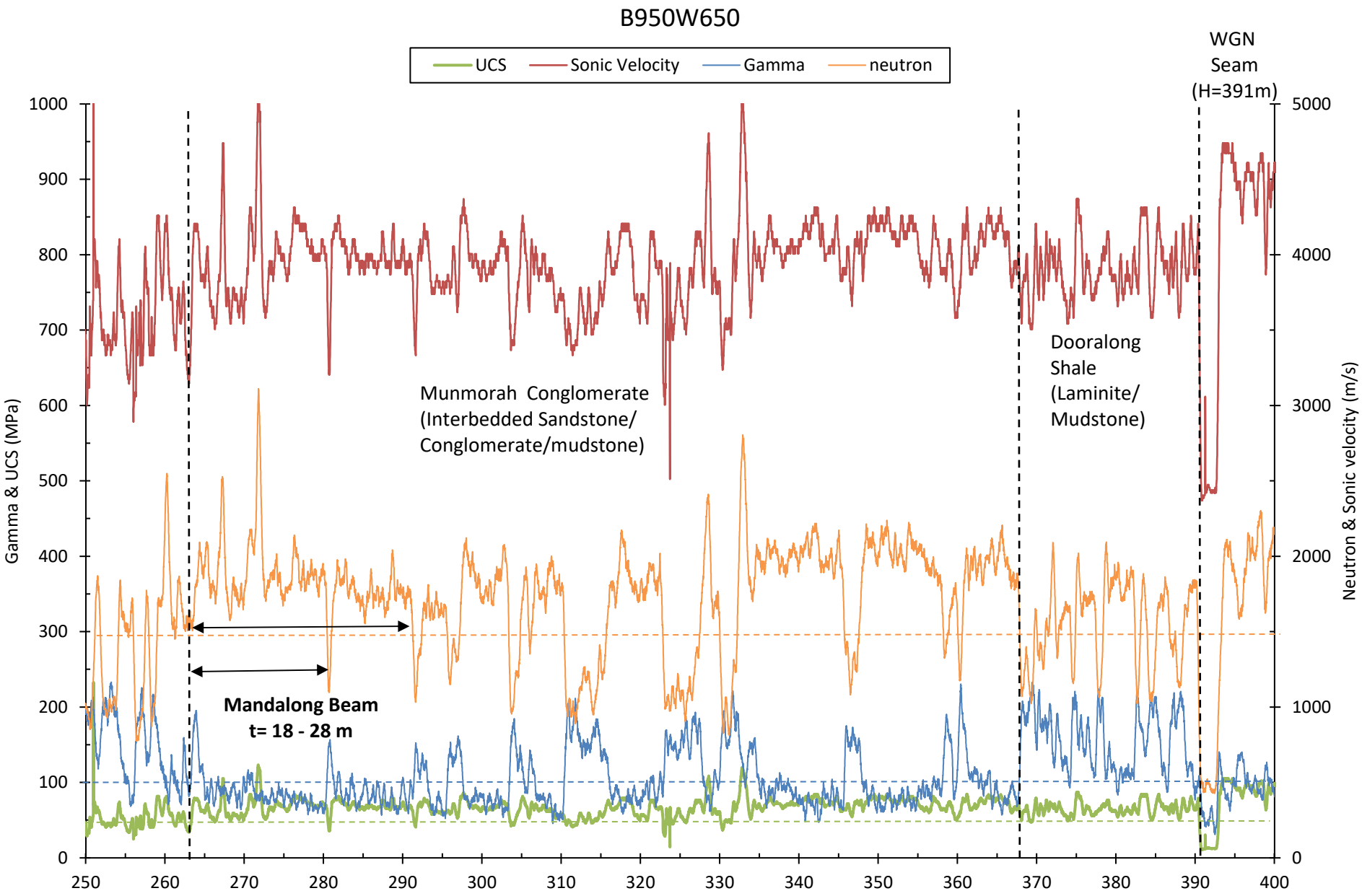

B900W700
Gamma
Neutron
Tuggerah Formation
(sandstone:siltstone:
mudstone)
Munmorah Conglomerate
(Interbedded Sandstone/
Conglomerate/mudstone)
Dooralong
Shale
(Laminite/
Mudstone)
WGN
Seam
(H=423m)
Mandalong Beam
t=16 m - 28 m
Gamma
Neutron
Depth (m)
0
100
200
300
400
500
0
200
400
600
800
1000
1200
1400
1600
1800
2000
250
300
350
400
450

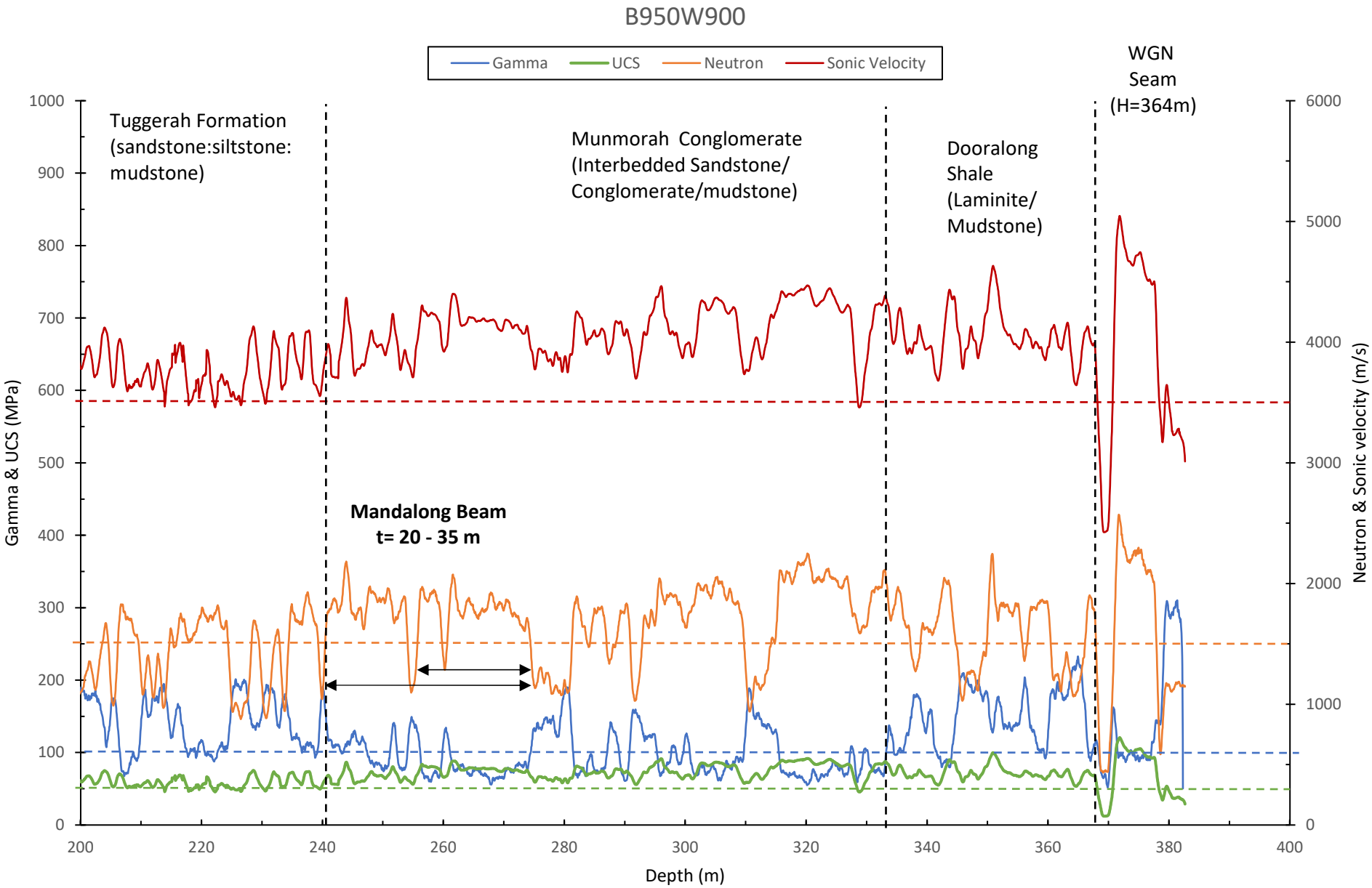

B900W800
Gamma
Neutron
Tuggerah Formation
(sandstone:siltstone:
mudstone)
Munmorah Conglomerate
(Interbedded Sandstone/
Conglomerate/mudstone)
Dooralong
Shale
(Laminite/
Mudstone)
WGN
Seam
(H=360m)
Mandalong Beam
t= 17 - 30 m
Gamma (API)
Neutron (API)
Depth (m)
500
450
400
350
300
250
200
150
100
50
0
3000
2500
2000
1500
1000
500
0
200
250
300
350
400

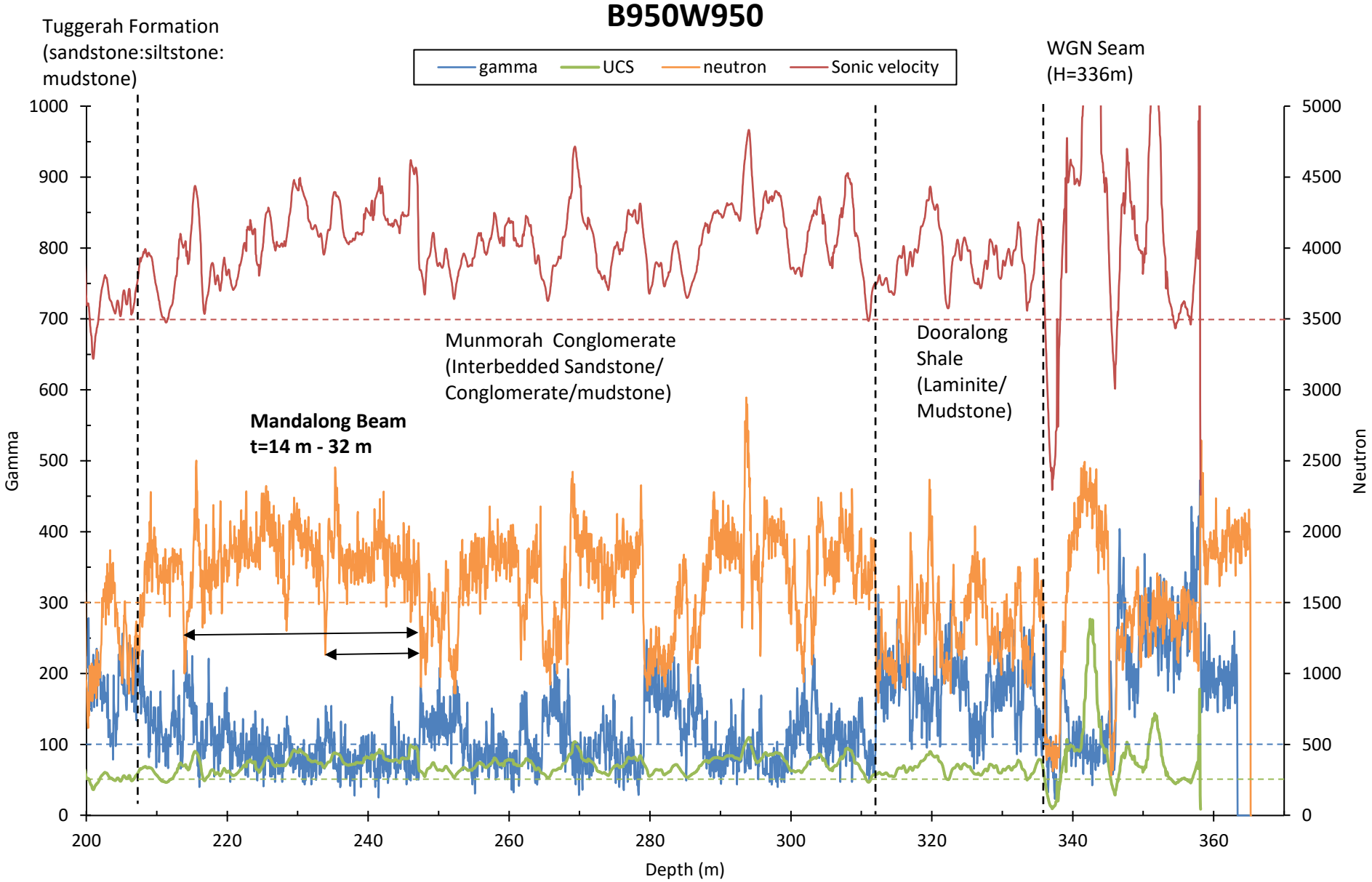

B900W900
gamma
neutron
Tuggerah Formation
(sandstone:siltstone:
mudstone)
Munmorah Conglomerate
(Interbedded Sandstone/
Conglomerate/mudstone)
Dooralong
Shale
(Laminite/
Mudstone)
West Wallarah
Seam (H=351m)
Mandalong Beam
t=13 m - 33 m
Gamma (API)
Neutron (API)
Depth (m)
0
50
100
150
200
250
300
350
400
450
500
0
500
1000
1500
2000
2500
3000
3500
4000
200
220
240
260
280
300
320
340
360
380

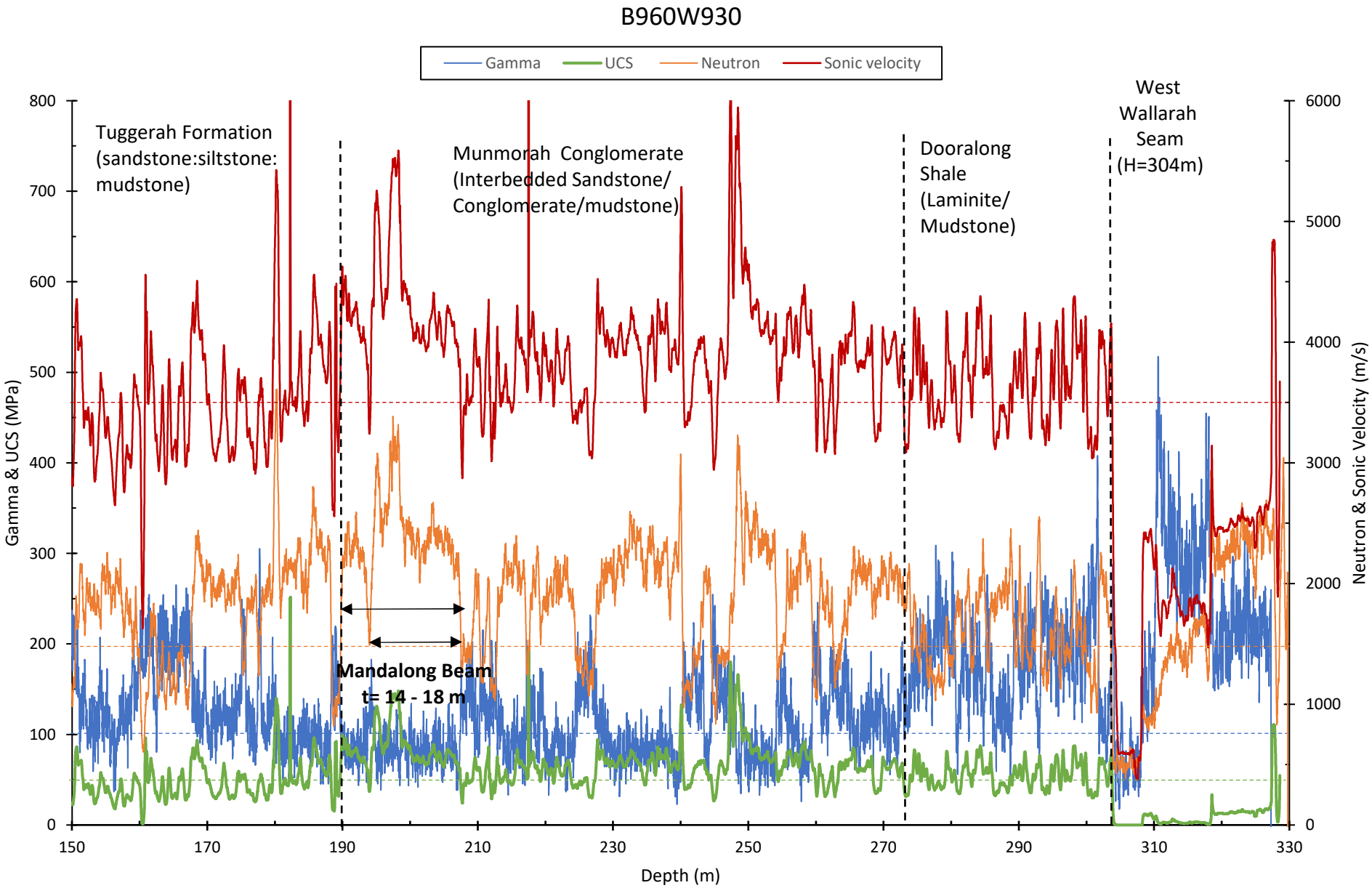

B900W925
Gamma
UCS
Neutron
Sonic Velocity
Tuggerah Formation
(sandstone:siltstone:
mudstone)
Munmorah Conglomerate
(Interbedded Sandstone/
Conglomerate/mudstone)
Dooralong
Shale
(Laminite/
Mudstone)
West Wallarah
Seam
(H=348m)
Mandalong Beam
t= 19 - 37 m
Gamma (API) & UCS (MPa)
Neutron & Sonic velocity (m/s)
Depth (m)
0
50
100
150
200
250
300
350
100
200
300
400
500
600
700
800
900
1000
1000
2000
3000
4000
5000
6000


B900W950
Sonic Velocity
UCS
Neutron
Gamma
West Wallarah Seam (H=330m)
Munmorah Conglomerate (Interbedded Sandstone/ Conglomerate/mudstone)
Dooralong Shale (Laminite/ Mudstone)
Mandalong Beam t= 19 - 39 m
Neutron (API) & Sonic Velocity (m/s)
Gamma (API) & UCS (MPa)
Depth (m)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
330
340
350
360


B950W650
UCS
Sonic Velocity
Gamma
neutron
WGN
Seam
(H=391m)
Munmorah Conglomerate
(Interbedded Sandstone/
Conglomerate/mudstone)
Dooralong
Shale
(Laminite/
Mudstone)
Mandalong Beam
t= 18 - 28 m
Gamma & UCS (MPa)
Neutron & Sonic velocity (m/s)
0
100
200
300
400
500
600
700
800
900
1000
0
1000
2000
3000
4000
5000
250
260
270
280
290
300
310
320
330
340
350
360
370
380
390
400


B950W900
Gamma
UCS
Neutron
Sonic Velocity
Tuggerah Formation
(sandstone:siltstone:
mudstone)
Munmorah Conglomerate
(Interbedded Sandstone/
Conglomerate/mudstone)
Dooralong
Shale
(Laminite/
Mudstone)
WGN
Seam
(H=364m)
Mandalong Beam
t= 20 - 35 m
Gamma & UCS (MPa)
Neutron & Sonic velocity (m/s)
Depth (m)
0
100
200
300
400
500
600
700
800
900
1000
0
1000
2000
3000
4000
5000
6000
200
220
240
260
280
300
320
340
360
380
400


B950W950
Tuggerah Formation
(sandstone:siltstone:
mudstone)
gamma
UCS
neutron
Sonic velocity
WGN Seam
(H=336m)
Munmorah Conglomerate
(Interbedded Sandstone/
Conglomerate/mudstone)
Dooralong
Shale
(Laminite/
Mudstone)
Mandalong Beam
t=14 m - 32 m
Gamma
Neutron
Depth (m)
1000
900
800
700
600
500
400
300
200
100
0
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
200
220
240
260
280
300
320
340
360


B960W930
Gamma
UCS
Neutron
Sonic velocity
Tuggerah Formation
(sandstone:siltstone:
mudstone)
Munmorah Conglomerate
(Interbedded Sandstone/
Conglomerate/mudstone)
Dooralong
Shale
(Laminite/
Mudstone)
West
Wallarah
Seam
(H=304m)
Mandalong Beam
t= 14 - 18 m
Gamma & UCS (MPa)
Neutron & Sonic Velocity (m/s)
Depth (m)
0
100
200
300
400
500
600
700
800
0
1000
2000
3000
4000
5000
6000
150
170
190
210
230
250
270
290
310
330

Appendix B

Water resources impact assessment









Mandalong Mine Modification 10

Water Resources Impact Assessment

Centennial Mandalong Pty Ltd

13 September 2021

→ The Power of Commitment



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Executive summary

Introduction

Mandalong Mine is an underground coal mine located approximately 35 km south-west of Newcastle on the western side of Lake Macquarie operated by Centennial Mandalong Pty Limited. Mandalong Mine consists of underground mine workings and surface facilities located at three sites: Mandalong Mine Access Site, Mandalong South Surface Site and Delta Entry Site.

GHD Pty Ltd was commissioned to prepare a Water Resources Impact Assessment to assess potential impacts of the Mandalong Mine Longwall Panel 34 (LW34) and adjustments to the mine plan (the proposed modification) on groundwater and surface water environments.

Centennial Mandalong is seeking to modify SSD-5144, pursuant to Section 4.55(2) of the EP&A Act, to change Mandalong's approved mine plan to include LW34. The addition of LW34 will maximise resource extraction within the West Wallarah Seam and Mandalong's development consent boundary and improve the continuity of coal extraction and employment at Mandalong. Two updates to Appendix 8 of SSD-5144 are also proposed.

Site description

The modification area for the WRIA primarily encompasses the 20 mm subsidence contour around the extraction area of LW34. The modification area is located within the Morans Creek and Buttonderry Creek catchments. These creeks are ephemeral and do not have surface water flow for the entire year. Generally, these watercourses flow for relatively brief periods following significant rainfall events. Morans Creek contributes to the wider Dora Creek catchment via Stockton Creek, while Buttonderry Creek ultimately reports to the Wyong River.

The groundwater sources near Mandalong Mine are generally low yielding and predominantly weathered and/or fractured sandstone, coal seams and clayey Quaternary alluvium. Two key hydrogeological units exist within the modification area: alluvial and fractured and porous rock (comprising of both coal seam and overburden rock) groundwater sources.

Water management

The objective of the water management system at Mandalong Mine is to separate clean and dirty water in order to manage impacts to water quality and to manage transfers between surface and underground water storages. Underground water is transferred to the former Cooranbong Colliery underground workings (known as the Cooranbong underground storage) where it is pumped to the Borehole Dam for discharge through a licensed discharge point (LDP001) at Cooranbong Entry Site (part of the Northern Coal Logistics Project SSD-5145). Sources of water that contribute to the underground storage include groundwater seepage, potable water required for underground mining equipment and various transfers from surface water storages.

Monitoring network

The existing groundwater monitoring network consists of standpipe monitoring bores installed in alluvial and fractured and porous rock groundwater sources. Monitoring is undertaken quarterly for levels and quality (pH and electrical conductivity). Some bores contain water level loggers for continuous monitoring of groundwater levels.

The existing surface water monitoring program consists of monthly and quarterly surface water quality monitoring at eleven locations, two of which are located on Morans Creek upstream of the modification area and one on Buttonderry Creek. Flow and level monitoring of Morans Creek was undertaken between 2006 and 2009 and restarted in 2017.

Groundwater levels

Alluvial groundwater levels have generally fluctuated over time within a range of 2 m to 3 m below ground level. A statistically significant relationship exists between alluvial groundwater levels and rainfall at most monitoring locations. No long-term changes in alluvial groundwater levels attributable to mining at Mandalong Mine are evident.

Analysis of monitoring data for fractured and porous groundwater sources indicates that depressurisation (by greater than 2 m) occurs up to 240 m above longwall panels at Mandalong Mine, with complete depressurisation occurring up to 120 m above longwalls. At a number of monitoring locations that have shown depressurisation due to mining, groundwater levels have stabilised or started to gradually increase towards pre-mining levels approximately three to five years after undermining occurring. As the depth of cover above the proposed additional longwall LW34 is approximately 300 to 450 m, it is therefore unlikely that there would be depressurisation of shallow rock aquifers (and associated potential groundwater dependent ecosystems) within this area.

Hydrogeological modelling was undertaken to estimate groundwater seepage into the Mandalong Mine workings and determine groundwater drawdown associated with Mandalong Mine and the proposed workings. The model predicts that underground mining at Mandalong Mine (including the proposed addition of LW34) is unlikely to result in a water table drop greater than 0.1 m (limit of accuracy of the model) within the alluvial groundwater throughout the period of mining. Any reductions in alluvial groundwater levels are expected to be temporary and localised and may occur during undermining as a result of the development of shallow tensile and compressive cracks and resulting localised increases in hydraulic conductivity and porosity. It is expected that these cracks would fill over time and the hydraulic conductivity and porosity should return to pre-mining values.

Loss of groundwater from the fractured and porous rock groundwater source to the existing, proposed and approved Mandalong Mine workings is predicted by the hydrogeological modelling to increase over the period of mining from 1.2 ML/day in 2020 to a peak of 2.0 ML/day in 2035. Modelled groundwater inflows for the proposed mine plan are less than for the approved mine plan (under Modification 9) by up to 0.3 ML/day. This is due to the shortening of the length of LW30 and the removal of LW33 from the mine plan. These proposed changes in the mine plan will also result in a contraction in the 2 m drawdown contour to the southwest of the proposed mine workings within layer 6 of the hydrogeological model (overburden rock to a height of 50 m above the coal seam) at the completion of mining. There are no registered bores to the southwest of the mine workings where the drawdown contours have contracted.

The predicted impacts on alluvial groundwater and fractured and porous rock groundwater attributable to the proposed addition of LW34 are expected to be less than the Level 1 minimal impact considerations from the NSW Aquifer Interference Policy and are therefore considered to be acceptable.

Groundwater quality

Alluvial groundwater pH is consistently within the range of 5 to 8 and groundwater EC varies considerably within the alluvium across the area of the Mandalong Mine workings, ranging from less than 1,000 µS/cm to over 10,000 µS/cm. Fractured and porous rock groundwater is consistently between pH 6 and 8, with EC typically ranging from about 6,000 µS/cm to over 10,000 µS/cm. No change in groundwater pH or EC resulting in a lowering of the beneficial use category is evident since longwall mining began in 2005.

It is not expected that the proposed addition of LW34 would reduce the beneficial use category of alluvial groundwater or fractured and porous rock groundwater in the vicinity of LW34.

Water and salt balance

Water and salt balance modelling for Mandalong Mine was undertaken for the projected life of the mine, from current conditions in 2022 to the end of mining in 2038. The predicted groundwater inflows that were obtained from hydrogeological modelling were incorporated into the water and salt balance model. To assess the impact of rainfall on the site, modelling was completed by using a historical time series of daily rainfall data extending over 132 years.

Slight changes in the water balance and salt balance of Mandalong Mine are expected as a result of the proposed modification. As the predicted groundwater inflows slightly decreased for proposed conditions, therefore discharges via LDP001 are slightly lower for proposed conditions, compared to approved conditions. Discharges via LDP001 in 2035 were modelled to be 1,170 ML/year under proposed conditions compared to 1,180 ML/year under approved conditions with a proportional decrease in the average salinity of the underground workings and discharge via LDP001.

Surface water quality

Subsidence fracturing may expose previously unweathered near-surface rock, which when weathered can release substances such as the metals aluminium, cobalt, iron, manganese, nickel and zinc into surface water or shallow groundwater. Elevated salinity and potentially ecotoxic metal concentrations could be observed downstream of areas with such subsidence fracturing. Baseline surface water quality monitoring has identified some metal species are elevated relative to default guideline values and nearby Morans Creek.

Watercourse geomorphology

Subsidence can impact watercourse integrity by changing channel morphology and behaviour due to changes in valley floor tilt and bed cracking. Potential impacts of the proposed modifications are shifts in overall geomorphic behaviour and character, including changes to geomorphic type. One short reach of a first order tributary of Mannering Creek was identified as potentially impacted outside of the previously assessed angle of draw of the approved workings. The watercourse was considered to be bedrock confined and therefore has low susceptibility to geomorphic impacts.

Downstream water users

No potentially impacted downstream surface water users were identified and therefore no impacts are expected.

Mitigation, management and monitoring

The site-specific water management plan for Mandalong Mine and regional discharge management plan will be reviewed and, if necessary, updated to include any changes to water management required by the proposed modification. These revised management plans will then be implemented. Extraction plans will be developed and implemented for each extraction area prior to mining, including the recommended additional watercourse stability monitoring.

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Glossary

Alkalinity	A measure of the ability of an aqueous solution to neutralise acids. Alkalinity of natural waters is due primarily to the presence of hydroxides, bicarbonates and carbonates. It is expressed in units of calcium carbonate ($CaCO_3$).
Alluvial	Deposition from running waters.
Ambient	Pertaining to the surrounding environment or prevailing conditions.
Aquifer	An underground layer of permeable material from which groundwater can be usefully extracted.
Australian Height Datum	A common national surface level datum approximately corresponding to sea level
Average recurrence interval	A statistical estimate of the average period in years between the occurrence of a flood of a given size or larger, e.g. floods with a discharge equivalent to the 1 in 100-year average recurrence interval flood event will occur on average once every 100 years.
Baseflow	The component of flow in a watercourse that is driven from the discharge of underground water.
Baseline monitoring	Monitoring conducted over time to collect a body of information to define specific characteristics of an area (e.g. species occurrence or water quality) prior to the commencement of a specific activity.
Bore	Constructed connection between the surface and a groundwater source that enables groundwater to be transferred to the surface either naturally or through artificial means.
Catchment	The land area draining through the main stream, as well as tributary streams, to a particular location.
Clean water	Water that has not come into physical contact with coal or mined carbonaceous material.
Cumulative rainfall departure	Monthly accumulation of the difference between the observed monthly rainfall and long-term average monthly rainfall.
Dewatering	The removal or pumping of water from an above or below ground storage, including the mine water within the water collection system of mine workings. Water removed from mine workings is regarded as dewatering unless the workings are flooded and at equilibrium with the surrounding strata (in which case the removal is considered groundwater extraction).
Dirty water	Water that has an elevated sediment load.
Discharge	The quantity of water per unit of time flowing in a stream, for example cubic metres per second or megalitres per day.
Drawdown	A reduction in piezometric head within an aquifer.
Electrical conductivity	A measure of the concentration of dissolved salts in water.
Ephemeral	Stream that is usually dry, but may contain water for rare and irregular periods, usually after significant rain.

Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or overland runoff before entering a watercourse and/or coastal inundation resulting from super elevated sea levels and/or waves overtopping coastline defences.
Floodplain	Area of land that is periodically inundated by floods up to the probable maximum flood event.
Fracture	Cracks within the strata that develop naturally or as a result of underground works.
Geomorphology	Scientific study of landforms, their evolution and the processes that shape them. In this report relates to the form and structure of waterways.
Goaf	The part of a mine from which the mineral has been partially or wholly removed, including the waste left in workings.
Groundwater	Water occurring naturally below ground level.
Groundwater extraction	For the purposes of this report, groundwater extraction has been defined as the removal of groundwater from a groundwater source or aquifer, either via direct removal for use via a production bore or via incidental flow of groundwater from the aquifer into the mine workings during and after mining. Groundwater extraction includes the pumping of underground water from flooded mine workings in equilibrium with the surrounding strata as well as the removal of water from perched aquifers recharged directly from rainfall infiltration.
Guideline value	The concentration or load of physicochemical characteristics of an aquatic ecosystem, below which there exists a low risk that adverse ecological effects will occur. They indicate a risk of impact if exceeded and should 'trigger' action to conduct further investigations or to implement management or remedial processes.
Headcut	Erosional feature where an abrupt vertical drop in the stream bed occurs, resembling a small waterfall when the stream is flowing or a short bluff when the stream is dry.
Hydrogeology	The area of geology that deals with the distribution and movement of groundwater in soils and rocks.
Hydrology	The study of rainfall and surface water runoff processes.
Infiltration	The downward movement of water into soil and rock. It is largely governed by the structural condition of the soil, the nature of the soil surface (including presence of vegetation) and the antecedent moisture content of the soil.
Interseam	The strata between the coal seams.
Ion	Electrically charged atom.
Licensed discharge point	A location where the premises discharge water in accordance with conditions stipulated within the site environmental protection licence.
Longwall	Longwall mining is a form of underground coal mining where a block of coal is mined using a longwall shearer. The longwall mining method is supported by roadway development, mined using a continuous miner unit.
Median	The middle value, such that there is an equal number of higher and lower values. Also referred to as the 50th percentile.
Overburden	The strata between the recoverable topsoil and the upper coal seam.

Percentile	The value of a variable below which a certain percent of observations fall. For example, the 80th percentile is the value below which 80% of values are found.
Permian Age	The youngest geological period of the Palaeozoic era, covering a span between approximately 250 and 290 million years.
pH	The value taken to represent the acidity or alkalinity of an aqueous solution. It is defined as the negative logarithm of the hydrogen ion concentration of the solution.
Potable water	Water of a quality suitable for drinking.
Reach	Defined section of a stream with a uniform character and behaviour.
Recharge	Inflow of water from surrounding strata into underground mine workings via infiltration. This can be as a result of rainfall events or from surrounding aquifers.
Riparian	Pertaining to, or situated on, the bank of a river or other water body.
Runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
Run of mine	Raw coal production (unprocessed).
Sediment	Soil or other particles that settle to the bottom of lakes, rivers, oceans and other waters.
Strata	Geological layers below the ground surface.
Stream order	Stream classification system, where order 1 is for headwater (new) streams at the top of a catchment. Order number increases downstream using a defined methodology related to the branching of streams.
Subsidence	The vertical difference between the pre-mining surface level and the post-mining surface level at a point.
Surface water	Water that is derived from precipitation or pumped from underground and may be stored in dams, rivers, creeks and drainage lines.
Topography	Representation of the features and configuration of land surfaces.
Tributary	A stream or river that flows into a main river or lake.
Turbidity	A measure of clarity (turbidity) of water. Turbidity in excess of 5 NTU is just noticeable to the average person.

Abbreviations

AHD	Australian Height Datum
AIP	NSW Aquifer Interference Policy
ARI	Average recurrence interval
bgl	Below ground level
BOD	Biochemical oxygen demand
BOM	Bureau of Meteorology
BSAL	Biophysical strategic agricultural land
c/t	Cut through
Centennial	Centennial Coal Company Limited
Centennial Mandalong	Centennial Mandalong Pty Limited
CES	Cooranbong Entry Site
CRD	Cumulative rainfall departure
DES	Delta Entry Site
DGV	Default guideline value
DPIW	Department of Primary Industries – Water
EC	Electrical conductivity
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPA	Environment Protection Authority
EPL	Environment protection licence
GDE	Groundwater dependent ecosystem
GHB	General head boundary
GHD	GHD Pty Ltd
HARTT	Hydrograph Analysis: Rainfall and Time Trends
HUA WSP	Hunter Unregulated and Alluvial Water Sources Water Sharing Plan
km	Kilometre
L/s	Litre per second
LDP	Licensed discharge point
LOR	Limit of reporting
LW	Longwall
m	Metre
m/mm	Metre per millimetre
m/month	Metre per month
m/s	Metre per second

m/year	Metre per year
mg/L	Milligram per litre
MHRDC	Maximum harvestable right dam capacity
ML	Megalitre
ML/day	Megalitre per day
ML/year	Megalitre per year
mm	Millimetre
mm/day	Millimetre per day
MMAS	Mandalong Mine Access Site
MR	Modification Report
MSSS	Mandalong South Surface Site
Mtpa	Million tonnes per annum
NCFPR WSP	North Coast Fractured and Porous Rock Groundwater Sources Water Sharing Plan
NTU	Nephelometric turbidity unit
NWQMS	National Water Quality Management Strategy
POEO Act	*Protection of the Environment Operations Act 1997*
ROM	Run of mine
SEE	Statement of Environmental Effects
SILO	Scientific Information for Land Owners
SSGV	Site-specific guideline value
t/year	Tonne per year
TARP	Trigger action response plan
TDS	Total dissolved solids
TKN	Total Kjeldahl nitrogen
TOC	Top of casing
TSS	Total suspended solids
Umwelt	Umwelt (Australia) Pty Limited
VWP	Vibrating wire piezometer
WAL	Water access licence
WM Act	*Water Management Act 2000*
WMP	Mandalong Mine Water Management Plan
WRIA	Water Resources Impact Assessment
WSP	Water sharing plan
µS/cm	Microsiemens per centimetre

1. Introduction

GHD Pty Ltd (GHD) was commissioned by Centennial Mandalong Pty Limited (Centennial Mandalong) to prepare a Water Resources Impact Assessment (WRIA) for the Mandalong Modification 10 (the proposed modification). Centennial Mandalong is a wholly owned subsidiary of Centennial Coal Company Limited (Centennial). Centennial is a wholly owned subsidiary of Banpu Company Limited (Banpu). This assessment forms part of a Modification Report (MR) to support an application to modify Mandalong's development consent SSD-5144 under Section 4.55(2) of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act).

1.1 Overview

Mandalong Mine (Mandalong) is an existing underground coal mine near Morisset, approximately 35 kilometres (km) south-west of Newcastle, predominantly in the Lake Macquarie local government area (LGA) (Figure 1.1). Mandalong is operated by Centennial Mandalong Pty Limited (Centennial Mandalong).

Centennial Mandalong has approval to extract run-of-mine (ROM) coal from the West Wallarah and Wallarah-Great Northern seams using a combination of longwall and continuous mining methods. Mandalong operates under State significant development (SSD) consent SSD-5144, which was granted on 12 October 2015 by the NSW Planning Assessment Commission under Part 4, Division 4.1 of the NSW Environmental Planning and Assessment Act 1979 (EP&A Act).

As identified in Mandalong's Mining Operations Plan (MOP) (Centennial Coal 2018), the progression of underground mining is regularly reviewed dependent on ongoing monitoring and geological conditions. Centennial Mandalong recently encountered poor geological conditions within the Mandalong Southern Extension Area, including a fault zone and igneous sill.

In response to these conditions and in order to maintain coal production, improve mining conditions and improve the financial viability of Mandalong, amendments to the approved mine plan were sought as part of a modification to SSD-5144 (herein referred to as MOD 9). As part of MOD 9, Centennial Mandalong sought approval to amend the approved mine plan, including the reorientation of LW30-LW33.

Since the approval of MOD 9 in April 2021, Centennial Mandalong has continued to review the progression of underground mining within the Mandalong Southern Extension Area. As a result of these investigations, the decision has been made to shorten LW30 and remove LW33 from the mine plan. The shortening of LW30 and removal of LW33 are estimated to result in the sterilisation of approximately 0.4 million tonnes (Mt) and 1.6 Mt of coal, respectively. Consequently, Centennial Mandalong has explored options to optimise the mine plan to access additional coal resources.

Centennial Mandalong is seeking to modify SSD-5144, pursuant to Section 4.55(2) of the EP&A Act, to change Mandalong's approved mine plan to include LW34 (herein referred to as MOD 10 or the proposed modification). The addition of LW34 will maximise resource extraction within the West Wallarah Seam and Mandalong's development consent boundary and improve the continuity of coal extraction and employment at Mandalong. Two updates to Appendix 8 of SSD-5144 are also proposed (Section 1.2.1 and Section 1.2.2).

1.2 Proposed modification

Centennial Mandalong is seeking to modify SSD-5144, pursuant to Section 4.55(2) of the EP&A Act, to include LW34. The previously approved and proposed mine plans for the Mandalong Southern Extension Area are shown in Figure 1.2.

LW34 will align with adjacent panels by maintaining the existing panel width of 200 m and all other mining geometry aspects will remain unchanged. Secondary extraction of coal as part of the proposed modification will remain within the currently assessed and approved footprint for secondary extraction.

No changes to the development consent boundary are required.

1.2.1 Exploration drilling

Centennial Mandalong is also seeking approval to amend one of the existing commitments in Appendix 8 of SSD-5144 that relates to exploration drilling. Centennial Mandalong is currently not permitted to undertake exploration drilling on total fire ban days. Total fire ban restrictions are typically based on NSW Rural Fire Service (RFS) regional mapping and local conditions may be of lower risk, particularly during certain hours of the day.

Centennial Mandalong propose to amend the commitment that currently reads “no drilling will be conducted on total fire ban days” to better define the activities that can and cannot be undertaken on a total fire ban day. Centennial Mandalong also propose to introduce a risk assessment process that can be undertaken prior to the commencement of any exploration activities on a total fire ban day.

1.2.2 Annual contributions

In consultation with Lake Macquarie City Council (LMCC) and in accordance with Centennial Mandalong’s corporate social responsibility objectives, The Lake Macquarie Foundation was established. In accordance with Appendix 8 of SSD-5144, Centennial Mandalong committed to distributing:

a) $50,000 upon the granting of the development consent; and

b) $50,000 on each anniversary of the granting of the development consent until the total amount given by the Donor (i.e. Centennial Mandalong) is $500,000.

Following consultation with LMCC and the Mandalong Mine Community Consultative Committee (CCC), an amendment to this commitment is proposed to allow the funds to be distributed via the CCC. The income from the fund will still be distributed to the communities of Mandalong and Morisset.

1.3 Limitations

This report: has been prepared by GHD for Centennial Mandalong Pty Ltd and may only be used and relied on by Centennial Mandalong Pty Ltd for the purpose agreed between GHD and Centennial Mandalong Pty Ltd as set out in Section 1 of this report.

GHD otherwise disclaims responsibility to any person other than Centennial Mandalong Pty Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

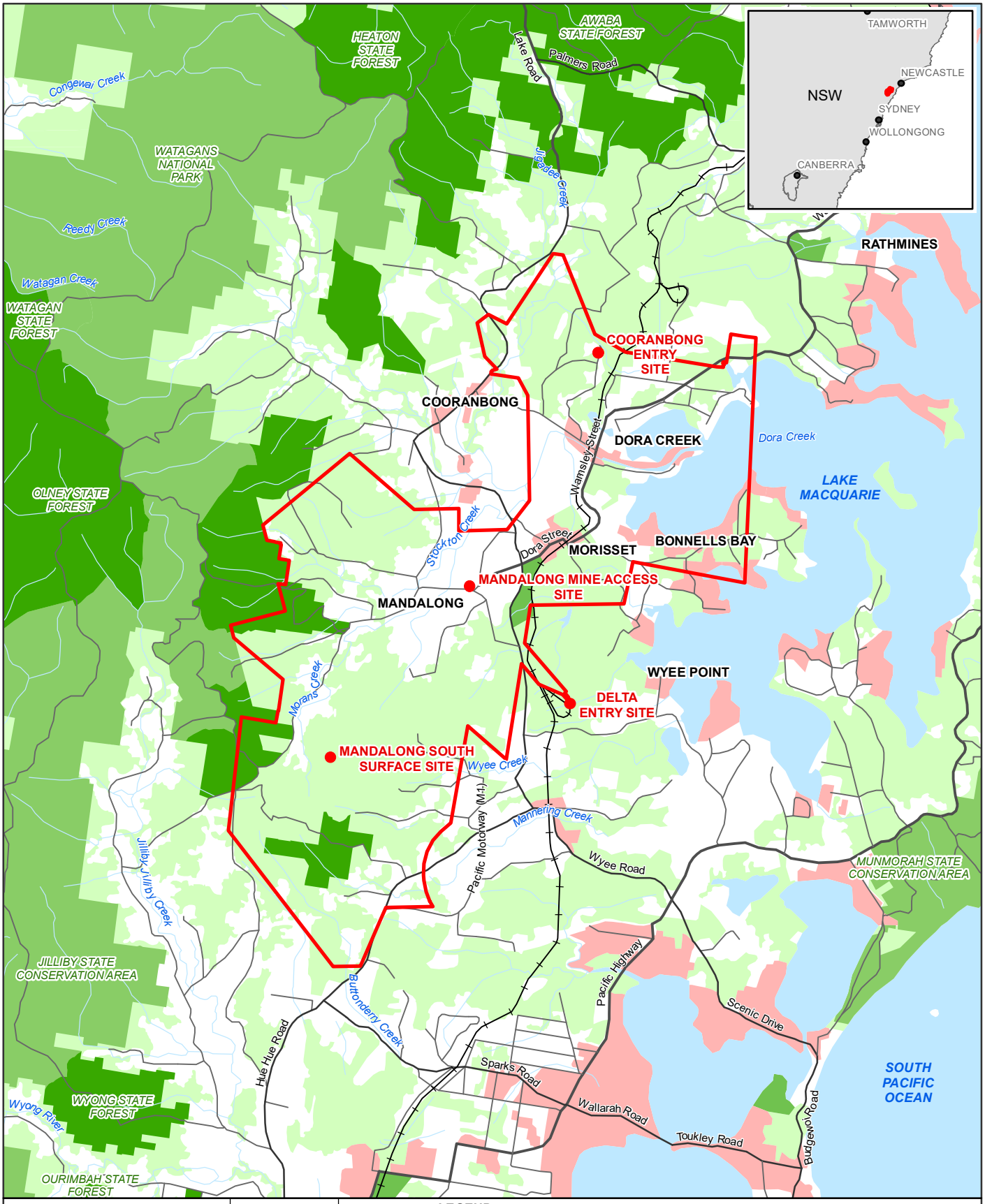
The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Centennial Mandalong Pty Ltd and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions (including the presence of hazardous substances and/or site contamination) may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.



1:150,000 for A4

0 0.5 1 2 3 4

Kilometers

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Site location
- Project application area
- Existing rail
- Principal road
- Secondary road
- Minor road
- Watercourse
- Built up area
- Recreation areas
- Nature conservation
- State forest
- Forest or shrub

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LOCATION	Mandalong
DRAWN	F.M
CHECKED	I.G
APPROVED	S.G.
SCALE	refer to scalebar

Centennial Mandalong Pty Ltd
Mandalong Mine Modification 10
Water Resources Impact Assessment

Locality Plan

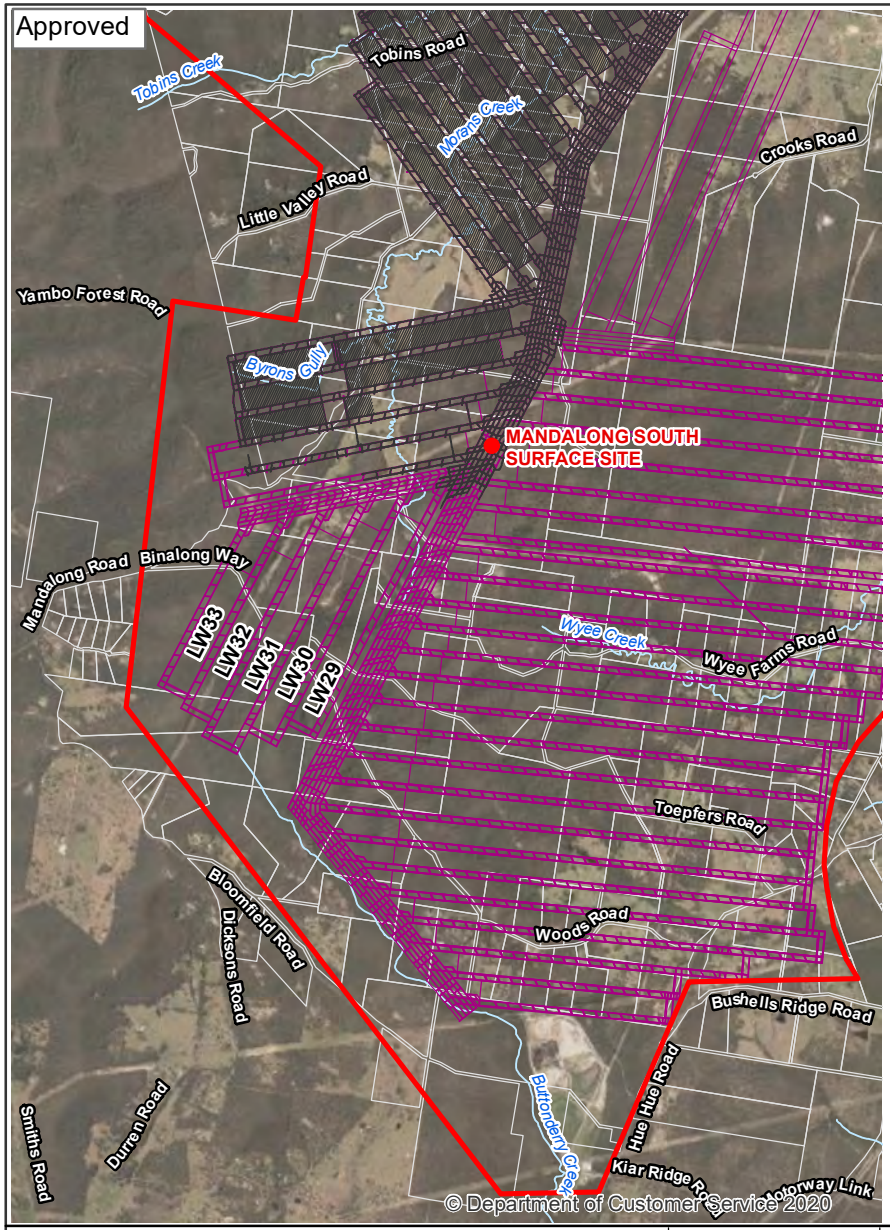
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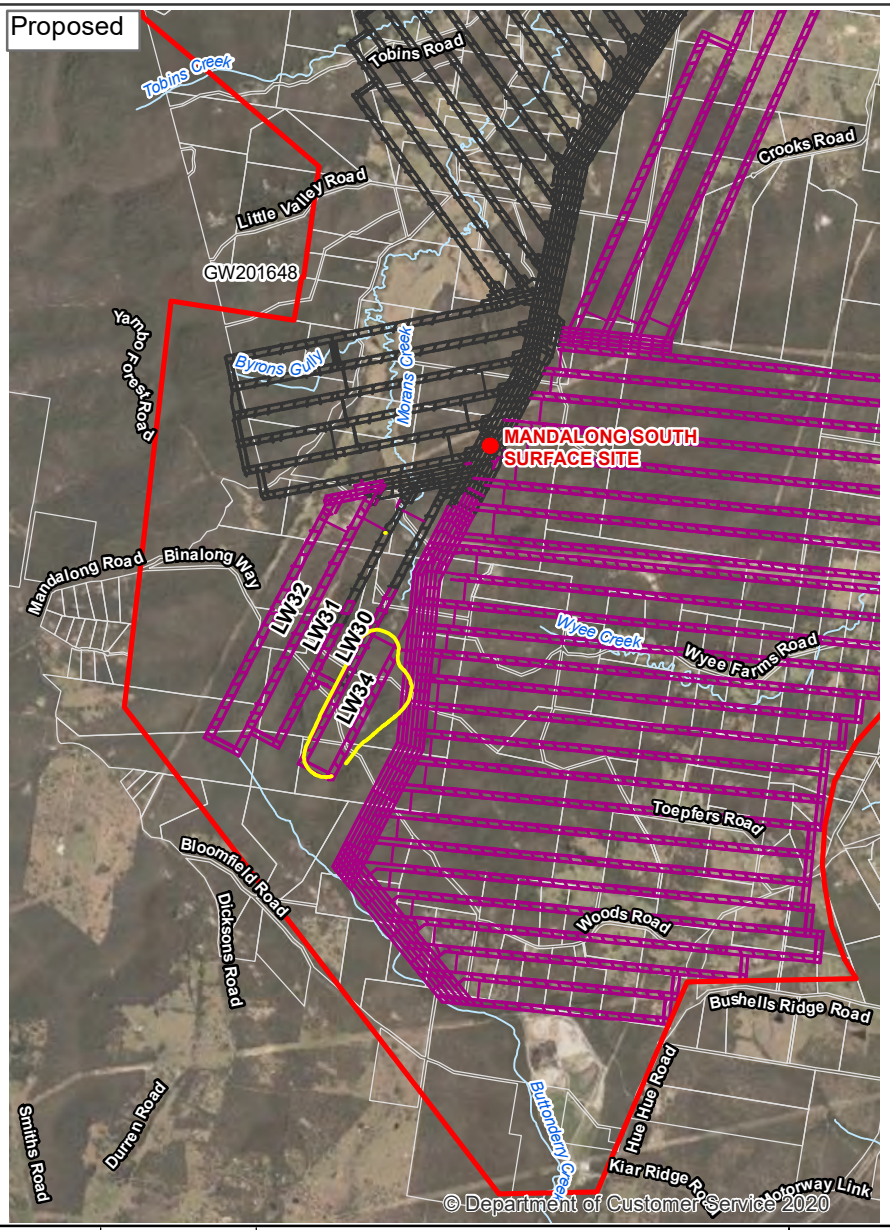
DATE 15/07/2021

Figure 1-1

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Hunter\Mandalong\12552553\WRIA\12552553_WRIA001_LocalityPlan_0.mxd

Data source: Commonwealth of Australia (Geoscience Australia): 250K Topographic Data Series 3, 2006; Centennial: Holdings Boundary, 2016. Created by: smacdonald, kpsroba, tmorton





LEGEND

- Site location
- Project application area
- Completed mine workings
- Approved and proposed mine workings
- Waterway
- Cadastre
- Modification area (20 mm subsidence contour)

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0 500 1,000 1,500 2,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

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GHD

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LOCATION	NEWSTAN
SEAM	W WALLARAH
DRAWN	TM
CHECKED	Z.L
APPROVED	S.G
SCALE	Refer to scalebar

Centennial Mandalong Pty Ltd
Mandalong Mine Modification 10
Water Resources Impact Assessment

Approved and Proposed Mine Plan

CENTENNIAL

DATE 3/09/2021

Figure 1-2

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Hunter\Mandalong\12552553\WRIA\12552553_WRIA017_Comparison_0_20210831.mxd

© LPI: DCTB / DTDB - 2012. LPI: Aerial Imagery, 2015. Geological Survey of NSW: Mining leases, 2020.

1.4 Modification area

The modification area for the WRIA primarily encompasses the 20 mm subsidence contour around the extraction area of LW34 as shown in Figure 1.2. The WRIA also considers impacts on mine water inflows, underground water storages, groundwater bores, groundwater receptors and downstream water users that extend beyond the modification area.

1.5 Overview of site operations

The currently approved Mandalong Mine comprises the following underground workings and surface infrastructure:

– MMAS, encompassing underground workings and associated surface infrastructure near Morisset
– Delivery of run of mine (ROM) coal from the underground workings to the Cooranbong Entry Site (CES). The CES coal handling and processing facilities are approved under the Northern Coal Logistics Project (SSD-5145).
– Delivery of ROM coal from the underground workings to the DES, located near Wyee at the Vales Point Rail Unloader Facility. The coal handling facility is approved under DA35-2-2004.
– MSSS, which is currently under construction, encompassing ventilation shafts, ventilation fans and underground delivery boreholes located approximately 6 km south-west of the MMAS.

1.6 Objectives of the water resources assessment

The primary objective of the WRIA is to determine the potential impacts of the proposed modification on the groundwater and surface water environments within the vicinity of the modification area and the broader regional environment. In broad terms, this involves an assessment of groundwater and surface water in terms of hydrogeology, hydrology, geomorphology, water quality and impacts on water users. The groundwater impact assessment has been undertaken with reference to the NSW Aquifer Interference Policy (DPI, 2012a).

1.7 Scope of work

The scope of work for the WRIA is as follows:

– Review existing assessments and data relevant to the modification
– Review relevant statutory requirements
– Establish the existing conditions for groundwater and surface water systems
– Identify components of the modification with the potential to impact groundwater and surface water environments.
– Undertake an assessment of the potential impacts of the modification on:
    - Groundwater levels and quality
    - Water and salt balance
    - Flooding
    - Waterway geomorphology
    - Surface water quality
    - Downstream water users, including licensed water users and basic landholder rights.
    - Develop measures to avoid, minimise and mitigate potential impacts of the modification and provide recommended management, monitoring and reporting requirements.

2. Legislation, policies and guidelines

2.1 Legislation

2.1.1 Environmental Planning and Assessment Act 1979

The EP&A Act, administered by the NSW Department of Planning, Industry and Environment (DPIE), is the core legislation relating to planning and development activities in NSW and provides the statutory framework under which development proposals are assessed. The EP&A Act aims to encourage the proper management, development and conservation of resources, environmental protection and ecologically sustainable development.

The WRIA forms part of a MR to support an application to modify SSD-5144 under Section 4.55(2) of the EP&A Act. The Minister for Planning (or delegate) will be the determining authority for the proposed modification.

2.1.2 Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations Act 1997* (POEO Act) is administered by the NSW Environment Protection Authority (EPA), which is an independent statutory authority and the primary environmental regulator for NSW. The objectives of the POEO Act are to protect, restore and enhance the quality of the environment. Some of the mechanisms that can be applied under the POEO Act to achieve these objectives include programs to reduce pollution at the source and monitoring and reporting on environmental quality. The POEO Act regulates and requires licensing for environmental protection, including for waste generation and disposal and for water, air, land and noise pollution.

Under the POEO Act, an environmental protection licence (EPL) is required for premises at which a 'scheduled activity' is conducted. Schedule 1 of the POEO Act lists activities that are scheduled activities for the purpose of the Act. Licence conditions relate to pollution prevention and monitoring and can control the air, noise, water and waste impacts of an activity.

Currently Mandalong Mine holds EPL 365 which covers coal mining to a scale of greater than 5 Mtpa in product and coal works to a scale of greater than 5 Mtpa. EPL 365 permits the discharge of surface water, mine water and runoff from the nearby CES via two licensed discharged points (LDPs – LDP001 and LDP002) into an unnamed drainage path that reports to Muddy Lake on the western side of Lake Macquarie. EPL 365 does not include any LDPs within the modification area. No changes to this licence are proposed as part of the modification.

2.1.3 Water Management Act 2000

The *Water Act 1912* has historically been the main legislation for managing water resources in NSW, however, has been progressively phased out and replaced by Water Sharing Plans (WSPs) under the *Water Management Act 2000* (WM Act). Once a WSP commences, existing licences under the *Water Act 1912* are converted to water access licences (WALs) and to water supply works and use approvals under the WM Act.

The aim of the WM Act, which is administered by the Department of Planning Industry and Environment – Water (DPIE Water) and Natural Resource Access Regulator (NRAR), is to ensure that water resources are conserved and properly managed for sustainable use benefiting both present and future generations. It is also intended to provide formal means for the protection and enhancement of the environmental qualities of waterways and in-stream uses as well as to provide for protection of catchment conditions.

2.1.3.1 Water sharing plans

Fresh water sources throughout NSW are managed via WSPs under the WM Act. Provisions within WSPs provide water to support the ecological processes and environmental needs of groundwater dependent ecosystems (GDEs) and waterways. WSPs also regulate how the water available for extraction is shared between the environment, basic landholder rights, town water supplies and commercial uses. Key rules within the WSPs specify when licence holders can access water and how water can be traded.

The modification area is covered by WSPs made under Section 50 of the WM Act. Each WSP consists of several water sources that are regulated by a water extraction entitlement. The boundaries of the applicable groundwater and surface water WSPs are shown in Figure 2.1 and Figure 2.2 respectively.

2.1.3.1.1 Groundwater sources

The North Coast Fractured and Porous Rock Groundwater Sources Water Sharing Plan (NCFPR WSP) commenced on 1 July 2016 and regulates the interception and extraction of groundwater from the fractured and porous rock aquifer within the WSP boundary.

Centennial Mandalong currently holds one WAL (WAL 39767) and one Works Approval (20WA218789) to extract up to 1,825 ML/year from the Sydney Basin North Coast groundwater source using a bore and pump from the existing Cooranbong underground storage at CES. No changes to this licence are proposed as part of the proposed modification.

Alluvial groundwater sources are covered by the Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources (HUA WSP) or the Water Sharing Plan for the Central Coast Unregulated Water Sources (CCU WSP). The HUA WSP commenced in 2009 and covers unregulated rivers and creeks and alluvial groundwater within the Hunter region. The CCU WSP commenced in 2009 and covers unregulated rivers and creeks and alluvial groundwater within the boundaries of the CCU WSP.

2.1.3.1.2 Surface water sources

The modification area is located at the watershed between water sources falling within two different WSPs:

– The Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources (HUA WSP), which commenced in 2009. The HUA WSP covers unregulated rivers and creeks and alluvial groundwater within the Hunter region. The modification area is located across the Dora Creek and South Lake Macquarie Water Source.
– The Water Sharing Plan for the Central Coast Unregulated Water Sources (CCU WSP), which commenced in 2009. The CCU WSP covers unregulated rivers and creeks and alluvial groundwater within the Hunter region. The modification area is located across the Jilliby Creek and Wyong River Water Source.

2.1.3.2 Basic landholder rights

Under the WM Act, extraction of water for basic landholder rights is protected by allocating and prioritising water for basic landholder rights. There are three types of basic landholder rights in NSW under the WM Act:

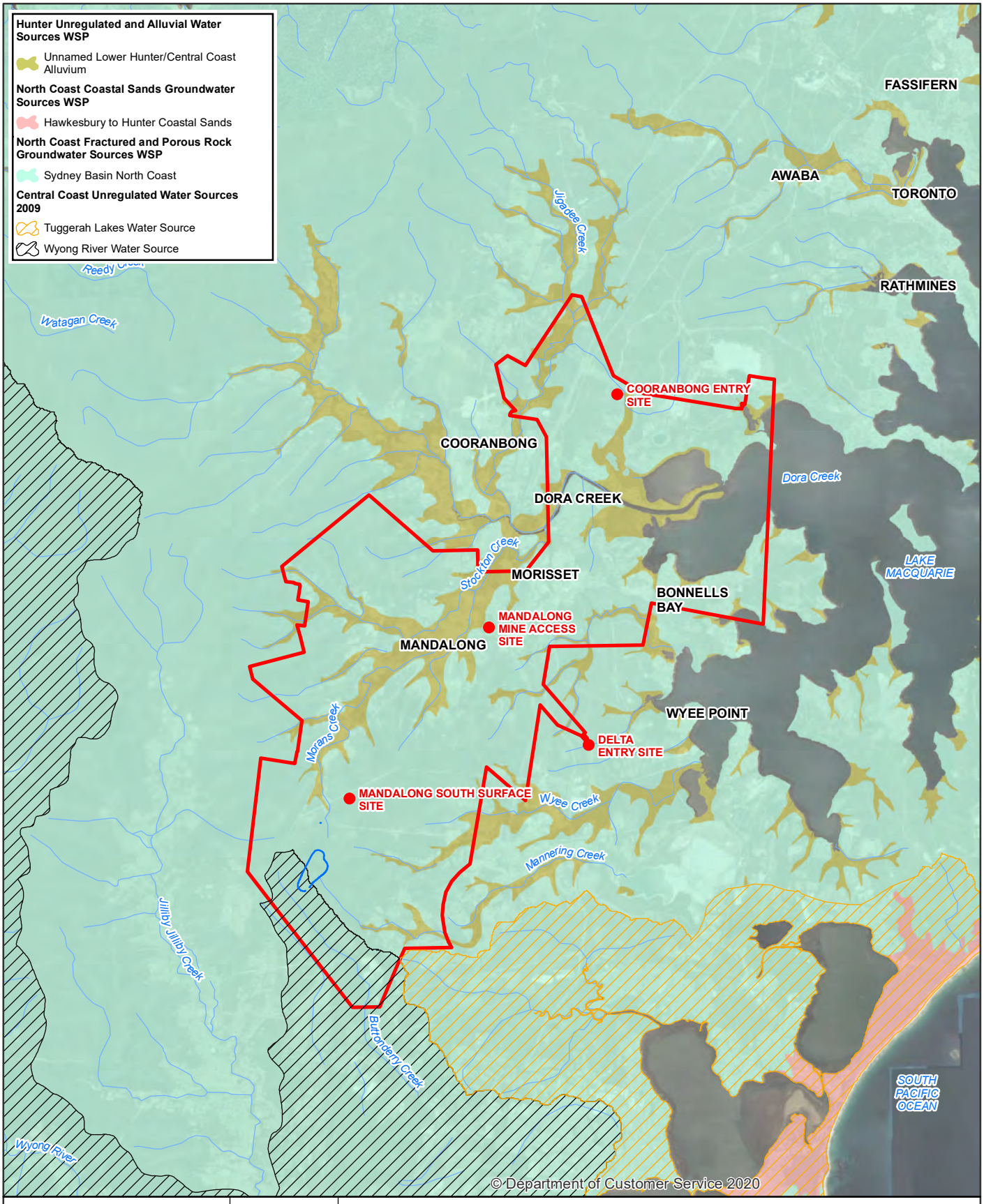
– Domestic and stock rights
– Native title rights
– Harvestable rights

2.1.3.2.1 Domestic and stock rights

Landholders are entitled to take water from a river, estuary or lake which fronts their land or from an aquifer which is underlying their land for domestic consumption and stock watering, without the need for a licence. However, a water supply work approval is required to construct a dam or a groundwater bore.

2.1.3.2.2 Native title rights

Anyone who holds native title with respect to water, as determined by the *Native Title Act 1993*, can take and use water for a range of purposes, including personal, domestic and non-commercial communal purposes. There are no native title rights in the HUA WSP and therefore this type of basic landholder rights has not been considered in the WRIA.



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0 1 2 3 4 5

Kilometers

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Site location
- Project application area
- Watercourse
- Modification area (20mm subsidence contour)

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LOCATION	Mandalong
DRAWN	K.S.
CHECKED	I.G.
APPROVED	S.G.
SCALE	refer to scalebar

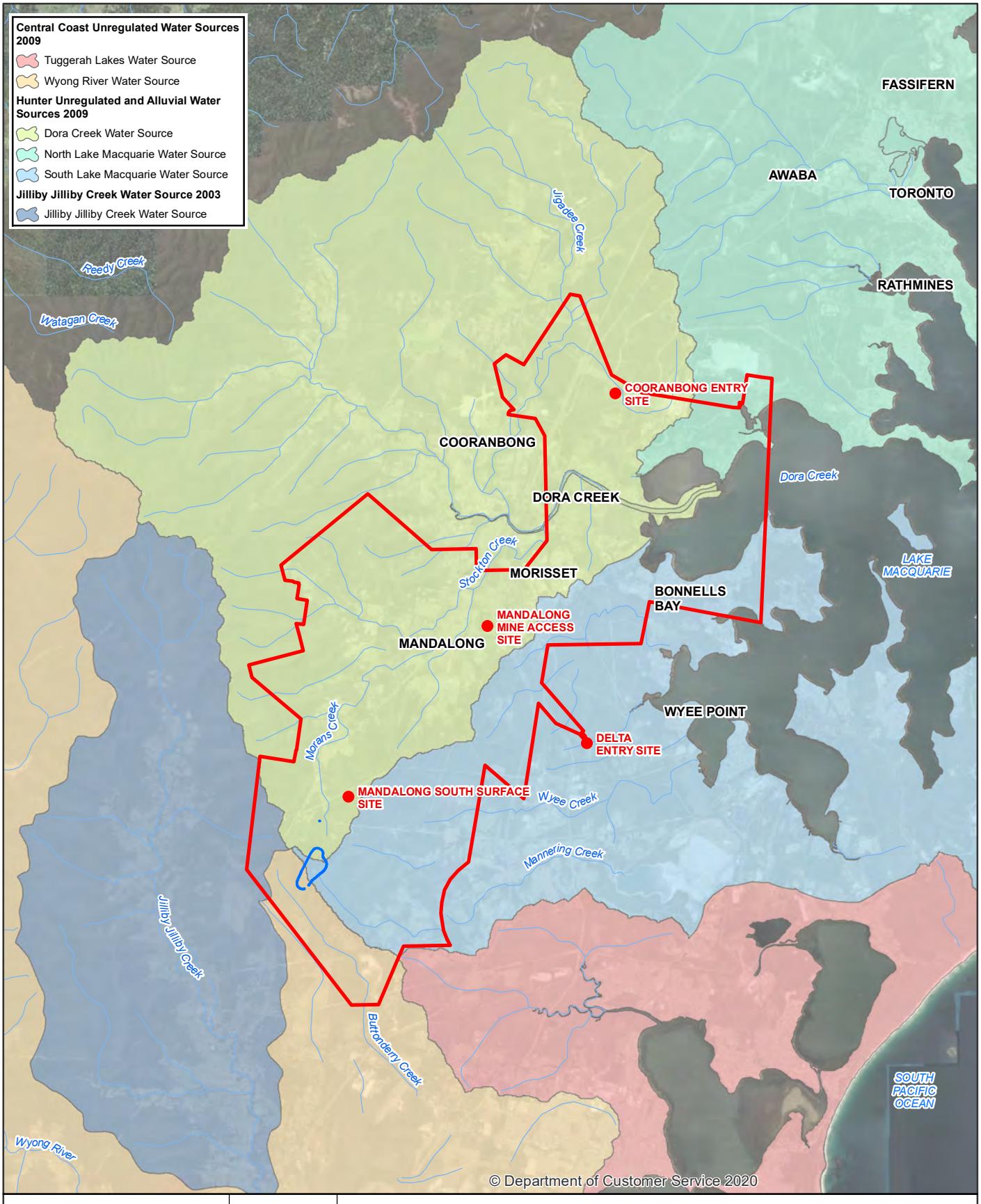
Centennial Mandalong Pty Ltd
Mandalong Mine Modification 10
Water Resources Impact Assessment
Water Sharing Boundaries - Groundwater

CENTENNIAL

DATE 31/08/2021

Figure 2-1

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Hunter\Mandalong\12552553\WRIA\12552553_WRIA003_GW_SharingBoundaries_A.mxd
Data source: LP: Imagery, 2015. Commonwealth of Australia (Geoscience Australia): 250K Topographic Data Series 3, 2006. Centennial: Mine workings, Extraction area, consent boundary, 2016. OOW: Pinneena, WSP, 2012.
Created by: smacdonald, kpsroba, tmorton



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0 1 2 3 4 5

Kilometers

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Site location
- Project application area
- Watercourse
- Modification area (20mm subsidence contour)

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LOCATION	Mandalong
DRAWN	K.S.
CHECKED	I.G.
APPROVED	S.G.
SCALE	refer to scalebar

Centennial Mandalong Pty Ltd
Mandalong Mine Modification 10
Water Resources Impact Assessment
Water Sharing Boundaries - Surface Water

CENTENNIAL

DATE 31/08/2021

Figure 2-2

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Hunter\Mandalong\12552553\WRIA\12552553_WRIA004_SW_SharingBoundaries_A.mxd

Data source: LPI:DCDB/Imagery, 2012/2015. Centennial: Mine workings, Extraction area, consent boundary, 2016. OOW: Pinneena, WSP, 2012. Created by: smacdonald, kpsroba, tmorton

2.1.3.3 Harvestable rights

Landholders are entitled to collect a portion of runoff from their property and store it in one or more dams up to a certain size, known as a 'harvestable right', which is determined from the total contiguous area of land ownership. In the Central and Eastern Divisions of NSW (where the proposed modification is located), landholders may capture and use up to 10% of the average regional rainfall runoff for their property without requiring a licence under the WM Act. The maximum harvestable right is the total volume of rainfall runoff that a landholder is entitled to use without requiring a licence. If the maximum harvestable right for a site is exceeded, licensing for the volume of water extracted from the surface water source exceeding the harvestable right is required under the WM Act.

The guidelines for determining the maximum harvestable right dam capacity (MHRDC) indicate that the following dams are exempt from the calculation of the MHRDC and do not require a licence (NOW 2010):

– Dams for the control or prevention of soil erosion
– Dams for the capture, containment and recirculation of drainage
– Dams without a catchment

2.1.3.4 Exemption from requirement for access licence

As specified by Clause 39 of the *Water Management (General) Regulation 2018*, dams solely for the capture, containment and recirculation of drainage and/or effluent, consistent with best management practice to prevent the contamination of a water source, are considered to be 'excluded works' and are exempt from the requirement for water supply works approval. The use of water from such dams is also exempt from the requirement for a WAL under Clause 39 of the *Water Management (General) Regulation 2018*.

2.1.3.5 Water used in mining activities

An amendment to the WM Act (Section 60I) came into effect 1 March 2013. This amendment provides that a WAL is required to take, remove or divert water from a water source (whether or not water is returned to that water source) or to relocate water from one part of an aquifer to another part of an aquifer in the course of carrying out a mining activity. Various activities are captured by the amendment including mining, mineral exploration and petroleum exploration.

2.1.3.6 Activity approvals

Section 91 of the WM Act details activity approvals to be considered with regards to developments proposed within a WSP. The two activity approvals stipulated under Section 91, namely controlled activity approvals and aquifer interference approvals, will not be required for the proposed modification.

Any works proposed within the defined riparian zone of a creek are to be carried out in accordance with the WM Act. Works undertaken on waterfront land (i.e. adjacent to a river, lake or estuary) require a controlled activity approval, unless defined as exempt. Controlled activity approvals are not required for projects that are defined as State significant developments. As such no controlled activity approvals will be required for any aspect of the proposed modification. However, DPIE-Water may be consulted in relation to proposed activities within existing riparian corridors, such as rehabilitation works following subsidence, which would provide a means of determining the suitability of engineering controls and general mitigation measures.

2.2 Policies

2.2.1 NSW Aquifer Interference Policy

The NSW Aquifer Interference Policy (DPI 2012a) was finalised in September 2012 and clarifies the water licensing and approval requirements for aquifer interference activities in NSW, including the taking of water from an aquifer in the course of carrying out mining. Many aspects of this policy will be given legal effect through an Aquifer Interference Regulation. Stage 1 of the Aquifer Interference Regulation commenced on 30 June 2011.

The Policy outlines the water licensing requirements under the *Water Act 1912* and WM Act. A water licence is required whether water is taken for consumptive use or whether it is taken incidentally by the aquifer interference activity (such as groundwater filling a void), even where that water is not being used consumptively as part of the activity's operation. Under the WM Act, a water licence gives its holder a share of the total entitlement available for extraction from the groundwater source. The WAL must hold sufficient share component and water allocation to account for the take of water from the relevant water source at all times.

Sufficient access licences must be held to account for all water taken from a groundwater or surface water source as a result of an aquifer interference activity, both for the life of the activity and after the activity has ceased. Many mining operations continue to take water from groundwater sources after operations have ceased. This take of water continues until an aquifer system reaches equilibrium and must be licensed.

The NSW Aquifer Interference Policy requires that potential impacts on groundwater sources, including their users and GDEs, be assessed against minimal impact considerations, outlined in Table 1 of the Policy. If the predicted impacts are less than the Level 1 minimal impact considerations, then these impacts will be considered as acceptable. The Level 1 minimal impact considerations relevant to the proposed modification are defined in Section 6.2.1.

2.2.2 NSW State Groundwater Policy

The objective of the NSW State Groundwater Policy Framework Document is to manage the State's groundwater resources so that they can sustain environmental, social and economic uses for the people of NSW. The NSW groundwater policy has three parts:

– NSW Groundwater Quantity Protection Policy
– NSW Groundwater Quality Protection Policy
– NSW Groundwater Dependent Ecosystems Policy

2.2.2.1 NSW Groundwater Quantity Protection Policy

The principles of this policy include:

– Maintain total groundwater use within the sustainable yield of the aquifer from which it is withdrawn
– Groundwater extraction shall be managed to prevent unacceptable local impacts
– All groundwater extraction for water supply shall be licensed. Transfers of licensed entitlements shall be allowed depending on the physical constraints of the groundwater system.

2.2.2.2 NSW Groundwater Quality Protection Policy

The objective of this policy is the ecologically sustainable management of the State's groundwater resources so as to:

– Slow, halt or reverse any degradation in groundwater resources.
– Direct potentially polluting activities to the most appropriate geological setting so as to minimise the risk to groundwater.
– Establish a methodology for reviewing new developments with respect to their potential impact on water resources that will provide protection to the resource commensurate with both the threat that the development poses and the value of the resource.
– Establish triggers for the use of more advanced groundwater protection tools such as groundwater vulnerability maps or groundwater protection zones.

Groundwater quality at the modification area is discussed in Section 5.3. Potential impacts on groundwater quality are assessed in Section 6.2.

2.2.2.3 NSW Groundwater Dependent Ecosystems Policy

This policy was designed to protect ecosystems which rely on groundwater for survival so that, wherever possible, the ecological processes and biodiversity of these dependent ecosystems are maintained or restored for the benefit of present and future generations. Potential GDEs in the modification area are identified in Section 5.5.2.

2.2.3 NSW State Rivers and Estuary Policy

The NSW State Rivers and Estuaries Policy (NSW Water Resources Council 1993) provides objectives and principles to achieve sustainable management of rivers and estuaries in NSW to ensure resource use is consistent with the long-term biological and physical function of the natural system. The objectives of the policy are “To manage the rivers and estuaries in NSW in ways which: slow, halt or reverse the overall rate of degradation in their systems; ensure the long-term sustainability of their essential biophysical functions; and maintain the beneficial use of these resources”. The policy details guiding principles for sustainable management of rivers and estuaries.

2.3 Guidelines

2.3.1 Approved Methods for the Sampling and Analysis of Water Pollutants in New South Wales

The document *Approved Methods for the Sampling and Analysis of Water Pollutants in New South Wales* (DEC 2004) provides the sampling and analysis methods to be used when acquiring water samples for compliance with environmental protection legislation, a relevant licence or relevant notice.

2.3.2 Australian and New Zealand Guidelines for Fresh and Marine Water Quality

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018) provide guidance for assessing and managing ambient water quality in a wide range of water resource types and according to specified environmental values, such as aquatic ecosystems, primary industries, recreation and drinking water. The revised Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018) were published in 2018 following scientific review of the ANZECC (2000a) guidelines. The Water Quality Management Framework (ANZG 2018) provides the key requirements for determining appropriate guideline values or performance criteria to evaluate the results of water quality monitoring programs.

The ANZG (2018) guidelines adopt a risk-based approach to assessing ambient water quality by providing the framework to tailor water quality guidelines to local environmental conditions. Guideline values provided by ANZG (2018) can be modified into regional, local or site-specific guideline values (SSGVs) by taking into account factors such as the level of modification of the ecosystem, natural variability in water quality at reference sites, and water hardness. Guideline values are applied to the receiving environment at the edge of the mixing zone and do not apply to mine water at the point of discharge. For the purposes of the WRIA, the median (for physicochemical parameters and nutrients) and 95th percentile (for toxicants) results for the downstream sites were compared to the applicable default guideline values (DGVs), as recommended by ANZG (2018).

2.3.3 NSW Water Quality and River Flow Objectives

The NSW Water Quality and River Flow Objectives (DECCW 2006) are the agreed environmental values and long-term goals for each catchment in NSW. The objectives are intended to be considered in assessing and managing the potential impacts of activities on waterways.

Water quality objectives for the Lake Macquarie and Tuggerah Lakes catchment are for the protection of aquatic ecosystems, visual amenity, primary and secondary contact recreation, livestock, irrigation and homestead water supply, drinking water, aquatic foods (cooked) and industrial water supplies. The water quality objectives are consistent with the national framework for assessing water quality provided by ANZG (2018) and have been considered in the assessment of surface water quality, discussed in Section 6.3.2.

The river flow objectives for the Lake Macquarie and the Tuggerah Lakes catchment are to: protect pools in dry times, protect natural low flows, protect important rises in water levels, maintain wetland and floodplain inundation, mimic natural drying in temporary waterways, maintain natural flow variability, maintain natural rates of change in water levels, manage groundwater for ecosystems, minimise effects of weirs and other structures, minimise effects of dams on water quality, make water available for unforeseen events and maintain or rehabilitate estuarine processes and habitats. The river flow objectives have been considered in the assessment of surface water flow in this assessment.

2.3.4 Using the ANZECC Guidelines and Water Quality Objectives in NSW

The document *Using the ANZECC Guidelines and Water Quality Objectives in NSW* (DEC 2006) provides guidance on applying the ANZECC (2000a; revised by ANZG 2018) framework for assessing water quality, including the use of water quality objectives for NSW.

2.3.5 Australian Guidelines for Water Quality Monitoring and Reporting

The *Australian Guidelines for Water Quality Monitoring and Reporting* (ANZECC 2000b) sets out a framework and guidance for the monitoring and reporting of fresh and marine surface water and groundwater. ANZECC (2000b) provides information for all aspects of a water quality monitoring program, including setting objectives, designing monitoring and sampling programs, laboratory analyses, data analysis and interpretation and reporting of results and conclusions.

The water quality monitoring program for the proposed modification has been established in accordance with the framework presented by ANZECC (2000b).

2.3.6 Managing Urban Stormwater: Soils and Construction

Managing Urban Stormwater: Soils and Construction – Volume 1 (the 'Blue Book'; Landcom 2004) outlines the basic principles for the design, construction and implementation of sediment and erosion control measures to improve stormwater management and mitigate the impacts of land disturbance activities on soils and receiving waters. This document relates particularly to urban development sites; however, it is relevant to the proposed modification as it provides guidance on the configuration of erosion and sedimentation controls, which may be necessary during construction and operation of the proposed modification.

Managing Urban Stormwater: Soils and Construction – Volume 2E Mines and Quarries (DECC 2008) provides specific guidelines, principles and minimum design standards for good management practice in erosion and sediment control during the construction and operation of mines and quarries. This document relates specifically to this project as a mine site.

2.3.7 Leading Practice Sustainable Development Program for the Mining Industry: Water Management

Leading Practice Sustainable Development Program for the Mining Industry: Water Management (DRET 2008) provides a discussion of several matters relating to water management at mine sites. The topics discussed broadly include the drivers for needing to improve water management, features of management and reporting systems and the document discusses technical and community requirements for site water management. The proposed modification has been developed to be consistent with this guideline document.

2.3.8 Guidelines for controlled activities on waterfront land

The NRAR has published a number of guidelines on types of controlled activities and the protection of waterfront land. Waterfront land includes the bed and bank of a river, lake or estuary, and all land within 40 m of the highest bank of the river, lake or estuary.

The guidelines provide recommendations for the design and construction of instream works and an indication of the width of riparian zones to be considered. The guidelines (NRAR 2018) focus on the following key requirements:

– Maintaining the natural geomorphic processes through the accommodation of the existing watercourse, allow for the natural movement of sediment, woody debris and not allowing for an increase or the construction of scour and erosion within the existing watercourse.
– Maintaining the existing watercourse hydrologic function through accommodation of low flows and not altering the natural bank full or flood flows.
– The use of scour protection when required for the protection of existing banks, using placed rock.
– Visual inspections and maintenance on the watercourse during the works.

As the proposed modification is SSD, controlled activity approvals are not required. Despite this, the assessment of potential impacts of the proposed modification on surface water has considered the guidelines for waterfront land and riparian corridors.

3. Site description

3.1 Topography

The terrain within the vicinity of the modification area is characterised by the headwaters of Morans Creek and Buttonderry Creek and the bounding valley slopes and elevated ridgelines. Rural residential areas around the floodplain are bordered by densely timbered ridgelines. Elevations within the vicinity of the modification area range from less than 30 m Australian Height Datum (AHD) along floodplains of drainage lines, to over 100 m AHD along the ridgelines.

3.2 Soils

Soil landscape mapping (Murphy 1993) indicates that the soil types within the modification area are typically sandy loams of moderate erodibility. Figure 3.1 presents the soil landscapes in the vicinity of the modification area, with a summary of the soil types, typical terrain and erodibility provided in Table 3.1.

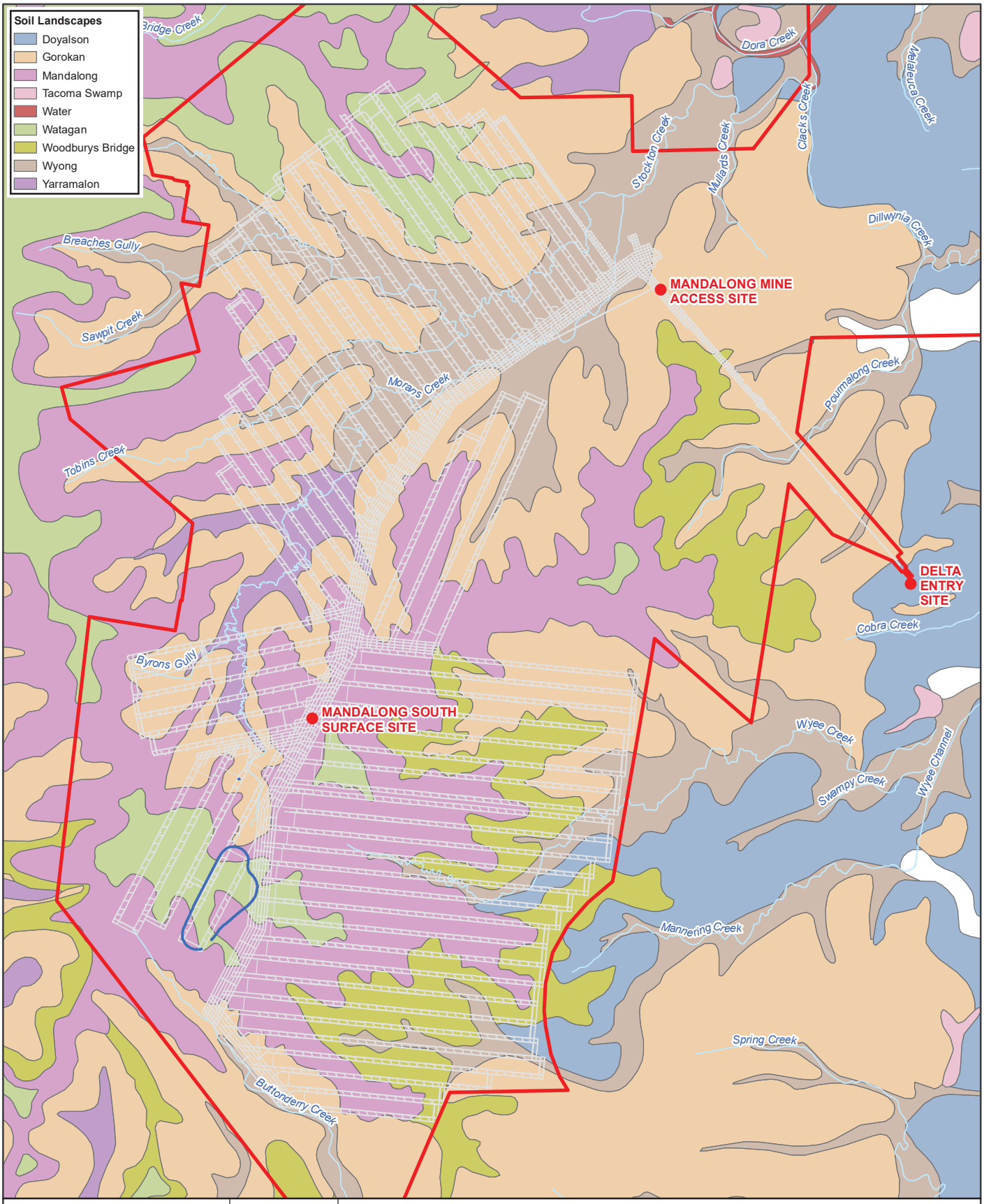
Table 3.1 Typical soils landscapes and erodibility (Murphy 1993)

Soil landscape group	Landscape	Typical terrain of landscape	Dominant topsoil	Erodibility
Colluvial	Mandalong	Upper slopes	Hard setting stony brown sand clay loam	Very high
Erosional	Gorokan	Foot slopes	Fine sandy loam to a sandy clay loam	Very high erosion hazard*
Alluvial	Yarramalong	Floodplains	Loose brown sands	Moderate to high
			Brown pedal loam	Moderate
	Wyong	Floodplains	Yellow and brown duplex soils	Moderate

** Murphy (1993) indicates that the Gorokan landscape includes moderate erodibility, however the assessment undertaken by GSSE (2013) indicates very high erosion hazard in this soil landscape.*

Areas of very high to extreme erodibility were identified within the Gorokan landscape. GSSE (2013) identified both the topsoil and subsoil within the Gorokan landscape as being sodic (i.e. high in sodium) with a poor structure. As the soil profile deepens, the sodic nature increased (based on exchangeable sodium percentage) (GSSE 2013).

The Gorokan landscape is typically located within the foot slope areas of the modification area. These areas are typically cleared of taller vegetation (trees) as part of the rural land use of the Morans Creek floodplain areas. The clearing and establishment of pasture within these areas typically results in an increase in the interaction between the groundwater and subsoil and topsoil layers. This increased groundwater interaction has the potential to increase the occurrence of tunnel erosion within the sodic soils of the Gorokan landscape. Other potential contributing factors to the occurrence of tunnel erosion include landowner activities and livestock.



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0 500 1,000 1,500 2,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

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- Site location
- Project application area
- Waterway
- Approved and proposed mine workings
- Modification area (20mm subsidence contour)

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Mandalong Mine Modification 10
Water Resources Impact Assessment

Soil Landscapes

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Figure 3-1

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Hunter\Mandalong\12552553\WRIA\12552553_WRIA005_SoilMapping_A.mxd

Data source: LPI:DCDB, 2012. Centennial: Mine workings, Extraction area, consent boundary, 2016. DECC: Soil Landscapes, 2008. Created by: smacdonald, kpsroba, tmorton

3.3 Climate

Daily rainfall data were obtained from the Scientific Information for Land Owners (SILO) database operated by the Queensland Government - Department of Science, Information Technology and Innovation (DSITI 2021). SILO patched point data are based on historical data from a particular Bureau of Meteorology (BOM) station with missing data interpolated from nearby stations.

For this assessment, SILO data were obtained for Cooranbong (Avondale) Station (station number 61012), which is located approximately 3 km north of Mandalong Mine. Figure 3.2 presents the historical annual SILO point rainfall data between January 1889 and June 2021.

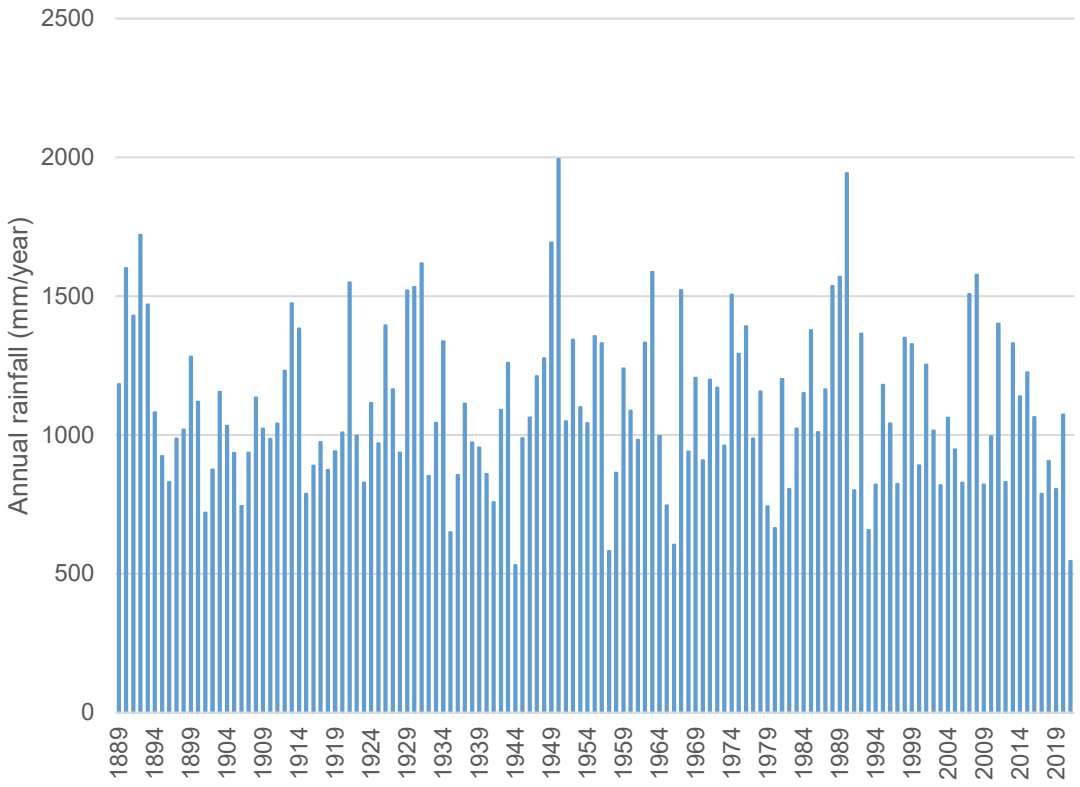


Figure 3.2 Historical annual rainfall record at Cooranbong (Avondale) Station

The annual statistics associated with the SILO data presented in Figure 3.2 are:

- Minimum rainfall total – 530 mm in 1944
- Median rainfall total – 1048.8 mm
- Average rainfall total – 1108 mm
- Maximum rainfall total – 1994 mm in 1950

Average daily rainfall and evaporation rates per month determined from the historical SILO point data between 1889 and 2021 are presented in Figure 3.3.

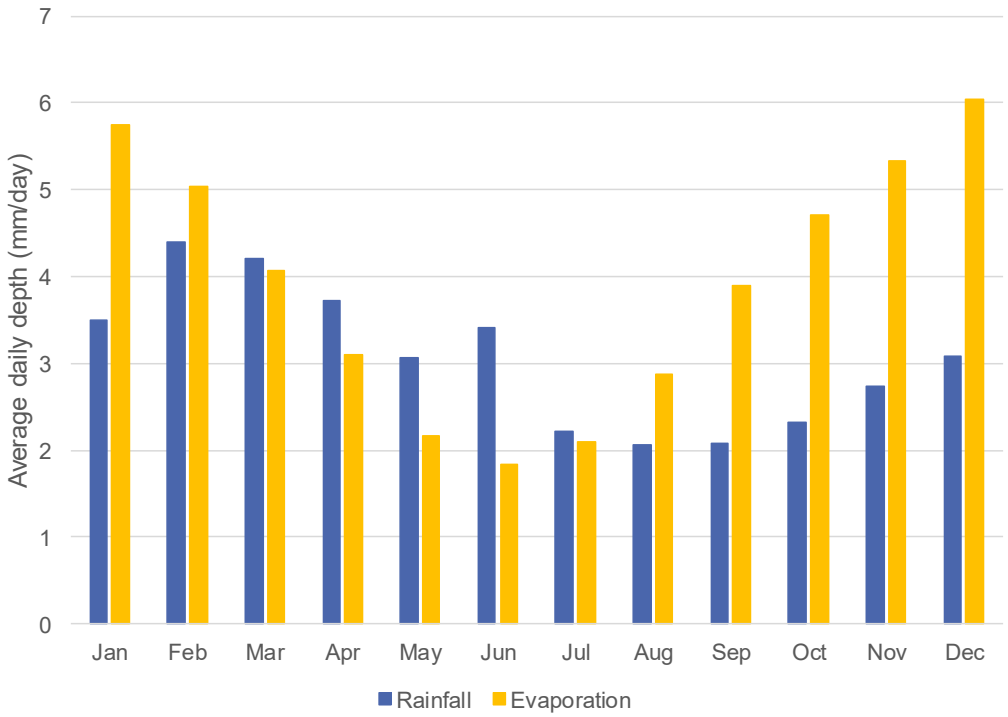


Figure 3.3 Average daily rainfall and evaporation rates

Total average annual evaporation is approximately 1399.1 mm, compared to the average annual rainfall total of 1108 mm. This gives an annual deficit (difference between annual rainfall and annual evaporation) of approximately 288 mm.

SILO patched point data from the Cooranbong (Avondale) Station between 1901 and 2020 were used to generate a cumulative rainfall deficit (CRD) curve, presented in Figure 3.4. A CRD curve is a monthly accumulation of the difference between the observed monthly rainfall and long-term average monthly rainfall. Any increase in the CRD curve reflects above average rainfall while a decrease in CRD curve reflects below average rainfall.

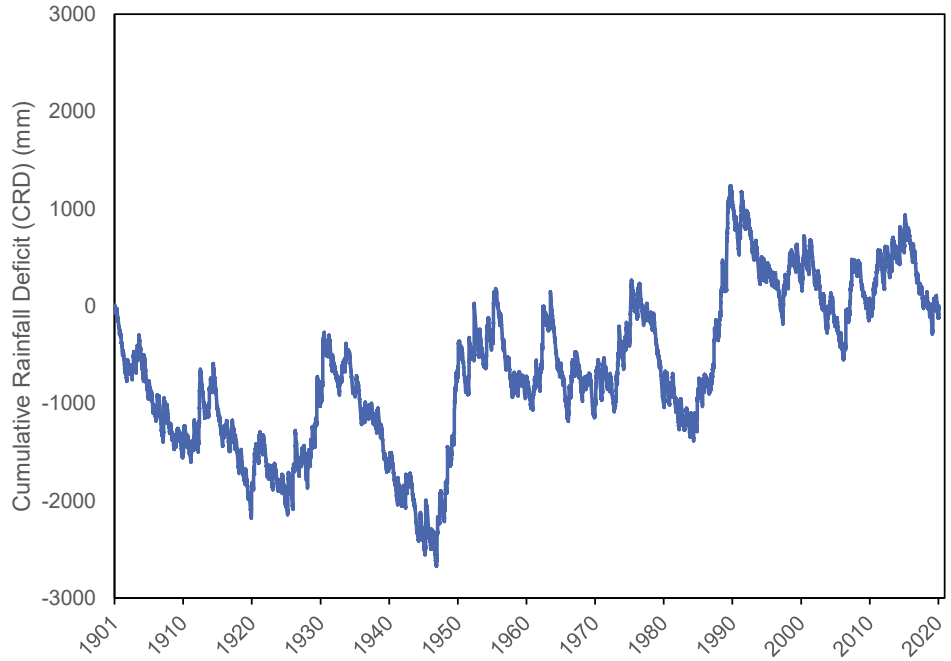


Figure 3.4 Cumulative rainfall deficit curve

Figure 3.4 shows a decreasing CRD trend 2016 to early 2020 indicating consistently below average rainfall over this period. .The CRD curve was generally increasing from February 2020 to December 2020 indicating generally above average rainfall over this period. Since the commencement of mining at Mandalong in 2005, there was generally above average rainfall from 2007 to 2016, as shown by the increasing CRD curve in Figure 3.4.

3.4 Geology

Mandalong Mine is located in the Newcastle Coalfield, which occupies the north-eastern portion of the Sydney Basin. The area in the vicinity of Mandalong Mine is underlain by Triassic claystone, sandstone and conglomerate, as well as Quaternary alluvial sediments along watercourses. The Triassic rocks are underlain by the Permian Newcastle Coal Measures, which regionally dips to the south at approximately 1 to 2 degrees.

The stratigraphy at Mandalong Mine is summarised in Table 3.2. This information has been sourced from the Newcastle Coalfields Regional Geology 1:100,000 map (DMR 1995) and exploration logs for Mandalong Mine.

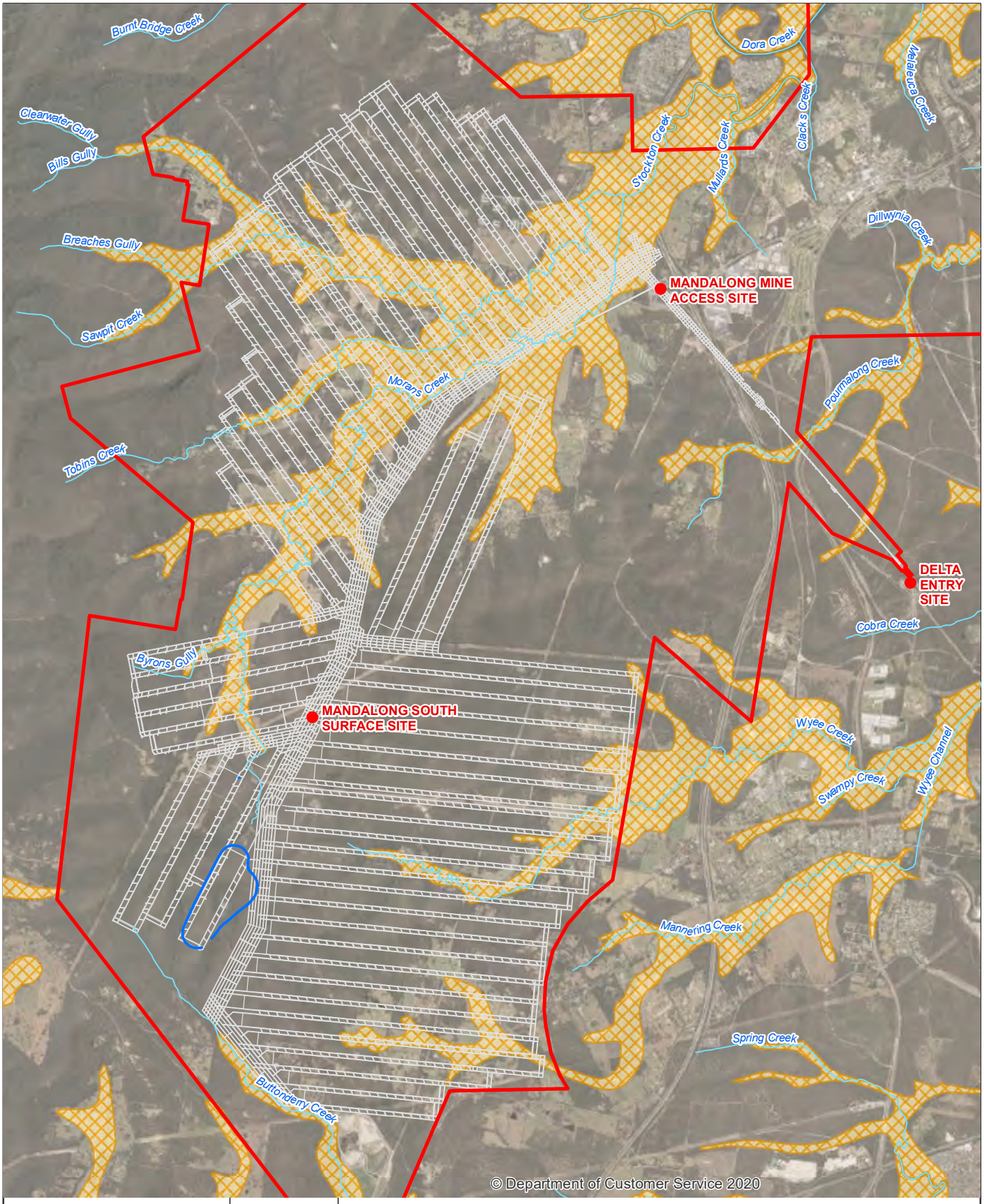
Table 3.2 Stratigraphic sequence

Period	Stratigraphy		Formation	Lithology
	Group	Subgroup		
Quaternary				Alluvium
Triassic	Narrabeen	Clifton	Patonga Claystone Tuggerah Formation Munmorah Conglomerate Dooralong Shale	Conglomerate, sandstone, siltstone, claystone
Permian	Newcastle Coal Measures	Moon Island Beach	West Wallarah Seam	Conglomerate, sandstone, siltstone, tuff, coal
		Awaba Tuff		Tuff

The approximate boundaries of the Quaternary alluvial sediments in the vicinity of Mandalong Mine are shown in Figure 3.5 and have been derived from the Soil Landscapes of the Newcastle 1:100,000 Sheet (Matthei 1995) and the Soil Landscapes of the Gosford-Lake Macquarie 1:100,000 Sheet (Murphy 1993). There is no mapped alluvium in the modification area.

The Newcastle Coal Measures are overlain by the Triassic Narrabeen Group. The Narrabeen Group comprises variable sequences of interbedded claystones, siltstones and fine to coarse grained sandstones. The Munmorah Conglomerate is a sandstone-dominated formation within the Narrabeen Group which typically occurs between 60 m and 140 m above the Newcastle Coal Measures (or a depth of approximately 40 m to 340 m below ground level (bgl)). The Munmorah Conglomerate at Mandalong Mine has been found to contain a thick pebbly sandstone/conglomerate layer which is geotechnically important in reducing surface subsidence impacts over longwall panels.

Depth of cover to the target seam (West Wallarah) ranges from approximately 300 m to 450 m in the modification area. This is similar to or greater than the depth of cover above the existing Mandalong Mine workings (approximately 150 m to 350 m depth of cover above the existing Mandalong Mine workings) and greater than the depth of cover above the Cooranbong workings (generally less than 100 m depth of cover above the Cooranbong workings). Depth of cover contours are shown in Figure 3.6.



1:60,000 for A4

0 305 610 1,220 1,830

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

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LEGEND

- Site location
- Project application area
- Alluvium
- Waterway
- Approved and proposed mine workings
- Modification area (20mm subsidence contour)

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APPROVED	S.G.
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Mandalong Mine Modification 10
Water Resources Impact Assessment

Location of Alluvium

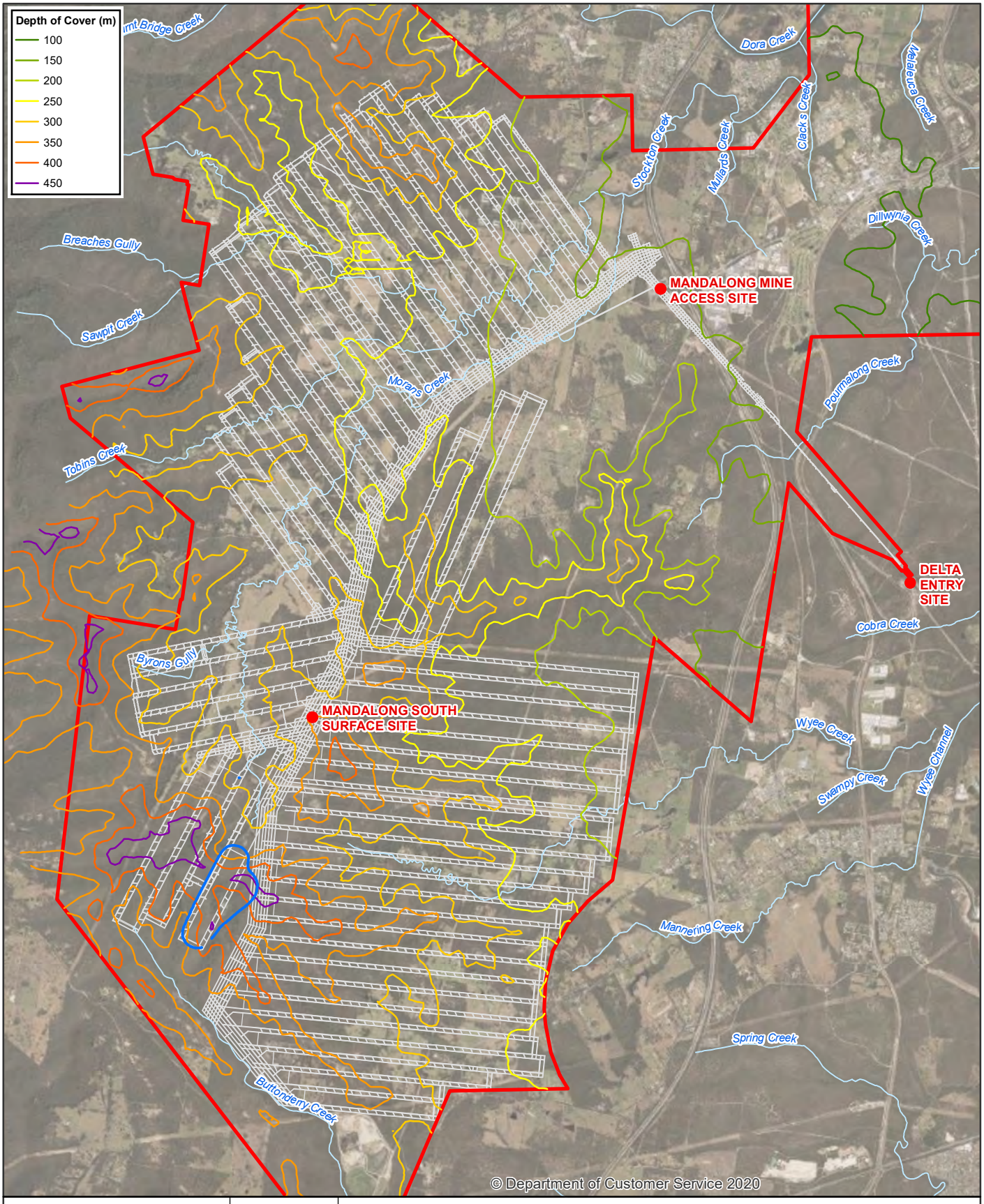
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Figure 3-5

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Hunter\Mandalong\12552553\WRIA\12552553_WRIA006_Alluvium_A.mxd

Data source: LPI:DCDB, 2012. OEH: Soil Landscapes, 2010. Centennial: Mine workings, Extraction area, consent boundary, 2016. Created by: smacdonald, kpsroba, tmorton



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0 300 600 1,200 1,800

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
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Water Resources Impact Assessment

Depth of Cover Above Target Seam

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DATE 6/09/2021

Figure 3-6

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Hunter\Mandalong\12552553\WRIA\12552553_WRIA007_DepthofCover_B.mxd

Data source: LPI:DCDB/Imgery, 2012/2015. Centennial: Mine workings, Extraction area, consent boundary, 2016. Created by: smacdonald, kpsroba, tmorton

3.5 Hydrogeology

The groundwater sources in the Mandalong Mine area are generally low yielding and predominantly weathered and/or fractured sandstone, coal seams and clayey quaternary alluvium.

3.5.1 Alluvial groundwater sources

The alluvium at Mandalong Mine forms an unconfined shallow aquifer with a water table typically ranging in depth from less than 1 m and up to about 3 m bgl and aquifer thickness less than 20 m. The alluvial water sources within the study area are covered under the HUA WSP. There is no alluvial groundwater within the modification area.

3.5.2 Fractured and porous rock groundwater sources

3.5.2.1 Coal seam

The piezometric head within the Permian coal seams tends to reduce towards the east, reflecting the natural topography, with reduced pressures at major surface drainage areas and in areas of coal extraction. Where coal seam groundwater has not been depressurised, the groundwater head generally tends to be in the order of 0 m AHD due to the coastal environment.

Permeability testing undertaken in 1996 and 1997 on the West Wallarah Seam and overburden strata in the existing Mandalong Mine area is reported in Pacific Power International (1997). Results indicate a variable hydraulic conductivity for the seam, ranging from 10^{-9} m/s to 10^{-5} m/s (0.03 m/year to 300 m/year). Areas of higher hydraulic conductivity coincide with areas where the coal is more intensively jointed or fractured, although the majority of the seam was generally found to be of lower hydraulic conductivity.

Permeability testing of the West Wallarah and Wallarah/Great Northern seams (at depths of 285 m to 300 m bgl) undertaken in 2011 as part of the Mandalong Southern Extension exploration program measured hydraulic conductivities ranging from approximately 0.75 m/year to 35 m/year (Sigra 2011).

Groundwater inflows into the existing Cooranbong and Mandalong workings from the coal seam and adjacent strata are reported by Centennial Mandalong to be relatively low. Further details on the underground water management can be found in Section 5.1.1.

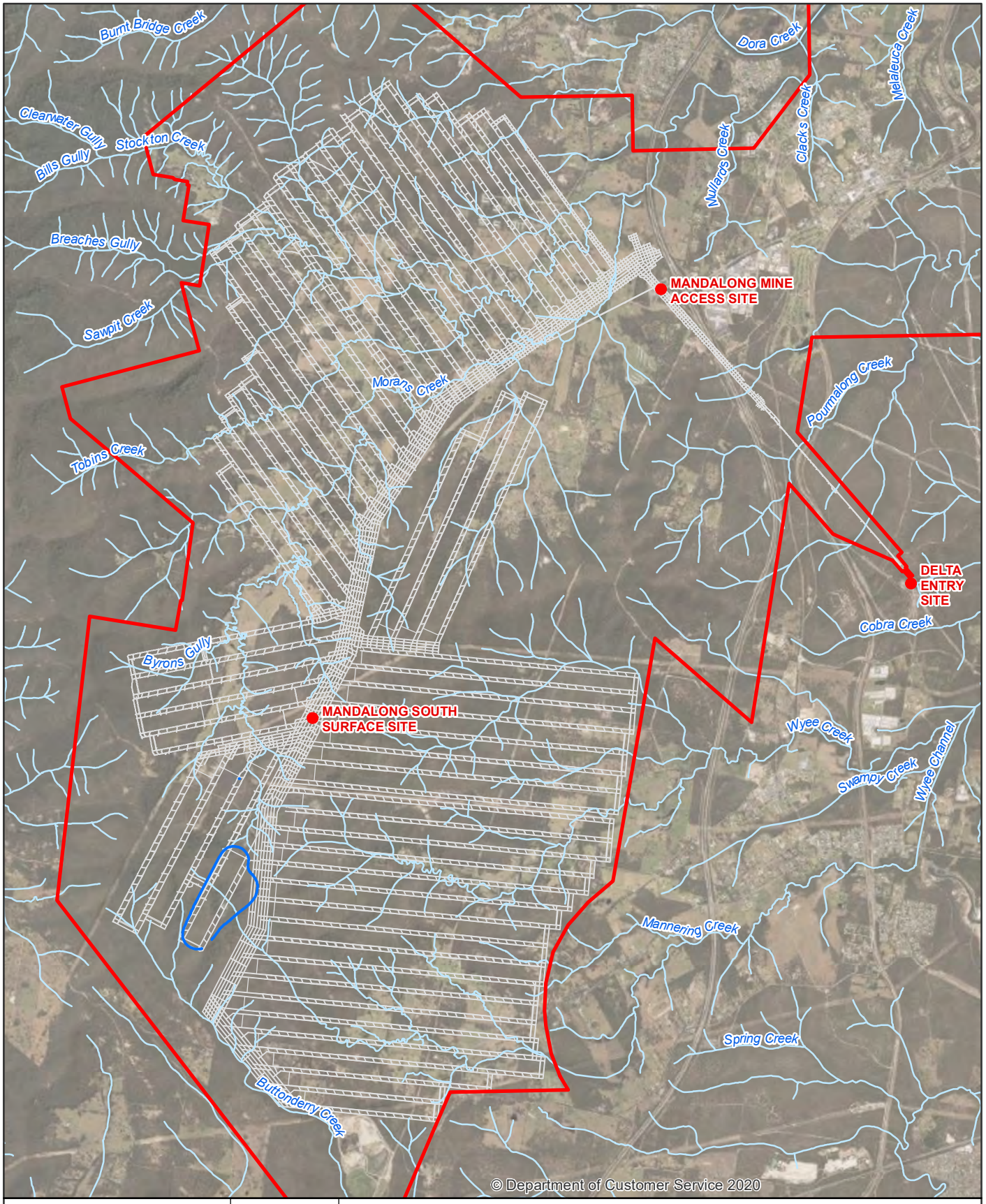
3.5.2.2 Overburden rock

The overburden and interseam strata within the Newcastle Coalfield tend to have very low hydraulic conductivities (in the order of 0.0003 m/year to 0.03 m/year), unless joints or fracturing creates a secondary permeability (Pacific Power International 1997). Groundwater within the overburden rock above the West Wallarah Seam primarily occurs within weathered or fractured Triassic sandstone. There is generally a downward vertical hydraulic gradient within the Triassic and Permian strata that overlay the West Wallarah Seam.

3.6 Hydrology

The modification area is located within the upper reaches of Morans Creek, Mannering Creek and Buttonderry Creek and includes several unnamed tributaries, as shown in Figure 3.7. Morans Creek is a north-easterly flowing tributary of Stockton Creek, which discharges into the estuarine reach of Dora Creek approximately 8 km north east of the modification area. Mannering Creek is a easterly flowing tributary of Lake Macquarie. Buttonderry Creek is a south-easterly flowing tributary of Wyong River, which discharges to Tuggerah Lake. The creeks are ephemeral, with periods of limited or no flow during low rainfall.

The additional area of secondary extraction proposed as part of this modification is contained within the catchment of Buttonderry Creek.



1:60,000 for A4

0 500 1,000 1,500 2,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

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LOCATION	Mandalong
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SCALE	refer to scalebar

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Mandalong Mine Modification 10
Water Resources Impact Assessment

Watercourses

CENTENNIAL

DATE 31/08/2021

Figure 3-7

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Hunter\Mandalong\12552553\WRIA\12552553_WRIA008_Watercourse_A.mxd

Data source: LPI:DCDB/Imagery, 2012/2015. Centennial: Mine workings, Extraction area, consent boundary, 2016. Created by: smacdonald, kpsroba, tmorton

4. Methodology

4.1 Potential impacts

The objective of the WRIA is to determine the potential impact of the proposed modification on the groundwater and surface water environments. The identification of potential impacts will enable the development of measures to avoid or mitigate impacts or provide the framework of monitoring programs that may be required for the proposed modification. The following potential impacts to groundwater and surface water systems were identified:

– Changes to the local water cycle
– Changes to regional catchment flows
– Altered groundwater and surface water quality downstream of the proposed modification
– Altered availability of groundwater and surface water to users downstream of the proposed modification

4.2 Groundwater environment

Potential groundwater impacts from the proposed modification have been predicted by two methods:

– Review of groundwater quality and quantity data within the existing Mandalong Mine area to identify groundwater impacts from previous longwall development.
– Utilising the existing hydrogeological model developed for Mandalong Mine as part of the Mandalong Southern Extension Project (GHD 2013a), recalibrated as part of the Mandalong Tonnage Production Project (GHD 2016a) and updated as part of the Mandalong Longwall Reorientation Project (Mod 9) (GHD 2020b).

4.2.1 Review of existing data

4.2.1.1 Groundwater levels

4.2.1.1.1 Alluvial water sources

Groundwater hydrographs were plotted for each of the alluvium bores in Table 5.1 and compared to the CRD curve for the rainfall dataset (as shown in Figure 3.4) to establish the relationship between groundwater levels and rainfall, and to identify whether natural or other anthropocentric factors have been influencing these groundwater levels.

Where possible, a statistical comparison was undertaken using HARTT (Hydrograph Analysis: Rainfall and Time Trends) statistical methodology, to reduce the uncertainty inherent with visual interpretation of the time series graphs. HARTT is an Excel based regression model developed by the Western Australian Department of Agriculture and Food that involves establishing an underlying time trend in groundwater level by separating the effect of above and below average rainfall. In this way, the relationship between groundwater change and atypical rainfall is established and it is possible to identify whether other factors are influencing groundwater level. Where conventional linear regression trend analysis is carried out for groundwater hydrographs, it is not possible to determine to what degree trends are associated with rainfall or other factors.

The HARTT analysis is based on the following regression equation (Ferdowsian et al. 2000):

$$D = c + aCRD_{t-L} + bt$$

Where D is the depth to groundwater in an unconfined aquifer, CRD is the Cumulative Rainfall Departure (mm), t is time (months), L is the time lag (months) between rainfall and its impact on groundwater, and *a*, *b* and *c* are constants estimated from the multiple regression analysis.

Constant *a* represents the effect of non-average rainfall on groundwater level in m/mm. The value of constant *a* cannot be negative, since this would imply that rainfall recharge results in a fall in groundwater level. Constant *b* is the underlying rate of groundwater change in m/month without the effect of rainfall. The constant *c* represents the steady state groundwater level with no rainfall effects and no time trends. The best fit regression line is the non-linear approximation of the observed hydrograph with the highest R^2 value.

The HARTT analysis also determines the statistical significance of the rainfall and time variables. A *p*-value of less than 0.05 suggests that there is a statistically significant relationship between the depth to groundwater and the variable.

Generally, when the constant *b* is negative and the *p*-value for time is less than 0.05, this suggests that there is a statistically significant decreasing trend in groundwater level that is independent of rainfall. To assess how mining may be related to this trend, it is necessary to investigate how trends vary spatially and over different time periods (i.e. pre- and post-mining).

Note that there are a number of limitations to the HARTT regression model:

– The model assumes that average monthly rainfall does not change over the analysis period (e.g. due to climate change) and that the rainfall dataset selected for the analysis is appropriate.
– The method is generally limited to shallow groundwater in unconfined aquifers
– The model assumes linear time trends

4.2.1.1.2 Deep groundwater sources

According to Ferdowsian et al. (2000), the HARTT method is generally limited to the analysis of relatively shallow groundwater from unconfined aquifers. Therefore, it was necessary to make a visual assessment of hydrographs from deeper bores in Table 5.1.

4.2.1.2 Groundwater quality

Groundwater pH and electrical conductivity (EC) have been summarised to analyse the beneficial use category of the groundwater source. The environmental value or beneficial use category of the groundwater sources at Mandalong Mine is at best ‘primary industry’ (specifically stock watering) with most of the groundwater only suitable for stock watering. Based on ANZECC (2000) guidelines, the groundwater pH should be in the range 6 to 8.5 and the EC generally should not exceed approximately 3,000 µS/cm for poultry, 3,700 µS/cm for dairy cattle and about 6,000 µS/cm for horses.

4.2.2 Hydrogeological model

Hydrogeological modelling was undertaken to estimate groundwater seepage into the Mandalong Mine workings and determine groundwater drawdown associated with Mandalong Mine and the modification. A hydrogeological model was previously developed for Mandalong Mine as part of the Mandalong Southern Extension Project (GHD 2013a). The hydrogeological model developed for the Mandalong Southern Extension Project reflected the most likely schedule of mining at Mandalong Mine. The hydrogeological model was recalibrated for updated groundwater inflow estimates as part of the Mandalong Tonnage Production Project (GHD 2016a).

The recalibrated hydrogeological model was most recently updated as part of Modification 9, the Mandalong Longwall Reorientation Project (GHD 2020b). The updated model was again updated and re-run for this assessment to reflect the removal of LW33, shortening of LW30 and proposed addition of LW34. No recalibration of the model was undertaken as part of the current update. A chronology of model development and updates in provided in Table 4.1.

Table 4.1 Overview of hydrogeological modelling

Project	Calibration target	Mining schedule
Mandalong Southern Extension Project (GHD 2013a)	Calibrated groundwater model to observed groundwater levels. Calculated groundwater inflow between December 2011 and June 2012 (GHD 2013a)	Most likely schedule of mining defined by Centennial Mandalong
Mandalong Tonnage Production Project (GHD 2016a)	Recalibrated model to observed groundwater inflow calculated by GHD (2014) and GHD (2015)	Schedule that reflected mining at a constant rate of 6.5 Mtpa
Mandalong Longwall Panel 22 to 23 Modification (GHD 2016b)	Utilised calibrated model from Mandalong Tonnage Production Project (GHD 2016a)	Updated most likely schedule of mining defined by Centennial Mandalong
Mandalong Longwall Panel 24 to 24A Modification	Utilised calibrated model from Mandalong Tonnage Production Project (GHD 2016a)	Updated most likely schedule of mining defined by Centennial Mandalong
Mandalong Longwall Reorientation Project (Mod 9)	Utilised calibrated model from Mandalong Tonnage Production Project (GHD 2016a)	Updated most likely schedule of mining defined by Centennial Mandalong
Mandalong Modification 10 (this WRIA)	Utilised calibrated model from Mandalong Tonnage Production Project (GHD 2016a)	Updated most likely schedule of mining defined by Centennial Mandalong

4.3 Surface water environment

4.3.1 Water and salt balance assessment

A water and salt balance assessment was undertaken to quantify the water and salt budgets, including inflows, outflows and net change in storage, in relation to the groundwater and surface water management systems for Mandalong Mine. A site water and salt balance was previously developed in GoldSim for the Mandalong Southern Extension Project (GHD 2013b), which is revised on an annual basis to assist in the management and reporting of water use at Mandalong Mine (GHD 2020a).

The water and salt balance model was updated to reflect the groundwater inflows into the underground workings predicted by hydrogeological modelling. The proposed modification does not propose any changes to the surface water management systems at MMAS, MSSS or DES and as such, these elements have not been presented.

The water management system for Mandalong Mine was modelled for the projected life of the mine, from conditions in 2021 to 2038. The model was created by representing the water and salt cycle as a series of elements, each containing pre-set rules and data, that were linked together to simulate the interaction of these elements within the water and salt cycle. The water and salt cycle was simulated over time in GoldSim and selected outputs from the modelled system were statistically summarised.

To assess the impact of rainfall on the site, modelling was completed by using a historical time series of daily rainfall data extending over 132 years, from January 1889 to June 2021 (refer Section 3.3). A total of 132 simulations were applied with each simulation modelling a different rainfall pattern.

The salt balance model was developed as an extension of the water balance model, with expected concentrations of salt applied to water inflows into the system. Transfers of the resulting salt loads were modelled throughout the site assuming instantaneous and complete mixing.

4.3.2 Waterway geomorphology

4.3.2.1 Desktop assessment

A desktop assessment of existing information was undertaken to identify and map the potential geomorphic impacts on upper unnamed tributaries of Buttonderry Creek and Mannering Creek.

Stream ordering followed the Strahler stream classification system where waterways are given an 'order' according to the number of additional tributaries associated with each waterway (Strahler 1952). Figure 4.1 demonstrates the Strahler stream ordering process for a generic catchment. Numbering begins at the top of a catchment with headwater ('new') flow paths being assigned as first order. Where two flow paths of order one join, the section downstream of the junction is referred to as a second order stream. Where two second order streams join, the waterway downstream of the junction is referred to as a third order stream, and so on. Where a lower order stream (e.g. first order) joins a higher order stream (e.g. third order), the reach downstream of the junction will retain the higher stream order.

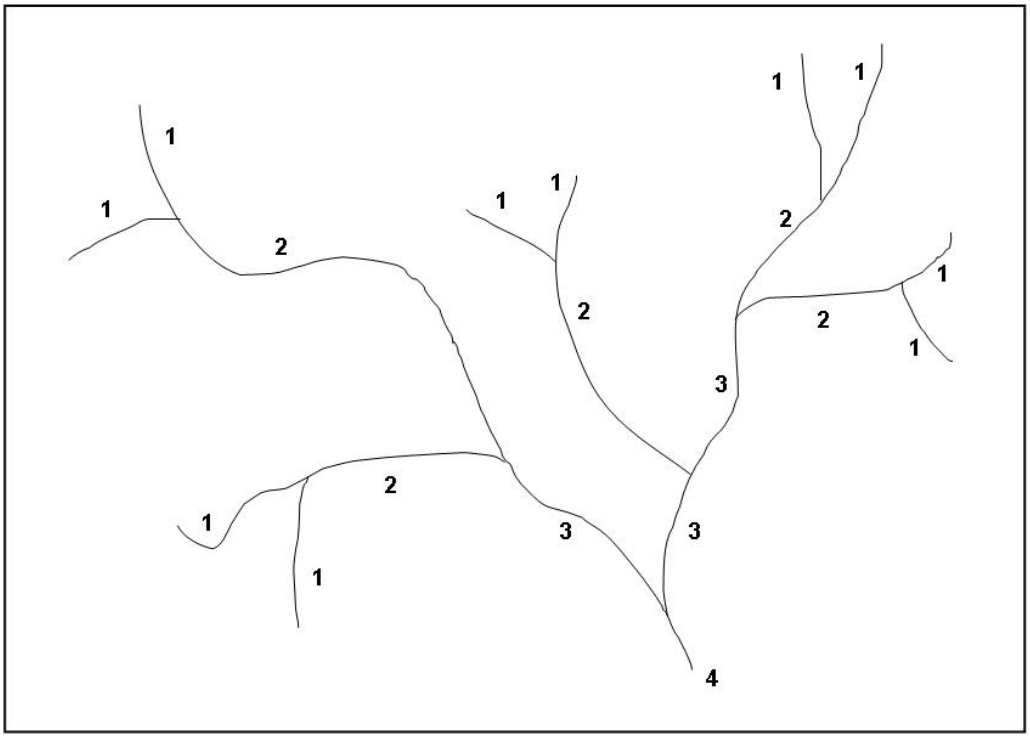


Figure 4.1 Generic stream order (after Strahler, 1952)

4.3.3 Surface water quality

The water quality assessment was undertaken in accordance with the assessment framework and methodologies outlined by ANZG (2018) and IESC (2019). Where an analytical result was below the limit of reporting (LOR) for a particular parameter, the detection limit was included in the analysis. This is one of the approaches recommended by ANZECC (2000a; Section 6.2.1).

4.3.4 Flood assessment

Umwelt Australia Pty Limited (Umwelt) has prepared a flood assessment (Umwelt 2021) to determine the impact on the flooding regime in the modification area as a result of underground mining at Mandalong Mine with a focus on LW34 and surrounds. The flood assessment also considered LW1-29 to allow for consideration of the cumulative impacts of underground mining. Relevant results from the flood assessment completed by Umwelt (2021) are summarised in Section 6.3.3.

4.4 Downstream water users

The potential impacts of the proposed modification on downstream water users were assessed by identifying sensitive groundwater and surface water receptors within the potential area of impact. The potential area of impact was estimated conservatively based on the results of the assessments on groundwater level and quality, water and salt balance, flooding, waterway geomorphology and surface water quality.

Groundwater users were identified by searching the NSW groundwater bore database (Water NSW 2020) for registered groundwater bores. Licensed surface water users and domestic and stock rights users with a water supply work approval were identified by searching for all lots within the potential area of impact in the *NSW Water Register* (WaterNSW 2020).

5. Existing conditions

5.1 Water management

5.1.1 Underground water management

The underground water management system at Mandalong Mine receives water from the Mandalong, Cooranbong and Delta underground workings. This water is transferred to a goaf within the former Cooranbong underground workings (known as the Cooranbong underground storage) via a series of collection points and pumps from various working areas underground. The goaf has a large volume and provides a filtration and sediment settlement function prior to being pumped to the Borehole Dam at the CES.

The inputs to the underground water management system consist of the following:

– Groundwater seepage from the coal seam and adjacent strata
– Supply of potable water to mining equipment within the Mandalong Mine workings (approximately 0.7 ML/day) and subsequent transfer of dirty mine water to the Cooranbong underground storage (approximately 0.4 ML/day to 0.7 ML/day).
– Transfer of surface water from Sediment Dams 1 and 2 at the CES (approximately 80 ML/year)
– Transfer of surface water from the 5 ML Dam at the CES (approximately 50 ML/year)
– Transfer of water from the Gross Pollutant Trap at the CES (also referred to as Coal Handling Plant Settlement Tank).

As shown in Figure 5.1, dirty water from the Mandalong Mine workings is pumped at a rate of approximately 0.4 ML/day from the 69 cut through (c/t) area into the Cooranbong underground storage. It is understood that some of the water within the Mandalong Mine workings (originating from potable supply and groundwater seepage) remains within the longwall goaf areas.

The water transferred from the Mandalong Mine workings is first allowed to settle at the Cooranbong settlement area shown in Figure 5.1. This water is then pumped at a rate of approximately 0.4 ML/day to 0.7 ML/day from the 151 c/t pump station to the Cooranbong underground storage dam. A dewatering bore extracts water from this underground storage dam, which is transferred to the Borehole Dam at the CES.

Water that is transferred from CES enters the Cooranbong underground storage via a series of passive infiltration bores. The location of this transfer point is shown in Figure 5.1. This water then drains under gravity to the Cooranbong underground storage dam.

5.1.2 Surface water management

Sources of water at the Mandalong Mine surface sites include potable water supply, rainfall, runoff and groundwater inflow into the underground mine workings. The primary water demands are for underground operations, machinery washdown, fire-fighting storage and staff amenities.

Surface water runoff from areas where there is no coal storage, transportation, handling or processing or any disturbance is considered to be clean water, as it is unlikely to be contaminated with coal fines or sediment. Runoff is diverted around dirty water and coal-contact catchments to avoid mixing with clean water runoff. Clean water runoff is typically from natural and impervious catchments such as areas of vegetation, sealed roads and sealed carparks.

Dirty water is runoff from disturbed areas and areas likely to contain suspended sediment, oils, grease and hydrocarbons. This typically includes workshop and fuel storage areas. Coal-contact water is runoff from catchments where coal storage, transportation, handling or processing occurs and is managed within the dirty water management systems.

Mandalong Mine has site-specific water management objectives that include:

– Maximise the separation of clean and dirty surface water systems
– Manage water discharge from the sites, in terms of volume and quality, to a level that is acceptable for environmental management and community expectations.
– Minimise water discharges from the premises by maximising, where practicable, opportunities for the reuse and recycling of water on site.
– Manage discharge to natural waterways in accordance with the relevant EPL conditions or as agreed with the EPA.

5.1.2.1 Mine water management

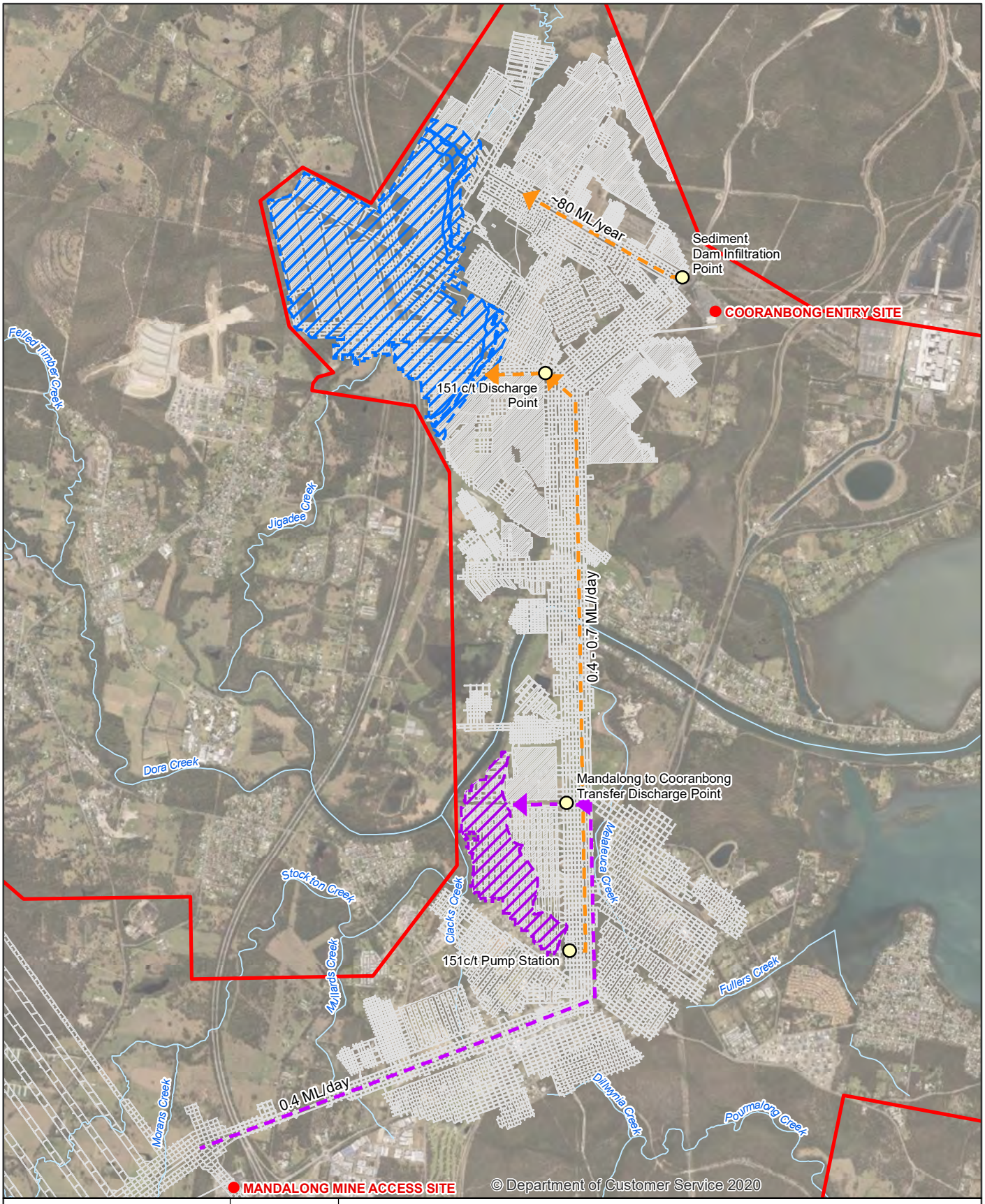
The Cooranbong dewatering bore extracts water from the Cooranbong underground storage. The extracted water is transferred by overland pipe to CES to the east and discharges into the Borehole Dam before discharging through LDP001 at CES. The Borehole Dam located upslope of the main CES is considered to be part of Mandalong Mine.

The approved extraction volume of 1,825 ML/year for the Cooranbong dewatering bore (WAL 39767) enables Mandalong Mine to sustainably manage the accumulation of water in the underground workings and align discharge volumes with LDP001 at CES which has a volumetric limit of 5 ML/day.

LDP001 at CES is located at the end of the discharge pipeline adjacent to an unnamed tributary of Muddy Lake. The pipeline receives mine water from the Borehole Dam and surface water from sediment dams at CES.

5.1.2.2 Potable water

Potable water is provided via connections to Hunter Water Corporation's reticulated potable water supply system. From the surface, potable water is transferred underground, where it is used for process water.



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Meters

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Site location
- Project application area
- Cooranbong Transfer Locations
- Cooranbong Goaf
- Cooranbong Settling
- Mandalong Mine Dirty Water Pump Transfer
- Water Transfer
- Waterway

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LOCATION	Mandalong
DRAWN	K.S.
CHECKED	I.G.
APPROVED	S.G.
SCALE	refer to scalebar

Centennial Mandalong Pty Ltd
Mandaling Mine Modification 10
Water Resources Impact Assessment

Underground Water Management

CENTENNIAL

DATE 15/07/2021

Figure 5-1

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Hunter\Mandalong\12552553\WRIA\12552553_WRIA010_Cooranbong_0.mxd

Data source: LPI:DCDB/Imagery, 2012/2015. Centennial: Mine workings, Extraction area, consent boundary, 2016. Created by: smacdonald, kpsroba, tmorton

5.2 Monitoring network

5.2.1 Groundwater monitoring network

A groundwater monitoring network has been progressively established at Mandalong Mine since 1997 and consists of mostly standpipe monitoring bores installed in alluvial and fractured and porous rock groundwater sources, as well as a series of five vibrating wire piezometers (VWP), now decommissioned, that were installed in an exploration hole in the Mandalong South area. The bores are monitored quarterly for groundwater levels and quality (pH and EC) while some bores contain water level loggers for continuous monitoring of groundwater levels. The monitoring program also includes landholder bore GW078043.

The locations of groundwater bores at Mandalong Mine are shown in Figure 5.2. Details of the groundwater bores are summarised in Table 5.1. At the end of 2016, monitoring ceased at a number of bores as detailed in the approved Water Management Plan (WMP). These inactive bores are summarised in Table 5.2.

Table 5.1 Groundwater monitoring bore details

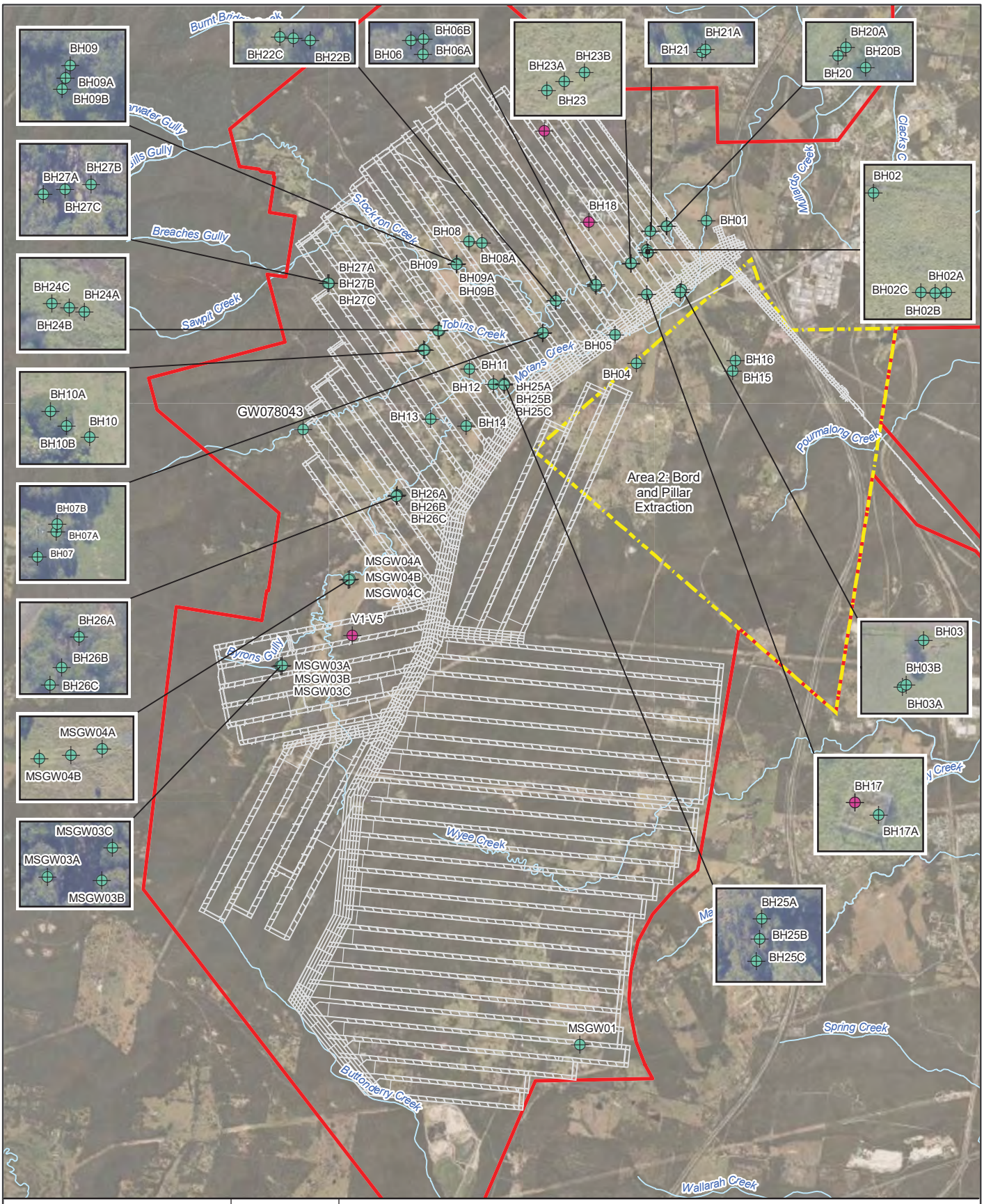
Bore	Monitoring period	Lithology	Longwall area
BH01	Aug 1997 – present	Alluvium	–
BH02A	Oct 2005 – present	Sandstone	LW3
BH03	Aug 1997 – present	Alluvium	–
BH03A	Nov 2005 – present	Alluvium	–
BH03B	Dec 2005 – present	Sandstone	–
BH04	Aug 1997 – present	Alluvium	–
BH05	Aug 1997 – present	Alluvium	–
BH06A	Nov 2005 – present	Sandstone	LW7
BH09	Aug 1997 – present	Alluvium	LW12
BH09A	Jun 2010 – present	Mudstone/sandstone	LW12
BH09B	July 2010 – present	Mudstone/sandstone	LW12
BH10	Aug 1997 – present	Alluvium	LW16
BH10A	Jun 2010 – present	Mudstone/sandstone	LW16
BH10B	Jun 2010 – present	Sandstone	LW16
BH11	Aug 1997 – present	Alluvium	LW15
BH12	Aug 1997 – present	Alluvium	LW14/15
BH13	Aug 1997 – present	Alluvium	LW18
BH14	Aug 1997 – present	Alluvium	LW17
BH20	Dec 2003 – present	Conglomerate	LW1
BH21	Dec 2003 –present	Conglomerate	LW2
BH23A	Jan 2006 – present	Mudstone	LW4/5
BH24A	Jun 2010 – present	Alluvium	LW15
BH24B	Jun 2010 – present	Sandstone	LW15
BH24C	Jun 2010 – present	Mudstone/sandstone	LW15
BH25A	Jun 2010 – present	Alluvium	LW14
BH25B	Jun 2010 – present	Sandstone	LW14
BH25C	Jun 2010 – present	Mudstone/sandstone	LW14
BH26A	Oct 2011 – present	Alluvium	LW22
BH26B	Oct 2011 – present	Sandstone	LW22

Bore	Monitoring period	Lithology	Longwall area
BH27A	Oct 2011 – present	Alluvium	LW18/19
BH27B	Oct 2011 – present	Sandstone	LW18/19
BH27C	Oct 2011 – present	Conglomerate	LW18/19
MSGW01	Sept 2011 – present	Alluvium	-
MSGW03A	Sept 2011 – present	Morans Creek alluvium	LW26
MSGW03B	Sept 2011 – present	Sandstone (Tuggerah)	LW26
MSGW03C	Sept 2011 – present	Conglomerate (Munmorah)	LW26
MSGW04A	Sept 2011 – present	Morans Creek alluvium	–
MSGW04B	Sept 2011 – present	Sandstone (Tuggerah)	–
MSGW04C	Sept 2011 – present	Conglomerate (Munmorah)	–
GW078043	Aug 2017 – present	Sandstone/Conglomerate	–

Table 5.2 Inactive groundwater monitoring bore details

Bore	Monitoring period	Lithology	Longwall area
BH02	Aug 1997 – Dec 2016	Alluvium	LW3
BH02B	Dec 2005 – Dec 2016	Alluvium	LW3
BH02C	Dec 2005 – Dec 2016	Alluvium	LW3
BH06	Aug 1997 – Dec 2016	Alluvium	LW7
BH06B	Dec 2005 – May 2009 (dry since June 2009)	Sandstone	LW7
BH07	Aug 1997 – Dec 2016	Alluvium	LW10/11
BH07A	Dec 2005 – Dec 2016 (bore blocked)	Conglomerate	LW10/11
BH07B	Jan 2006 - July 2018	Siltstone	LW10/11
BH08	Aug 1997 – Dec 2016	Alluvium	LW11
BH08A	No data – Dec 2016	Sandstone	LW11
BH15	Sep 2003 – February 2015 (bore blocked since Oct 2013)	Fassifern Seam	–
BH16	No data – dry	Great Northern Seam	–
BH17	Apr 2003 – Apr 2008 (now decommissioned)	Conglomerate	LW5
BH17A	Oct 2005 – Dec 2016	Alluvium	LW5
BH18	Apr 2003 – Oct 2007 (now decommissioned)	Conglomerate	LW5
BH19	Apr 2003 – Nov 2006 (now decommissioned)	Conglomerate	LW4
BH20A	Dec 2003 – Dec 2016	Alluvium	LW1
BH20B	Oct 2004 – Dec 2016	Siltstone	LW1
BH21A	Dec 2003 – Dec 2016	Alluvium	LW2
BH22A	Dec 2005 – Dec 2016	Alluvium	LW9
BH22B	Dec 2005 – Dec 2016	Sandstone	LW9
BH22C	Dec 2005 – Oct 2008 (now blocked)	Conglomerate	LW9
BH23	Jan 2006 – Dec 2016	Conglomerate	LW4/5
BH23B	Jan 2006 – Dec 2016	Alluvium	LW4/5

Bore	Monitoring period	Lithology	Longwall area
BH26C	Oct 2011 – Dec 2016 (blocked at 35 m at Jan 2018)	Conglomerate	LW22
VWP			
V1	Oct 2011 – Oct 2018	West Wallarah Seam	LW25
V2	Oct 2011 – Oct 2018	West Wallarah Seam	LW25
V3	Oct 2011 – Oct 2018	Shale (Dooralong)	LW25
V4	Oct 2011 – Oct 2018	Conglomerate (Munmorah)	LW25
V5	Oct 2011 – Oct 2018	Conglomerate (Munmorah)	LW25



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Meters

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Groundwater Monitoring Bore
- Decomissioned Groundwater Monitoring Bore
- Project application area
- Waterway
- Area 2
- Approved and proposed mine workings

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LOCATION	Mandalong
SEAM	West Wallarah
DRAWN	KS
CHECKED	TT
APPROVED	SG
SCALE	refer to scalebar

Centennial Mandalong Pty Ltd
Mandalong Mine Modification 10
Water Resources Impact Assessment

Groundwater monitoring bore locations

CENTENNIAL

DATE 16/08/2021

Figure 5-2

GIS Filename: C:\Users\IJGILM~1\AppData\Local\Temp\arcD838\12552553_WRIA011_GroundwaterMonitoring_0.mxd

© Centennial: Boundary; Mine Plan, Monitoring; 2016. LPI: DTDB/Imagery, 2012/2015.

5.2.2 Surface water monitoring network

5.2.2.1 Surface water quality

Sporadic surface water quality monitoring commenced at Mandalong Mine in 1996. A formal surface water quality monitoring program commenced in 1999, with monthly and quarterly surface water quality monitoring occurring at ten locations. Five of these locations are within the Stockton Creek catchment area and cover the upper, middle and lower reaches of Stockton Creek, the convergence of Stockton Creek and Morans Creek, and downstream of the convergence prior to discharging into Dora Creek.

Surface water quality monitoring has been undertaken on Morans Creek since 2011 at SWMP06 and SWMP07, located downstream of the modification area, as shown in Figure 5.3. Surface water quality monitoring has only recently commenced on Buttonderry Creek, at location SWMP08, however Central Coast Council undertake monitoring upstream of the Buttonderry Waste Management Facility, at location BTU, as shown in Figure 5.3.

5.2.2.2 Flow monitoring

There exists two public watercourse stream gauges located on Jilliby Creek (ID 211010) and Wyee Creek (ID 211001). Both are not continuously monitored sites and the data is considered to be unreliable. Centennial Mandalong installed a flow and level gauge on Morans Creek in 2006 and recorded data up until 2009. Monitoring at the flow and level gauge on Morans Creek recommenced in 2017. The gauge is approximately 8 km downstream of LW30-34, as shown in Figure 5.3.

5.3 Groundwater environment

5.3.1 Review of existing data

5.3.1.1 Groundwater levels

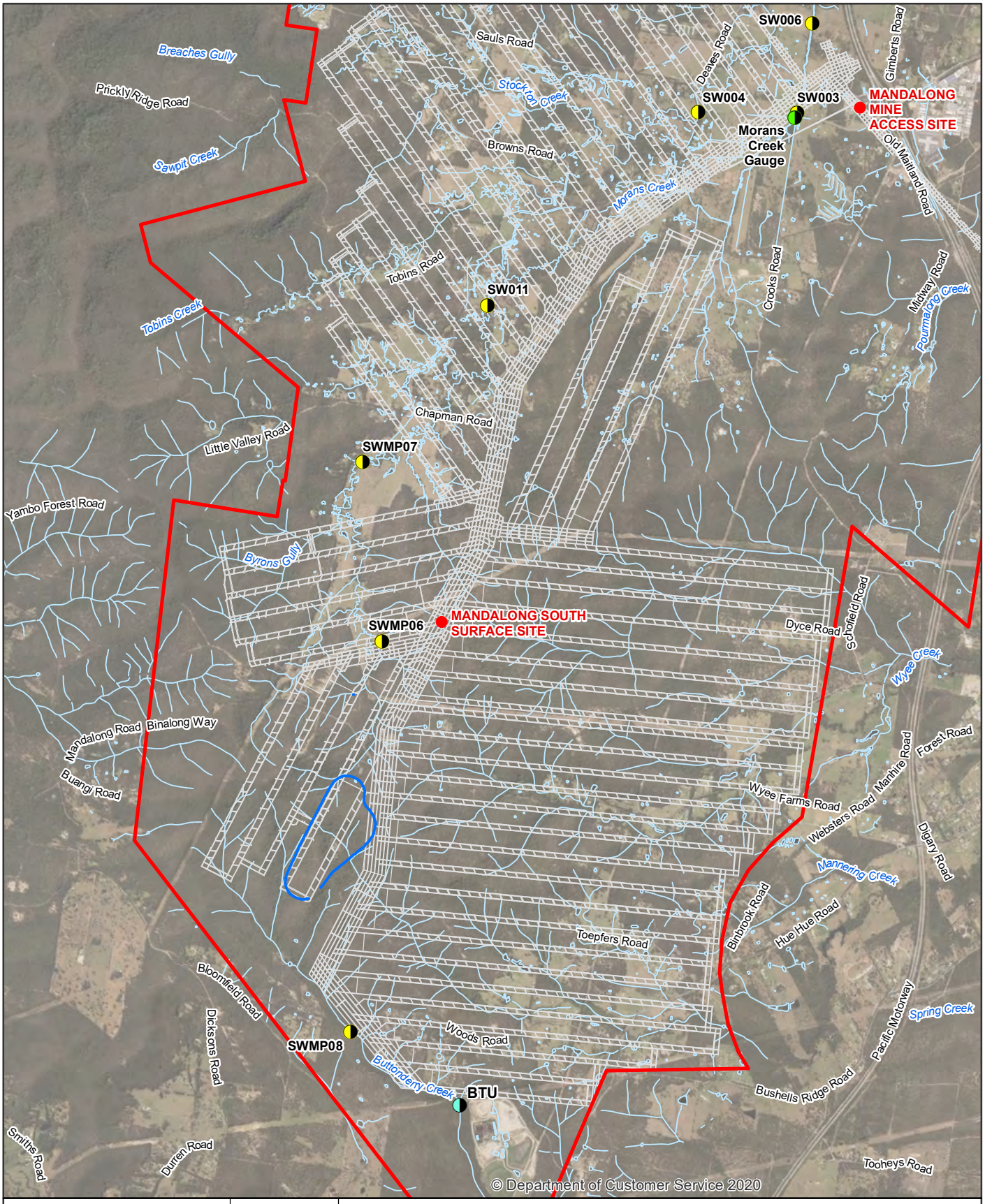
5.3.1.1.1 Alluvial groundwater sources

Groundwater hydrographs for each of the alluvial monitoring bores at Mandalong Mine listed in Table 5.1 have been plotted and compared to the CRD curve. These hydrographs are shown in Appendix A

The recorded groundwater elevations for each alluvial monitoring bore are shown in blue in each hydrograph in Appendix A. The groundwater level at each monitoring location has generally fluctuated over time within a range of 2 m to 3 m bgl.

Groundwater levels at Mandalong Mine have been recorded manually and the limit of reading of the measuring tape is 10 mm. When considering the accuracy achievable by the field technician, the limit of accuracy of an individual measurement may be up to ± 50 mm. Therefore, groundwater monitoring is unlikely to detect changes in groundwater level of less than 10 mm at a particular bore from one monthly monitoring round to the next. When water pressure loggers have been used to monitor groundwater levels, the limit of accuracy for corrected levels is also 10 mm since this is the accuracy of the top of casing (TOC) elevation measurement.

The CRD curve is shown in green in each hydrograph in Appendix A. HARTT analysis has been undertaken for each alluvial dataset to establish the relationship between groundwater levels and rainfall and detect underlying trends in groundwater levels that are independent of rainfall. The best fit HARTT regression line is shown in red in each hydrograph. The HARTT statistical output for each alluvial hydrograph is shown in Table 5.3.



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0 500 1,000 1,500

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Surface water monitoring location
- Buttonderry WMF monitoring location
- Morans Creek Gauge
- Site location
- Project application area
- Waterway (field surveyed)
- Approved and proposed mine workings
- Modification area (20mm subsidence contour)

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LOCATION	Mandalong
DRAWN	F.M
CHECKED	I.G
APPROVED	S.G.
SCALE	refer to scalebar

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Mandalong Mine Modification 10
Water Resources Impact Assessment

Surface Water Monitoring Locations

CENTENNIAL

DATE 31/08/2021

Figure 5-3

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Hunter\Mandalong\12552553\WRIA\12552553_WRIA012_SW_Monitoring_A.mxd

Data source: LPI:DCDB/Imagery, 2012/2015. Centennial: Mine workings, Extraction area, consent boundary, 2016. Created by: smacdonald, kpsroba, tmorton

Table 5.3 HARTT analysis results for alluvial monitoring bores

Bore	R^2	Rainfall coefficient a(m/mm)	p-value (rain)	Time coefficient b(m/month)	p-value (time)	c (m)
BH01	0.552	0.001	0.000	-0.002	0.000	2.702
BH03	0.658	0.001	0.000	-0.003	0.000	5.085
BH03A	0.453	0.001	0.000	-0.001	0.015	4.941
BH04	0.346	0.001	0.000	-0.001	0.000	8.573
BH05	0.421	0.001	0.000	-0.004	0.000	9.476
BH09	0.315	0.001	0.000	0.000	0.579	15.547
BH10	0.317	0.001	0.000	0.001	0.000	17.788
BH11	0.182	0.001	0.000	-0.001	0.030	15.081
BH12	0.415	0.001	0.000	-0.004	0.000	13.633
BH13	0.286	0.001	0.000	-0.004	0.000	15.629
BH14	0.370	0.001	0.000	-0.001	0.000	15.504
BH24A	0.561	-0.002	0.000	-0.014	0.000	17.140
BH24A (post Aug 2014)	0.838	0.000	0.719	0.024	0.000	14.312
BH25A	0.602	0.002	0.000	-0.013	0.000	12.867
BH26A	0.329	0.001	0.005	-0.006	0.000	18.855
MSGW01	0.274	0.001	0.002	-0.004	0.003	40.756
MSGW03A	0.023	0.001	0.440	0.011	0.004	31.116
MSGW04A	0.285	0.000	0.001	-0.003	0.004	23.768

The R^2 value of the HARTT regression line gives a measure of the quality of fit of the non-linear regression line to the observed hydrograph. This value was greater than 50% for 5 of the 15 datasets, indicating that one third of the hydrographs can be reasonably modelled by HARTT variables (CRD and linear time trends) alone. Lower R^2 values indicate the groundwater level data cannot be accurately modelled by HARTT variables and that other factors are in affect (i.e. surface water interaction, groundwater abstraction, etc.). However, it is considered that this analysis still provides a reasonable indication of trends. The *c* parameter relates to the intercept of the regression and the initial water level in each bore.

p-values test the null hypothesis that the coefficient has no effect. Low *p*-values (<0.05) reject the null hypothesis and indicate the coefficient is meaningful to the model. The *p*-value for the coefficients of rainfall and time have been assessed. The *p*-value for the rainfall variable *a* is less than 0.05 for all hydrographs except BH24A (post-August 2014 dataset), and MSGW03A indicating that there is a significant relationship between groundwater level and CRD at the majority of alluvial monitoring locations. The rainfall coefficient suggests that alluvial groundwater levels respond by approximately 1 mm per mm of CRD (or atypical rainfall), which is less than the limit of accuracy of groundwater level measurements. Due to this strong relationship it is difficult to identify the underlying trend visually.

The *p*-value for the time variable *b* is less than 0.05 for all hydrographs, excluding BH09, indicating statistically significant linear time trends (independent of rainfall) in groundwater levels. Where the *p*-value is greater than 0.05, time trends are statistically insignificant, and the time coefficient *b* cannot be relied upon to describe historical trends or predict future groundwater levels. At BH09 the time-related p-value was high, indicating that groundwater level prediction is unreliable at this site. The magnitudes of the statistically significant temporal trends (both increasing and decreasing) were small compared to the precision of groundwater level gauging (i.e. 0.01 m) for all bores except MSGW03A, BH24A and BH25A. Overall decreasing trends are evident at BH24A and BH25A. Water levels have been varying without trend at MSGW03A.

Visual inspection of the hydrograph for BH24A indicated that groundwater levels fell after undermining at BH24A from approximately 16.8 m AHD in January 2014 to 14.8 m AHD in August 2014. Analysis of the post-August 2014

hydrograph indicates that levels at this monitoring location have shown a statistically significant increasing trend (independent of rainfall) with levels responding to CRD.

Visual inspection of the hydrograph for BH25A indicated that the decreasing trend in groundwater level at this location is not completely attributable to mining. The visual inspection of the hydrograph indicated that post-mining groundwater levels initially remained within the observed range of pre-mining levels. Groundwater levels at BH25A continued to decrease between January 2018 and October 2018 potentially due to decreasing CRD over this period. Since October 2018, groundwater levels at BH25A were slightly higher, with groundwater levels responding to CRD. Visual review of the hydrograph did indicate some temporary, short-term variation in groundwater levels following mining, with trends increasing with CRD more recently.

MSGW04A is within 400 m of completed longwalls at Mandalong Mine, however has not been undermined. Visual inspection of the hydrograph for MSGW04A indicates that a relatively large drop in groundwater levels occurred between July 2016 and January 2017 with groundwater levels falling 1.6 m over this period. This drop may be related to significantly below average rainfall over this period. Since January 2017 groundwater levels at MSGW04A have continued to generally respond to changes in CRD.

The variation in groundwater levels at BH24A and BH25A are considered to be a result of the development of shallow tensile and compressive cracks resulting in localised increases in hydraulic conductivity and porosity. It is expected that these cracks would fill over time and the hydraulic conductivity and porosity should return to pre-mining values. This has been observed at other alluvial bores that had a temporary reduction in groundwater levels post mining, such as BH22A. The depth of cover above the coal seam at monitoring bores BH24A and BH25A is approximately 170 m to 200 m. The depth of cover above MSGW04A is approximately 275 m.

MSGW01 is located in the vicinity of future longwalls within the Mandalong Southern Extraction Area.. MSGW01 is located over 3 km to the south east of the active mining area. Visual inspection of hydrographs indicates a relatively large fall in groundwater levels at MSGW01 of 1.8 m between July 2016 and February 2017. This drop in groundwater levels corresponded with a period of considerably below average rainfall. Additionally, MSGW01 is located in the Wyee Creek catchment. Underground mining has not extended into the Wyee Creek catchment. Therefore the variability in groundwater levels at MSGW01 is not considered to be related to mining at Mandalong Mine.

5.3.1.1.2 Fractured and porous rock groundwater sources

According to Ferdowsian et al. (2000), the HARTT method is generally limited to the analysis of relatively shallow groundwater from unconfined aquifers. Therefore, it was necessary to make a visual assessment of hydrographs from deeper bores to identify existing impacts on fractured and porous rock groundwater sources. Hydrographs for deeper monitoring bores at Mandalong Mine are shown in Appendix A.

At the time of this assessment, all deeper monitoring bores had been directly undermined by longwall panels with the exception of MSGW04B and MSGW04C. These bores are screened within Triassic sandstone and conglomerate. Mining has occurred within 400 m of MSGW04B and MSGW04C.

Groundwater levels at MSGW04C were relatively constant at around 20 m AHD for the first 12 months of monitoring. Following this initial period of monitoring groundwater levels have shown a large amount of variability. This variability in groundwater levels is due to purging of the bore for sampling. MSGW04C was most recently sampled in November 2015. Following sampling, the bore recovered over a number of months. A decreasing trend at MSGW04C has been occurring since December 2016. This decreasing trend is not related to purging of the bore for sampling and is likely due to mining in the vicinity of MSGW04C.

Groundwater levels at MSGW04B were relatively constant at around 22.5 m AHD for the first 12 months of monitoring between September 2011 and September 2012. Following this period of monitoring groundwater levels showed a decreasing trend. This decreasing trend may be partially attributable to sampling of MSGW04C. Visual review of the hydrograph indicates groundwater levels at MSGW04B began to fall at a faster rate in late 2014. This was potentially due to mining approaching MSGW04B, with longwall mining occurring within approximately 1.8 km from the bore at this time. However this decreasing trend may also be due to purging of MSGW04C for sampling.

Groundwater levels at MSGW04B continued to fall until July 2018. As MSGW04C has not been purged since November 2015, it is likely that this decreasing trend is in part attributable to mining in the vicinity of MSGW04C. Since July 2018, groundwater levels at MSGW04B have displayed an increasing trend.

Monitoring bores BH02A, BH03B, BH06A, BH09A, BH09B, BH10A, BH10B, BH23A, BH24B, BH24C, BH25B, BH25C, BH26B, BH27B, MSGW03B and MSGW03C screened within the sandstone and siltstone of the Tuggerah Formation, have been directly undermined by existing workings. By visual assessment, following undermining there appeared to be a consistent drop in groundwater elevation at most of these locations (with the exception of BH26B and BH27B). At most locations the fractured and porous rock groundwater sources monitored by these bores are approximately 120 m to 230 m above the coal seam.

At a number of these locations (including BH03B, BH09A, BH09B, BH10A, BH23A, BH24B, BH25B and BH25C), groundwater levels have re-stabilised to between 10 m AHD and -14 m AHD or have shown slight increases towards pre-mining levels at approximately three to five years post-undermining.

A strong trend in recovery of groundwater levels post-undermining is evident at BH06A, with levels returning to near pre-mining levels as of late 2020. At MSGW03B, visual review of the hydrograph indicates groundwater levels have responded to CRD, including after undermining.

Monitoring bores BH20, BH21, BH27C and MSGW03C, screened within the Munmorah Conglomerate, have been undermined by existing longwalls and groundwater elevations at all locations have dropped over the monitoring period. Groundwater levels at BH20 and BH21 initially decreased between 2005 and 2007, with stabilising trends occurring into late 2020. In the first 12 months of monitoring at MSGW03C, groundwater levels were stable. In mid-2012 levels suddenly decreased and then increased to initial levels in 2013. A gradual decreasing trend is evident between 2013 and late 2020, with levels more quickly decreasing from 2018 to when it was observed dry in mid 2019. At the VWPs a drop in groundwater pressure following undermining in January 2018 is also evident at V3 and V4 installed in the Munmorah Conglomerate and at V2 installed in the Dooralong Shale.

The only coal seam bore (not including the VWPs) is BH15 in the Fassifern Seam, underlying the West Wallarah Seam and Awaba Tuff. Monitoring of this bore ceased in November 2014 due to bore damage. Groundwater elevations at this location fluctuated between 12 m AHD and 14 m AHD over the monitoring period. By visual assessment there appears to be some degree of response to CRD in groundwater elevations reported at BH15 but no depressurisation is evident.

At the VWPs in the target coal seam (V1 and V2) both recorded very constant pressures between approximately 0 m AHD and 5 m AHD. Groundwater pressure at V1 and V2 started to decline in mid-2017 as longwall mining approached. There was a sharp drop in groundwater pressures in January 2018 due to undermining.

Overall, analysis of deeper groundwater monitoring data indicates that depressurisation of fractured and porous rock groundwater sources (by greater than 2 m) occurs up to 240 m above the Mandalong longwall panels. Complete depressurisation tends to occur up to 120 m above the longwalls. At a number of monitoring locations that have shown depressurisation due to mining, groundwater levels have stabilised or started to gradually increase towards pre-mining levels approximately three to five years after undermining occurring.

5.3.1.2 Groundwater quality

5.3.1.2.1 Alluvial groundwater sources

Previous assessment of alluvial groundwater quality (GHD 2013c) indicated that at most alluvial bores the groundwater pH is consistently within the range of 5 to 8 and groundwater EC varies considerably within the alluvium across the mining area, ranging from less than 1,000 µS/cm to over 10,000 µS/cm.

As discussed in the Mandalong Southern Extension Project response to submissions, there is variability in groundwater EC at a number of alluvial monitoring bores at Mandalong Mine. As part of the response to submissions process it was identified that this variability in EC was attributable to sampling of bores by bailing without initial purging. Since January 2015, alluvial monitoring bores at Mandalong Mine have been sampled using low flow techniques where possible (i.e. peristaltic pump or Micro-purge pump) with initial purging until pH and EC stabilise. Additionally, bores that were identified as being regularly submerged by surface water have been regularly purged to remove potential influence of surface water on monitoring results. Following the update of the groundwater monitoring methodology, variability in observed EC has reduced.

Groundwater pH and EC reported at alluvial monitoring bores at Mandalong Mine is summarised in Appendix B. The groundwater pH and EC indicates that current alluvial groundwater quality is generally within the range reported by GHD (2013c) and no change in groundwater pH or EC resulting in a lowering of the beneficial use category is evident since longwall mining began in 2005.

5.3.1.2.2 Fractured and porous rock groundwater sources

Review of groundwater quality data by GHD (2013c) indicated that there is considerable spatial variability in groundwater pH within the fractured and porous rock groundwater source. However, at some monitoring locations the pH is consistently in the moderately to highly alkaline range. The review of groundwater quality data indicated that groundwater pH generally remained within the pre-mining range during and after undermining (GHD 2013c).

GHD (2013c) also reports that groundwater EC within the fractured and porous rock water sources typically ranges from about 6,000 µS/cm to over 10,000 µS/cm. The review of groundwater quality data by GHD (2013c) indicated that groundwater EC generally remains within the pre-mining range during and after undermining or reduces over time.

As discussed above, as part of the response to submissions process it was identified that variability in monitoring results for EC was occurring at a number of monitoring bores at Mandalong Mine and this variability was attributable to sampling of bores by bailing without initial purging. Since January 2015, deeper monitoring bores at Mandalong Mine have also been sampled using low flow techniques where possible (i.e. peristaltic pump or Micro-purge pump). Additionally, bores that were identified as being regularly submerged by surface water have been regularly purged to remove potential influence of surface water on monitoring results. Following the update of the groundwater monitoring methodology, variability in observed EC has reduced.

Groundwater pH and EC reported at fractured and porous rock monitoring bores at Mandalong Mine is summarised in Appendix B. The groundwater pH and EC indicates that current fractured and porous rock groundwater quality is generally within the range reported by GHD (2013c) and no change in groundwater pH or EC resulting in a lowering of the beneficial use category is evident since longwall mining began in 2005.

5.3.2 Hydrogeological model

The MODFLOW flow budget results for the recalibrated hydrogeological model for current conditions in 2021 are presented in Table 5.4. This flow budget incorporates the entire model domain, which extends well beyond the footprint of Mandalong Mine as outlined in GHD (2013a).

Table 5.4 Hydrogeological model predictions for existing conditions

	Existing conditions	
	Alluvium and outcropping rock [1] (ML/year)	**Rock (ML/year)**
INPUTS		
Recharge	4055	0
GHB [2]	1325	350
Storage	4	368
Other zones	540	575
TOTAL INPUTS (rounded)	**5925**	**1293**
OUTPUTS		
Drains [3]	3645	383
GHB [2]	229	28
Storage	1476	342
Other zones	575	540
TOTAL OUTPUTS (rounded)	**5925**	**1293**
BALANCE		
Inputs – outputs	**0**	**0**

1. Layer 1 of MODFLOW model
2. General head boundary
3. Transfer from alluvium and outcropping rock to drains is baseflow. Transfer from fractured and porous rock to drains is inflow to mine workings.

The flow budget indicates that the inflow of groundwater into mine workings is 1.05 ML/day in 2021, which comes from the fractured and porous rock groundwater sources.

5.4 Surface water environment

5.4.1 Water and salt balance assessment

5.4.1.1 Water balance results

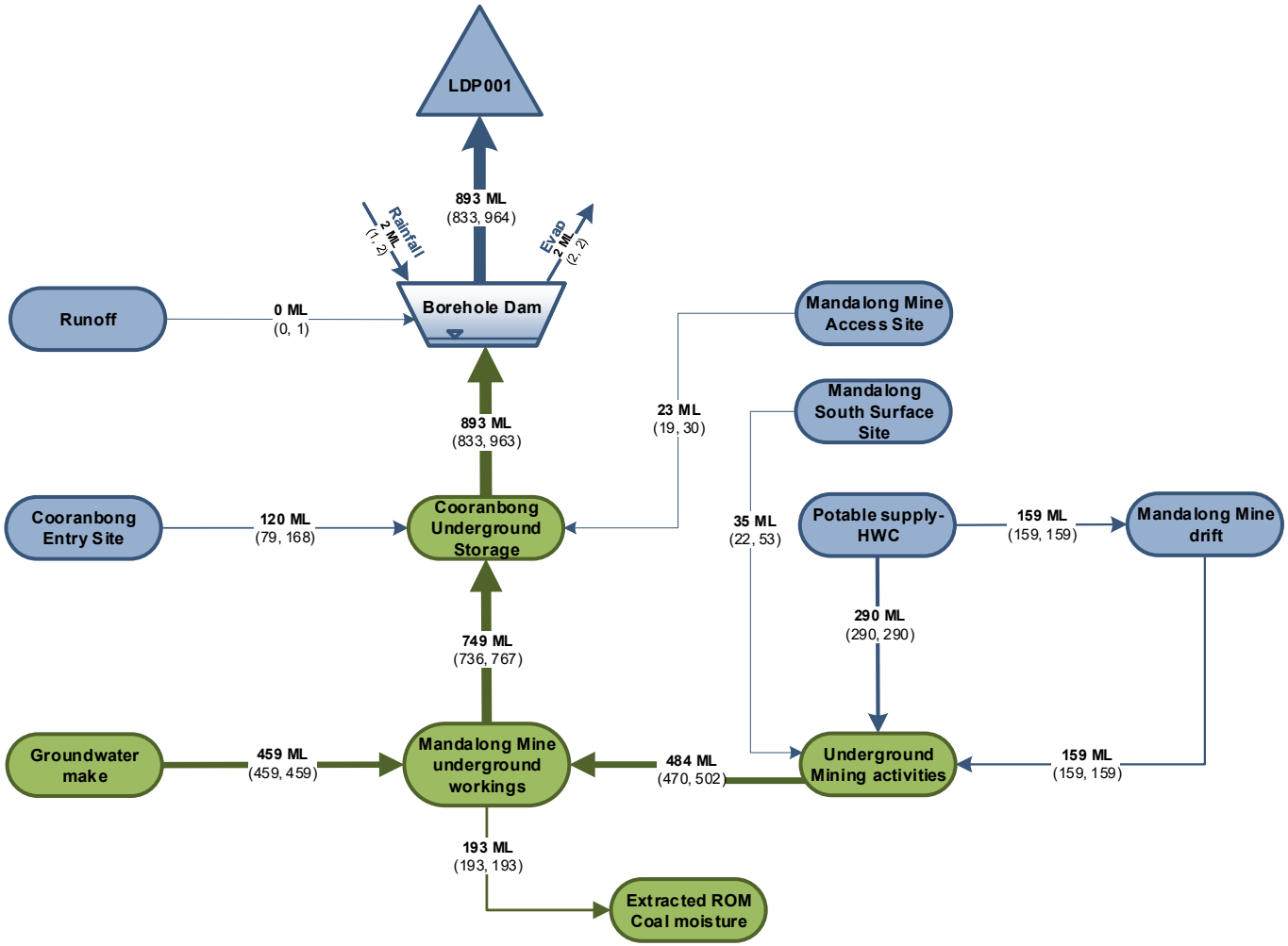
The existing conditions of the water management system for Mandalong Mine was modelled based on conditions in 2022, using a historical time series of daily rainfall data extending over 132 years. A total of 132 simulations were applied with each simulation modelling a different rainfall pattern (refer Section 4.3.1). As a result, 132 annual totals were available for each element within the water balance model, thereby representing a wide range of possible rainfall conditions.

Water balance modelling estimated the annual volumetric transfers between the water cycle components under existing conditions, as shown in Figure 5.4. As the proposed modification does not propose any changes to the surface water management at MMAS, MSSS or DES, these elements of the water cycle have not been presented for clarity.

The results present the average annual transfers between water management elements as well as the 10th percentile and 90th percentile values. The purpose of displaying the three results for each water transfer is to show the average transfer volume and an indication of the range of values expected due to possible variation in rainfall.

The 10th percentile represents the value at which 10% of the modelled outputs were less than this value. Similarly, the 90th percentile represents the value at which 90% of the modelled outputs were less than this value. The 10th and 90th percentile values have been used (rather than minimum and maximum values) to remove the impact of skewing by infrequent to extreme wet and dry conditions.

From the results provided in Figure 5.4, average annual inputs and outputs for the water balance under existing conditions in 2022 were summarised, as shown in Table 5.5. The main inputs of water to the Mandalong Mine water cycle include potable water supply and groundwater inflow into the underground workings; and the main output of water is the discharge to LDP001.



Legend

- Underground storage
- Underground process
- Surface storage
- Surface process
- Licensed discharge point
- X (X,X) — Mean (10^{th} percentile, 90^{th} percentile)
- Surface water flow
- Groundwater flow

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Mandalong Mine
Modification 10 Water Resources Impact Assessment

Water management schematic Annual water transfers Existing conditions (2022)

Project No. 12552553
Revision No. A
Date 10/08/2021

FIGURE 5-4

Created by: Tyler Tinkler

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Print date: 10/08/2021 21:07

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Table 5.5 Summary of average annual water inputs and outputs under existing conditions

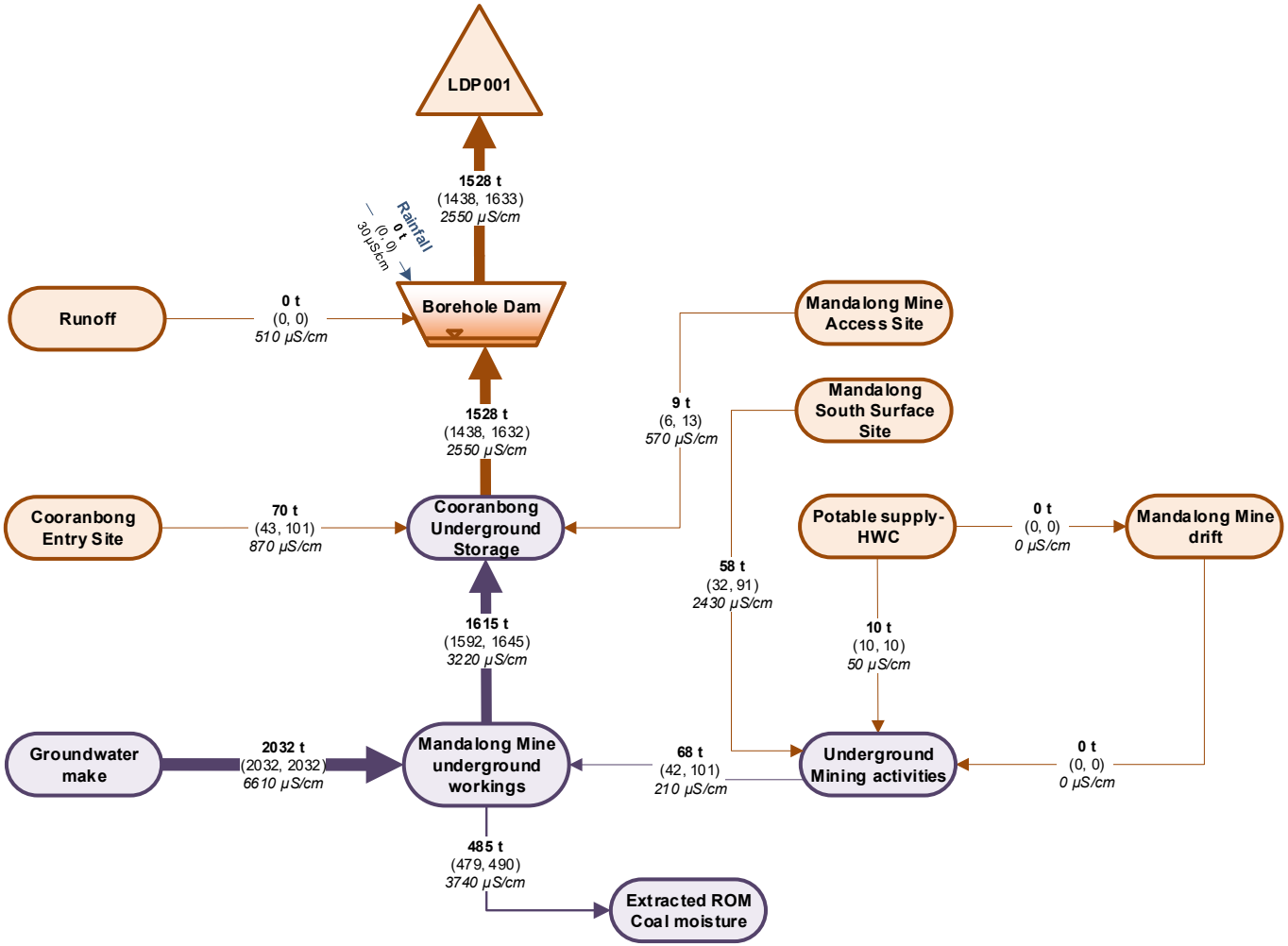
Water management element	Existing conditions
	2022 (ML/year)
INPUTS	
Rainfall and catchment runoff	2
Transfer from CES to underground workings	120
Transfer from MSSS to underground workings	35
Transfer from MMAS to underground workings	23
Potable water supply	449
Groundwater inflow into underground workings	459
TOTAL INPUTS (rounded)	**1088**
OUTPUTS	
Evaporation	2
Discharge to LDP001	893
ROM moisture loss	193
TOTAL OUTPUTS (rounded)	**1088**
CHANGE IN STORAGE	
Borehole Dam	0
Cooranbong underground storage	0
TOTAL CHANGE IN STORAGE (rounded)	**0**
BALANCE	
Inputs – outputs – change in storage	0

Table 5.5 shows the main inflows at Mandalong Mine are groundwater intercepted by the underground workings and potable water used for underground mining operations, with some relatively minor rainfall related influences transferred from the surface. This water flux is mainly discharged via LDP001, with some losses in ROM coal moisture.

5.4.1.2 Salt balance results

As discussed in Section 4.3.1, the salt balance model was developed as an extension of the water balance model with expected concentrations of salt applied to water inflows into the system. Similar to the water balance, salt balance modelling provided 132 possible annual totals of salt transfers between the water cycle components of Mandalong Mine under existing conditions, as shown in Figure 5.5. As with the water balance results, the salt balance results present the average annual salt transfers as well as the 10th percentile and 90th percentile values to provide an indication of the range of values expected due to possible variation in rainfall. In addition to the salt transfer quantities, the average salinity of each transfer is also displayed on the figure.

From the results provided in Figure 5.5, average annual inputs and outputs for the salt balance under existing conditions in 2022 were summarised, as shown in Table 5.6.



Legend

- Underground storage
- Underground process
- Surface storage
- Surface process
- Licensed discharge point
- Surface water flow
- Groundwater flow
- X, •(X,X), XX — Mean (10th percentile, 90th percentile) Mean EC

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Mandalong Mine
Modification 10 Water Resources Impact Assessment

Water management schematic
Annual salt transfers
Existing conditions (2022)

Project No. 12552553
Revision No. A
Date 10/08/2021

FIGURE 5-5

Created by: Tyler Tinkler

\\ghdnet\ghd\AU\Newcastle\Projects\22\12552553\Tech\Water_balance\Visio\12552553-VIS-Mandalong_Mine_SWB-Salt_transfers-Existing_2022.vsdm
Print date: 10/08/2021 21:05
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Table 5.6 Summary of average annual salt inputs and outputs under existing conditions

Water management element	Existing conditions
	2022 (tonne/year)
INPUTS	
Rainfall and catchment runoff	0
Transfer from CES to underground workings	70
Transfer from MSSS to underground workings	58
Transfer from MMAS to underground workings	9
Potable water supply	10
Groundwater inflow into underground workings	2032
TOTAL INPUTS (rounded)	**2178**
OUTPUTS	
Discharge to LDP001 from Borehole Dam	1528
ROM moisture loss	485
TOTAL OUTPUTS (rounded)	**2013**
Borehole Dam	0
Cooranbong underground storage	165
TOTAL CHANGE IN STORAGE (rounded)	**165**
BALANCE	
Inputs – outputs – change in storage	0

Table 5.6 shows that main salt flux at Mandalong Mine is associated with interception of relatively saline groundwater, which is diluted by relatively less saline potable water prior to discharge via LDP001. The average salinity of the underground storage is simulated to increase slightly in proportion to the forecast increase in groundwater intercepted.

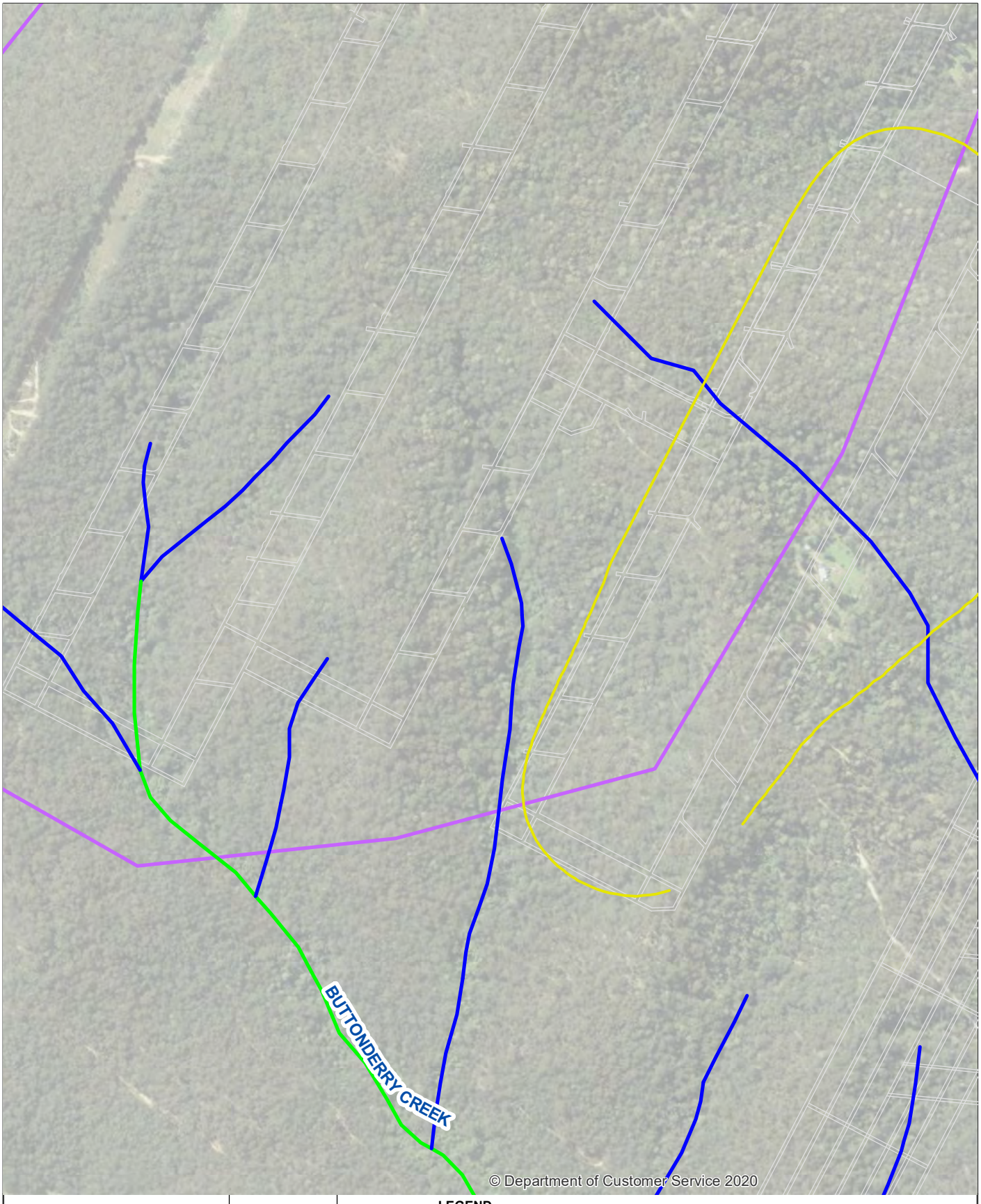
5.4.2 Waterway geomorphology

5.4.2.1 Previous studies

During a field survey conducted in June 2011 (Umwelt 2011), sections of Buttonderry Creek displayed evidence of scouring, including bank erosion and deposition of sandy sediments within the creek bed. Ponding was also observed within the main channel of Buttonderry Creek.

5.4.2.2 Stream order and watercourse type

The potentially impacted watercourses are shown in Figure 5.6. The first and second order tributaries of Buttonderry Creek and Morans Creek within the 20 mm subsidence contour are within the previously assessed angle of draw of the approved workings. There is a short order reach of a first order tributary of Mannering Creek within the 20 mm subsidence contour of LW34 outside the previously assessed angle of draw of the approved workings. Based on inspection of topography and aerial imagery, this reach of watercourse is likely to be a headwater system. Headwater systems consist of confined, bedrock dominated channels with limited alluvial deposits and no floodplains. Headwater channels are typically high gradient and found in upper catchment low stream order watercourses. Vegetation associated with headwaters is open and less water-dependent than other systems in the modification area.



1:8,000 for A4

0 30 60 120 180 240

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- First order stream
- Second order stream
- Watercourse
- Angle of draw - approved workings
- Approved and proposed mine workings
- Modification area (20mm subsidence contour)

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LOCATION	Mandalong
DRAWN	F.M
CHECKED	I.G
APPROVED	S.G.
SCALE	refer to scalebar

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Mandalong Mine Modification 10
Water Resources Impact Assessment

Stream order and watercourse type

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Figure 5-6

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Hunter\Mandalong\12552553\WRIA\12552553_WRIA009_GeomorphExtent_0.mxd

Data source: LPI:DCDB/Imagery, 2012/2015. Centennial: Mine workings, Extraction area, consent boundary, 2016. Created by: smacdonald, kpsroba, tmorton

5.4.3 Surface water quality

An assessment of the available surface water quality data was undertaken to establish baseline water quality values for Buttonderry Creek. The available monitoring locations are described in Section 5.2.2.1.

A statistical summary of the available water quality data for sites BTU and SWMP08 is presented in Table 5.7 and compared to the default guideline values (DGVs) in accordance with ANZG (2018). ANZG (2018) recommends that the median results for physical and chemical stressors be compared to DGVs. As insufficient baseline data has been collected to reliably derive SSGVs for SWMP08, water quality is also compared to the SSGVs derived for Morans Creek as part of the existing WMP.

Table 5.7 Statistical summary of BTU and SWMP08 water quality

Parameter	Units	ANZG (2018) DGVs	Morans Creek SSGV	BTU (2018 to 2020)		SWMP08 (September 2019 to March 2021)	
				Count	Median	Count	Median
Physicochemical parameters							
EC	µS/cm	350	940	9	**550**	7	282
pH	pH units	6.5–9.0	6.2-9.0	9	7.0	7	6.63
TDS	mg/L	NA	NA	1	1200	7	197
TSS	mg/L	50	47	1	18	6	8.5
Total hardness	mg/L	NA	NA	-	-	7	41
Turbidity	NTU	50	58	4	48	7	27.5
Major Ions							
Bicarbonate alkalinity	mg/L	NA	NA	-	-	7	36
Total alkalinity	mg/L	NA	NA	1	70	7	36
Sulfate as SO_4	mg/L	NA	NA	1	5.7	1	2
Chloride	mg/L	NA	NA	1	440	7	47
Calcium	mg/L	NA	NA	1	24	7	5
Magnesium	mg/L	NA	NA	1	50	7	4
Potassium	mg/L	NA	NA	1	8.8	7	32
Sodium	mg/L	NA	NA	1	240	7	36
Dissolved metals							
Aluminium	mg/L	0.055	0.78	1	**0.26**	7	**0.44**
Arsenic	mg/L	0.024	0.001	1	**0.003**	3	**0.002**
Barium	mg/L	NA	0.066	1	**0.17**	7	0.054
Boron	mg/L	0.37	0.05	-	-	1	**0.06***
Cadmium	mg/L	0.0002	0.0001	1	<0.0002	-	-
Chromium	mg/L	0.001	0.001	1	**0.002**	3	0.001
Cobalt	mg/L	0.0025	0.001	1	**0.018**	6	**0.007**
Copper	mg/L	0.0014	0.002	1	**0.002**	6	**0.0015**
Iron	mg/L	0.3	3.61	9	**10.0**	7	**1.58**
Lead	mg/L	0.0034	0.0034	1	<0.001	1	0.002
Manganese	mg/L	1.9	1.9	1	**3.2**	7	0.763
Mercury	mg/L	0.0006	0.0006	1	<0.0001	-	-
Nickel	mg/L	0.011	0.011	-	-	7	0.005

Parameter	Units	ANZG (2018) DGVs	Morans Creek SSGV	BTU (2018 to 2020)		SWMP08 (September 2019 to March 2021)	
				Count	Median	Count	Median
Zinc	mg/L	0.008	0.008	1	**0.024**	6	**0.0085**
Nutrients							
Ammonia	mg/L	0.9	0.9	8	0.115	4	0.18
NO_x	mg/L	0.04	NA	-	-	1	0.01
TN	mg/L	0.35	1.52	6	0.03	7	**1.1**
TP	mg/L	0.025	0.11	1	0.01	7	**0.07**
TKN	mg/L	NA	NA	-	-	7	1.1
Other parameters							
BOD	mg/L	NA	NA	1	<5	4	3
Fluoride	mg/L	NA	NA	1	<0.5	1	0.1

Note: Bold blue highlight indicates that the value exceeds the DGV. **Bold underline** indicates that the value exceeds the SSGV. **Bold underline with blue** highlight indicates the value exceeds both DGV and SSGV. '-' indicates that no value was recorded for the analyte. '*' Total barium value used due to no available results for dissolved barium

The observed median water quality at SWMP08 exceeded the DGVs for aluminium, cobalt, copper, iron, zinc, total nitrogen and total phosphorous. Of these, median concentrations of cobalt (substantially higher) and zinc (slightly elevated) also exceeded the Moran's Creek SSGVs. The elevated cobalt, compared to the DGVs and Morans Creek SSGVs, is most likely attributable to the pre-mining geology of the Buttonderry Creek catchment.

Water quality at BTU was similar to SWMP08, where the observed median water quality at BTU exceeded the DGVs for EC, aluminium and copper and the SSGVs for arsenic and barium. Both the DGVs and SSGVs were exceeded at BTU for chromium, cobalt, iron, manganese and zinc.

5.5 Downstream water users

5.5.1 Groundwater users

The search of the NSW groundwater bore database (WaterNSW 2020) identified 167 bores in a 5 km radius of the existing, approved and proposed Mandalong Mine workings. Identified bores are shown in Figure 5.7.

The majority (84 bores) were registered as monitoring/test bores, one bore was registered for monitoring/town water supply and the remainder (82 bores) were registered for domestic, irrigation, farming and/or stock use.

The registered domestic and stock bores that were identified primarily extract groundwater from the Triassic sandstone and conglomerate formations with yields generally less than 1 L/s.

The search identified three bores (GW201651, GW201652, and GW201653) within 2 km of LW34. These bores are Mandalong Mine monitoring bores. No bores within the modification area were identified.

5.5.2 Groundwater dependent ecosystems

The potential vegetation GDEs within the project application area (RPS 2017) include:

– Coastal Wet Gully Forest
– Alluvial Tall Moist Forest
– Freshwater Wetland Complex

Potential GDEs generally coincide with the creeks and drainage lines. The watercourses identified within the modification area are the reaches of Morans Creek and Buttonderry Creek. Shallow unconfined alluvium has been identified along these two creek lines, however there is no mapped alluvium within the modification area.

Ecological communities within the area are likely to be utilising shallow aquifers associated with ephemeral drainage lines and have therefore been considered as unlikely to be entirely groundwater dependent. This occurrence has been supported by the fact that the plant species within this vegetation community are not restricted to alluvial drainage lines; they can occur along moist sheltered gully areas, creek lines, as well as dry slopes. Therefore, they can be termed as facultative ecosystems.

Facultative ecosystems have been described as (DPI 2012b):

"a GDE that is not entirely dependent on groundwater, and may rely on groundwater on a seasonal basis or only during extended drought periods. At other times, water requirements may be met by soil or surface water".

The facultative GDEs that have been identified as having potential to occur within the modification area generally exist as moist sheltered gully forest along creek lines and are not considered to be completely reliant on groundwater for its persistence (RPS 2017).

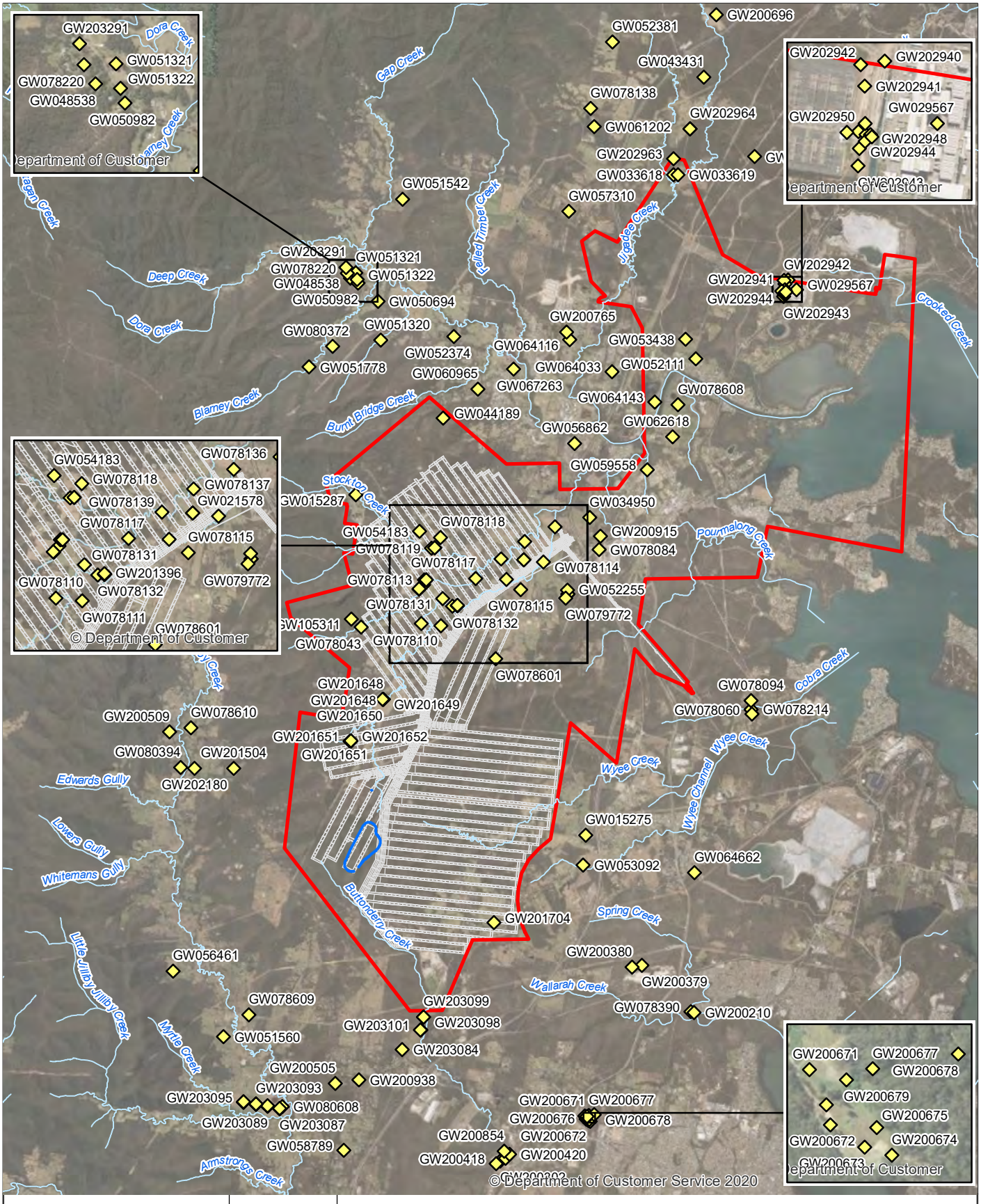
No high priority GDEs, listed within the relevant WSPs, are located in the vicinity of the modification area.

5.5.3 Surface water users

Licensed surface water users were identified by searching the *NSW Water Register* (WaterNSW 2020) for all lots within a 2 km radius of Buttonderry Creek. Licenced water users were identified on the Wyong River, however the modification area comprises less than 1 percent of the total catchment area of Wyong River and therefore potential impacts on downstream water users on Wyong River were considered negligible and excluded from the assessment.

No downstream surface water users were identified on Buttonderry Creek.

Licenced surface water on Morans Creek and Mannering Creek users were previously identified and assessed by GHD (2017). GHD (2017) identified that adverse impacts to downstream water users was unlikely to occur due to the low risk of potential impacts and the ephemeral nature of waterways.



1:125,000 for A4

0 1 2 3 4

Kilometers

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Registered bore
- Project application area
- Waterway
- Approved and proposed mine workings
- Modification area (20mm subsidence contour)

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LOCATION	Mandalong
DRAWN	F.M
CHECKED	I.G
APPROVED	S.G.
SCALE	refer to scalebar

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Landholder bores

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Figure 5-7

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Hunter\Mandalong\12552553\WRIA\12552553_WRIA014_LandHolder_Bores_A.mxd

Data source: LPI:DCDB/Imagery, 2012/2015. Centennial: Mine workings, Extraction area, consent boundary, 2016. OOW: Pinneena, Registered Bore, 2010. Created by: smacdonald, kpsroba, tmorton

6. Impact assessment

6.1 Water management

As part of the proposed modification, underground water will be managed by water transfers within the underground workings of Mandalong Mine including the Cooranbong underground storage. Water extracted from the underground workings will be managed via the existing pumping system of Mandalong Mine.

The overall layout of the Mandalong Mine surface sites will remain unchanged, with no changes proposed to the approved infrastructure as part of this modification. The likely increases in underground water volume from existing conditions due to continued mining will result in an increase in daily discharges from the Borehole Dam through LDP001 at CES. The volume of the Borehole Dam is expected to be able to cater for the predicted increase in groundwater volumes for approved and proposed conditions (refer Section 6.3).

Potable water will continue to be serviced by the existing connections to Hunter Water Corporation's reticulated potable water system. There are not expected to be any appreciable increases in potable water usage as a result of the proposed modification.

No changes to any licences held by Mandalong Mine are required by the proposed modification.

6.2 Groundwater environment

6.2.1 Impact assessment criteria

The NSW Aquifer Interference Policy (AIP) requires that potential impacts on groundwater sources, including their users and GDEs, be assessed against minimal impact considerations, outlined in Table 1 of the AIP. If the predicted impacts meet the Level 1 minimal impact considerations, then these impacts will be considered as acceptable. The Level 1 minimal impact considerations for less productive fractured and porous rock water sources have been adopted for the assessment of potential groundwater impacts and are as follows:

- Water table: less than or equal to 10% cumulative variation in the water table, allowing for typical climatic 'post-water sharing plan' variations, at a distance of 40 m from any high priority groundwater dependent ecosystem or high priority culturally significant site listed in the schedule of the relevant WSP. A maximum of a 2 m water table decline cumulatively at any water supply work.
- If more than 10% cumulative variation in the water table, allowing for typical climatic 'post-water sharing plan' variations, 40 m from any high priority GDE; or high priority culturally significant site; listed in the schedule of the relevant water sharing plan then appropriate studies (including the hydrogeology, ecological condition and cultural function) will need to demonstrate to the Minister for Land and Water's satisfaction that the variation will not prevent the long-term viability of the dependent ecosystem or significant site. If more than 2 m decline cumulatively at any water supply work then make good provisions should apply.
- Water pressure: a cumulative pressure head decline of not more than a 2 m decline at any water supply work.
- If the predicted pressure head decline is greater than the requirement above, then appropriate studies are required to demonstrate to the Minister's satisfaction that the decline will not prevent the long-term viability of the affected water supply works unless make good provisions apply.
- Water quality: any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity.
- If the predicted change in water quality is greater than the requirement above, then appropriate studies will need to demonstrate to the Minister's satisfaction that the change in groundwater quality will not prevent the long term viability of groundwater ecosystems, significant sites or affected water supply works.

6.2.2 Hydrogeological model predictions

The MODFLOW flow budget results for the transient run of the hydrogeological model for 2035 (predicted maximum groundwater inflow) under proposed conditision are presented in Table 6.1. These results represent the proposed mining plan for Mandalong Mine under the modification and include mining in Area 2 (refer Figure 5.2).

The MODFLOW flow budget results for Modification 9 (reorientation of longwalls (GHD, 2020b)) for the predicted peak year of groundwater make (2035) are also presented in Table 6.1 for reference. These results represent the currently approved mining plan for Mandalong Mine and include mining in Area 2.

The differences between the proposed mine plan and the approved mine plan include a slight decrease in mine inflows (i.e. 5 ML/year in 2035). This difference is attributed to the shortening of LW30 and removal of LW33 from the mine plan.

Table 6.1 Hydrogeological model predictions for proposed conditions

	Proposed conditions		Approved conditions [1]	
	Year of maximum mine inflow (2035)		2035	
	Alluvium and outcropping rock [2] (ML/year)	Rock (ML/year)	Alluvium and outcropping rock [2] (ML/year)	Rock (ML/year)
INPUTS				
Recharge	4,055	0	4,055	0
GHB [3]	1,323	349	1,323	349
Storage	1	716	1	721
Other zones	554	576	554	576
TOTAL INPUTS	**5,933**	**1,641**	**5,933**	**1,646**
OUTPUTS				
Drains [4]	3,822	735	3,822	740
GHB [3]	232	29	232	29
Storage	1303	323	1,303	323
Other zones	576	554	576	554
TOTAL OUTPUTS	**5,933**	**1,641**	**5,933**	**1,646**
BALANCE				
Inputs – outputs	**0**	**0**	**0**	**0**

1. Results predicted as part of the approved Modification 9 (GHD 2020b).
2. Layer 1 of MODFLOW model.
3. General head boundary.
4. Transfer from alluvium to drains is baseflow. Transfer from fractured and porous rock to drains is inflow to mine workings.

6.2.2.1 Alluvial groundwater sources

The updated hydrogeological model indicates that the proposed modification is unlikely to result in a water table drop greater than 0.1 m within the alluvial groundwater throughout the period of mining. This prediction is based on no increase in the hydraulic conductivity of strata within the surface zone. Note that a head prediction of 0.1 m is considered to be the limit of accuracy of the model based on the limit of accuracy of observation groundwater level data used to calibrate the model. This prediction is consistent with historical groundwater level monitoring data which shows minimal or temporary changes to alluvial groundwater levels from mining.

The MODFLOW flow budget results, shown in Table 6.1, suggest that there is unlikely to be an increase in the movement of shallow groundwater within the surface strata (extending to a depth of 15 m bgl) to underlying aquifers as a result of the proposed and approved workings. The flow budget predicts a net gain of groundwater into alluvium from the fractured and porous rock strata. The flow budget indicates that recharge into alluvial sediments and groundwater flow from the fractured and porous rock aquifer will generally remain in storage within the alluvial sediments or discharge to creek lines or drainage lines as seepage. These modelled results are consistent with the previous predictions under approved conditions (GHD 2020b).

Based on existing groundwater quality data for Mandalong Mine, it is not expected that the proposed addition of LW34 would reduce the beneficial use category of alluvial groundwater sources (i.e. primary industry) in the vicinity of Mandalong Mine.

Overall, the predicted impacts on alluvial groundwater sources attributable to the proposed modification meet the Level 1 minimal impact considerations from the NSW Aquifer Interference Policy as outlined in Section 6.2.1 and are therefore considered to be acceptable.

6.2.2.2 Fractured and porous rock groundwater sources

Figure 6.1 shows the total predicted groundwater inflows into the drained workings from the updated transient model. Total groundwater inflows into the connected Cooranbong Colliery, Mandalong Mine and Mandalong South workings are predicted to peak at approximately 2.0 ML/day (735 ML/year) in 2035. It is noted that this groundwater take is well below the existing entitlement of 1,825 ML/year. The peak predicted groundwater inflow is slightly lower than the peak groundwater inflow assessed as part of Modification 9 (GHD 2020b) which is also presented in Figure 6.1. The minor differences in results are predominantly attributed to the changes in the size and number of longwalls, including the shortening of the length of LW30 and the removal of LW33 from the mine plan.

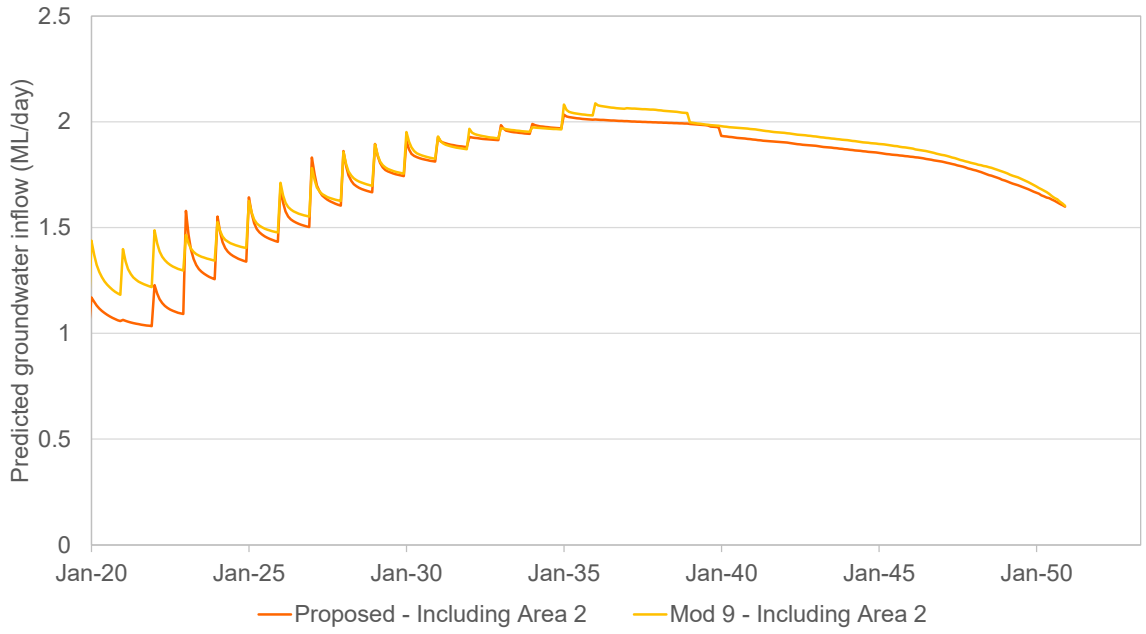


Figure 6.1 Modelled groundwater inflows into the Cooranbong, Mandalong and Mandalong South workings

The MODFLOW flow budget results for current conditions (2021) (shown in Table 5.4) and predicted maximum groundwater inflow (2035) for proposed conditions indicate that between 2020 and 2035 modelled outputs into drains from fractured and porous rock aquifer increase. This increased output is due to an increase in groundwater inflows into the mine over time. The increase in groundwater inflows into the mine is offset by a decrease in net groundwater storage in the fractured and porous rock aquifer as shown in Table 6.1.

The hydrogeological model has been used to predict the depressurisation of fractured and porous rock groundwater sources overlying the proposed and approved Mandalong Mine workings. Uncertainty analysis has not been undertaken as part of this assessment. This assessment has not included recalibration of the hydrogeological model and has therefore only included results from the best-fit calibrated model.

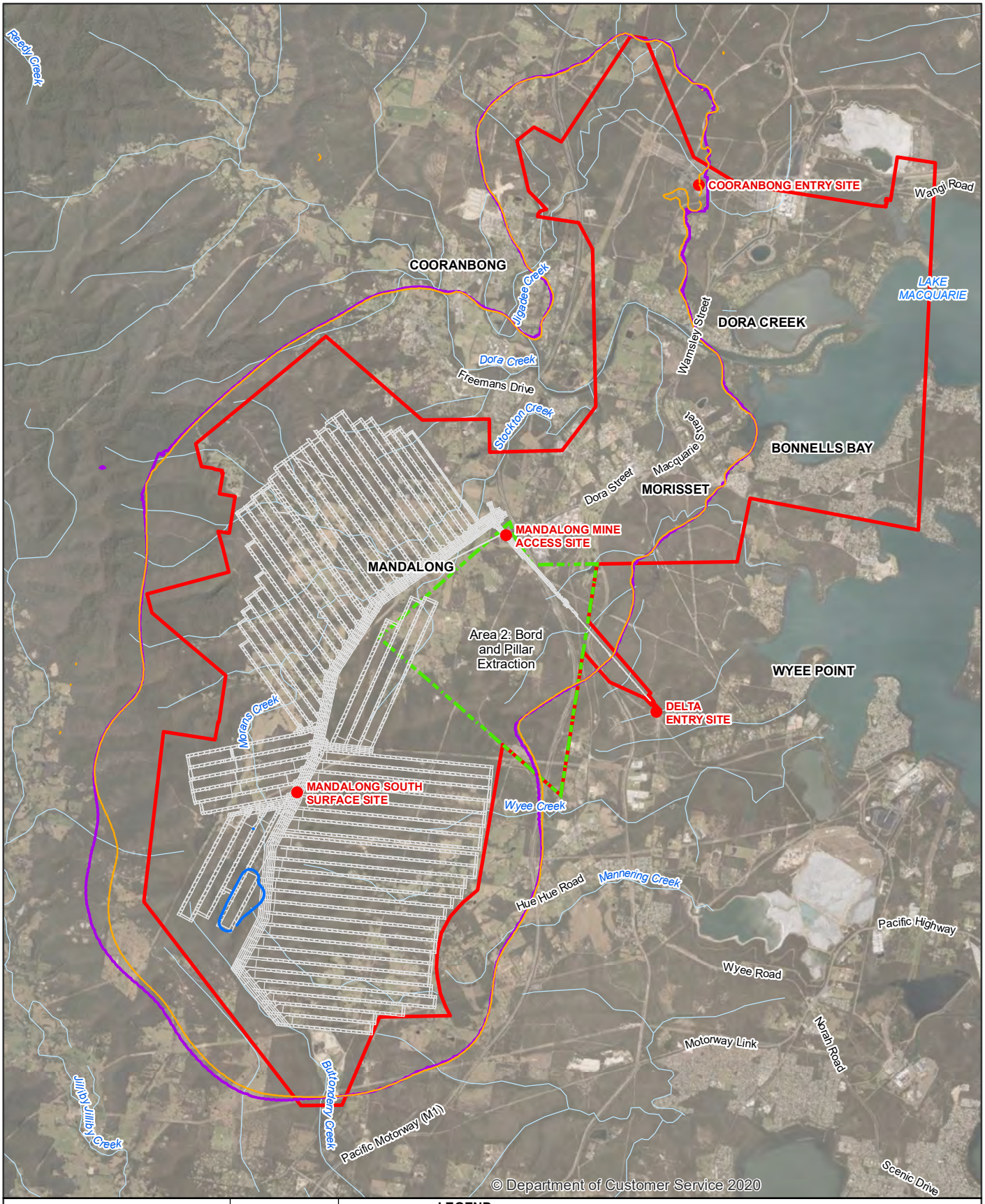
Based on the results from the hydrogeological model, the predicted location of the 2 m drawdown contour within layer 6 of the hydrogeological model (overburden rock to a height of 50 m above the coal seam) at the completion of mining in 2038 is approximately 1.7 km from the proposed LW34. The predicted 2 m drawdown contour is presented in Figure 6.2. As shown in Figure 6.2, the revisions to the mine plan result in the 2 m drawdown contour contracting by approximately 700 m to the south and west (compared to approved conditions). This reduction in the drawdown contour is attributable to the shortening of LW30 and removal of LW33 from the mine plan.

The maximum predicted drawdown in the overburden within this zone of depressurisation is approximately 253 m which occurs at the southern extent of LW34. This is slightly greater than the maximum predicted drawdown over the LW30-33 of 250 m for the Mod 9 mine plan.

Under the mining schedule modelled for the proposed modification, mining of LW34 is completed in 2022 and modelled inflows were estimated to be 1.2 ML/day. This is less than the rate of modelled inflow at the end of mining of the western longwalls under the approved mine plan (GHD, 2020). Note that under the approved mine plan mining of the western longwalls was scheduled to be completed in 2023.

Based on existing groundwater quality data for Mandalong Mine, it is not expected that the proposed addition of LW34 would reduce the beneficial use category of fractured and porous rock groundwater sources (i.e. primary industry) in the vicinity of Mandalong Mine.

Overall, the predicted impacts on fractured and porous rock groundwater sources attributable to the proposed addition of LW34 are expected to meet the Level 1 minimal impact considerations from the NSW Aquifer Interference Policy as outlined in Section 6.2.1 and are therefore considered to be acceptable.



1:100,000 for A4

0 500 1,000 2,000 3,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Site location
- Project application area
- Approved Drawdown Contour (2 m) - including Area 2
- Proposed drawdown contour (2 m) - including Area 2
- Area 2
- Approved and proposed mine workings
- Watercourse
- Modification area (20mm subsidence contour)

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LOCATION	Mandalong
DRAWN	K.S.
CHECKED	I.G.
APPROVED	S.G.
SCALE	refer to scalebar

Centennial Mandalong Pty Ltd
Mandalong Mine Modification 10
Water Resources Impact Assessment
Groundwater Drawdown Contour - Fractured and Porous Rock Groundwater Sources

CENTENNIAL

DATE 31/08/2021

Figure 6-2

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Hunter\Mandalong\12552553\WRIA\12552553_WRIA016_GW_Drawdown_A.mxd

Data source: Commonwealth of Australia (Geoscience Australia): 250K Topographic Data Series 3, 2008. LPI:DCDB/Imagery, 2012/2015. Centennial: Mine workings, consent boundary, 2016. Created by: smacdonald, kpsroba

6.3 Surface water environment

6.3.1 Water and salt balance assessment

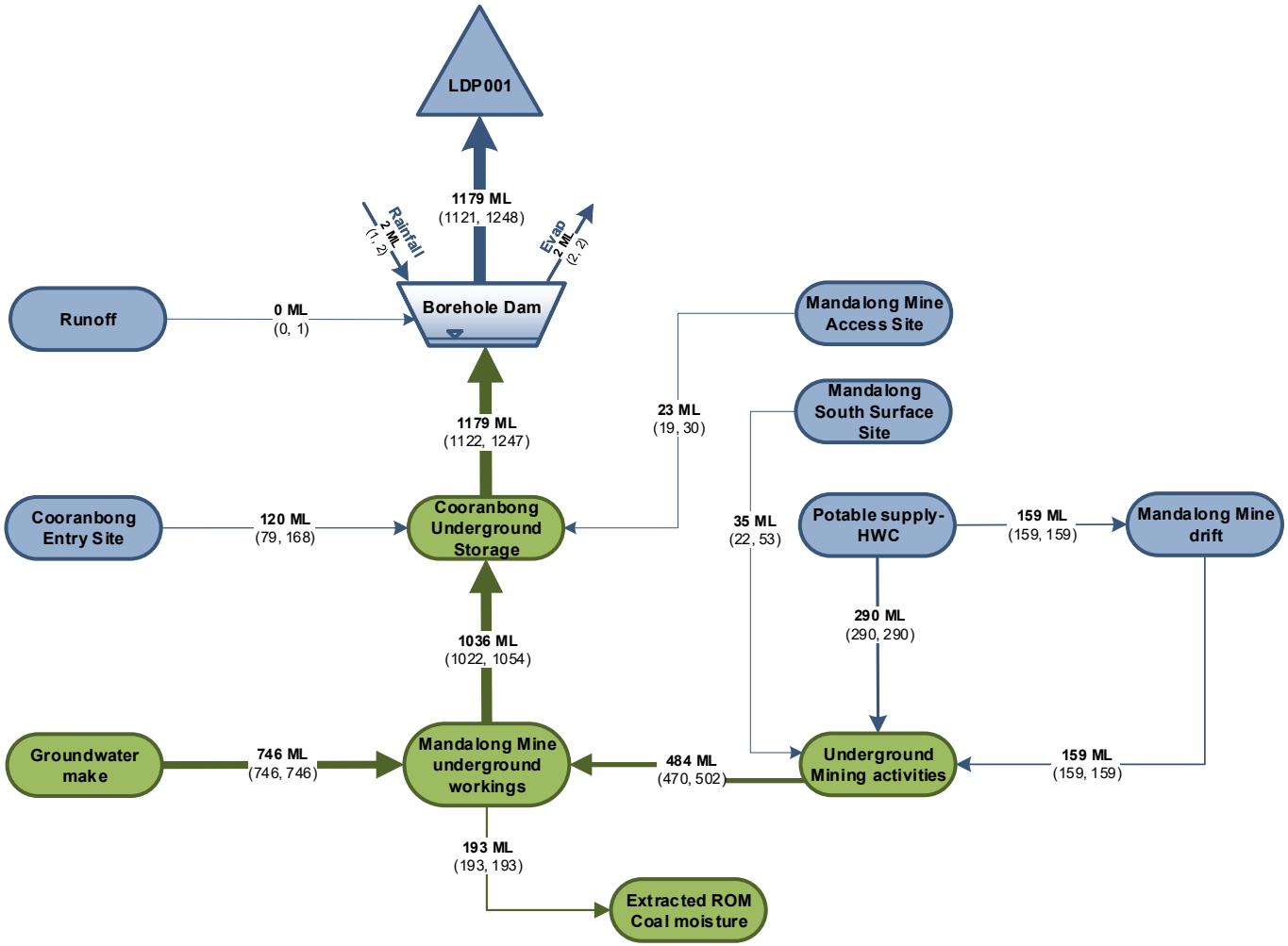
As discussed in Section 4.3.1, the water and salt cycle for Mandalong Mine was modelled for the projected life of the mine. The inputs to and outputs from the water management system were unchanged from the existing conditions, as discussed in Section 5.4.1.

The predicted groundwater inflows that were obtained from hydrogeological modelling, presented in Figure 6.1, were incorporated into the water and salt balance model. Results presented for the proposed conditions are the year 2035, corresponding to the predicted maximum groundwater inflow and therefore the greatest potential impact over the life of mine, as shown in Figure 6.1. The results are presented in Figure 6.3 and Figure 6.4 with a summary presented in Table 6.2.

Table 6.2 Summary of average annual water balance under future conditions

Water management element	Approved conditions	Proposed conditions
	2035 (ML/year)	2035 (ML/year)
INPUTS		
Rainfall and catchment runoff	2	2
Transfer from CES to underground workings	120	120
Transfer from MSSS to underground workings	35	35
Transfer from MMAS to underground workings	23	23
Potable water supply	449	449
Groundwater inflow into underground workings	746	736
TOTAL INPUTS (rounded)	**1375**	**1365**
OUTPUTS		
Evaporation	2	2
Discharge to LDP001	1180	1170
ROM moisture loss	193	193
TOTAL OUTPUTS (rounded)	**1375**	**1365**
CHANGE IN STORAGE		
Surface water storage	0	0
Cooranbong underground storage	0	0
TOTAL CHANGE IN STORAGE (rounded)	**0**	**0**
BALANCE		
Inputs – outputs – change in storage	0	0

The water balance modelling results indicate that rainfall, runoff, evaporation, transfers from CES and potable water supply to the underground workings were predicted to be similar for approved and proposed conditions. The predicted groundwater inflows, on the other hand, slightly decreased for proposed conditions, and therefore discharges via LDP001 are slightly lower for proposed conditions, compared to approved conditions. Due to the slight nature of the modelled difference, the proposed modification is not expected to affect the distribution of daily discharges via LDP001.



Legend

- Underground storage
- Underground process
- Surface storage
- Surface process
- Licensed discharge point
- Surface water flow
- Groundwater flow
- X (X,X) — Mean (10^{th} percentile, 90^{th} percentile)

GHD

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Mandalong Mine
Modification 10 Water Resources Impact Assessment

Water management schematic
Annual water transfers
Approved conditions (2035)

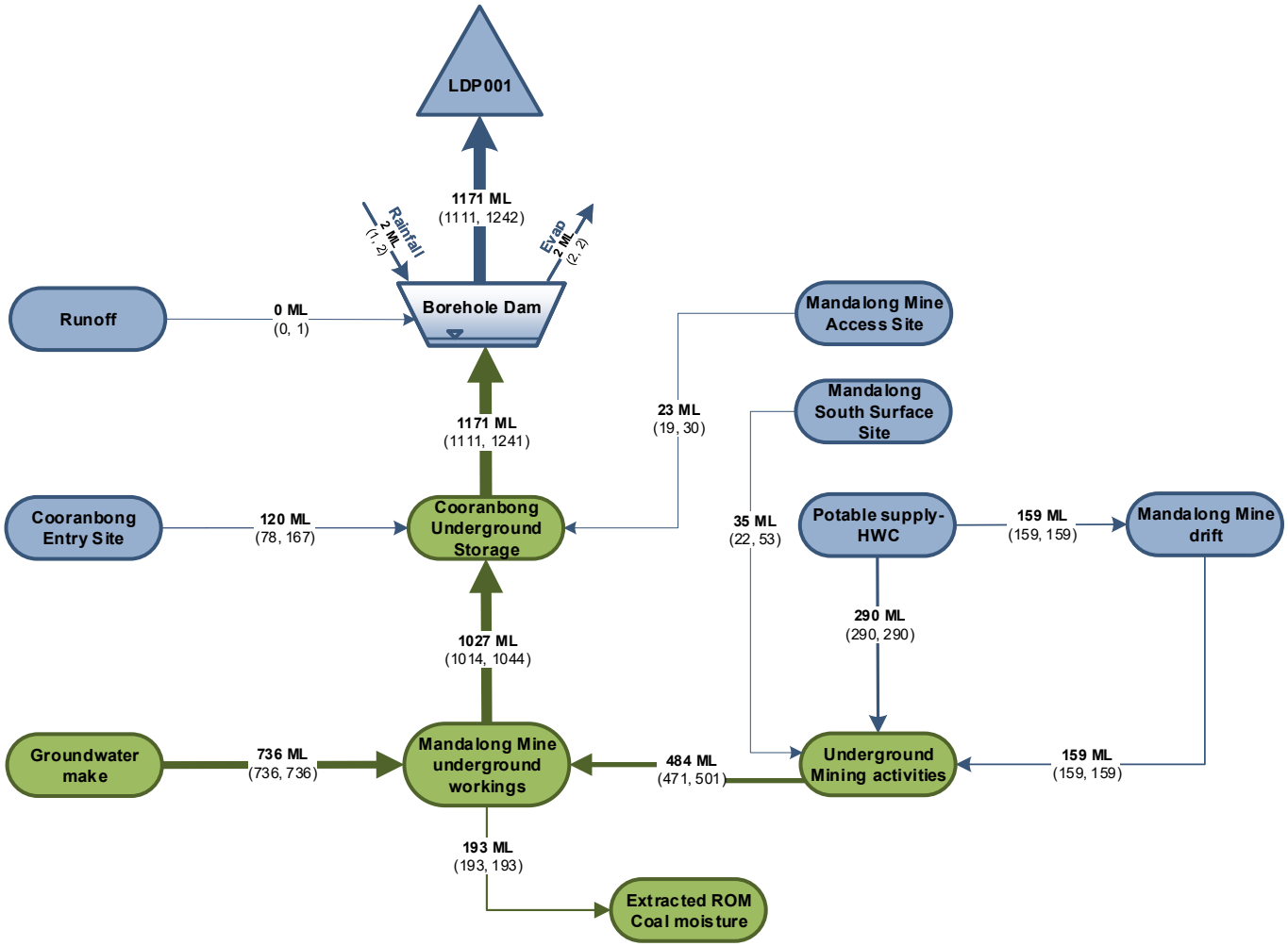
Project No. 12552553
Revision No. A
Date 07/07/2021

FIGURE 6-3

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Legend

- Underground storage
- Underground process
- Surface storage
- Surface process
- Licensed discharge point
- Surface water flow
- Groundwater flow
- X (X,X): Mean (10^{th} percentile, 90^{th} percentile)

Centennial Coal Company Limited
Mandalong Mine
Modification 10 Water Resources Impact Assessment

Water management schematic
Annual water transfers
Proposed conditions (2035)

Project No. 12552553
Revision No. A
Date 07/07/2021

FIGURE 6-4

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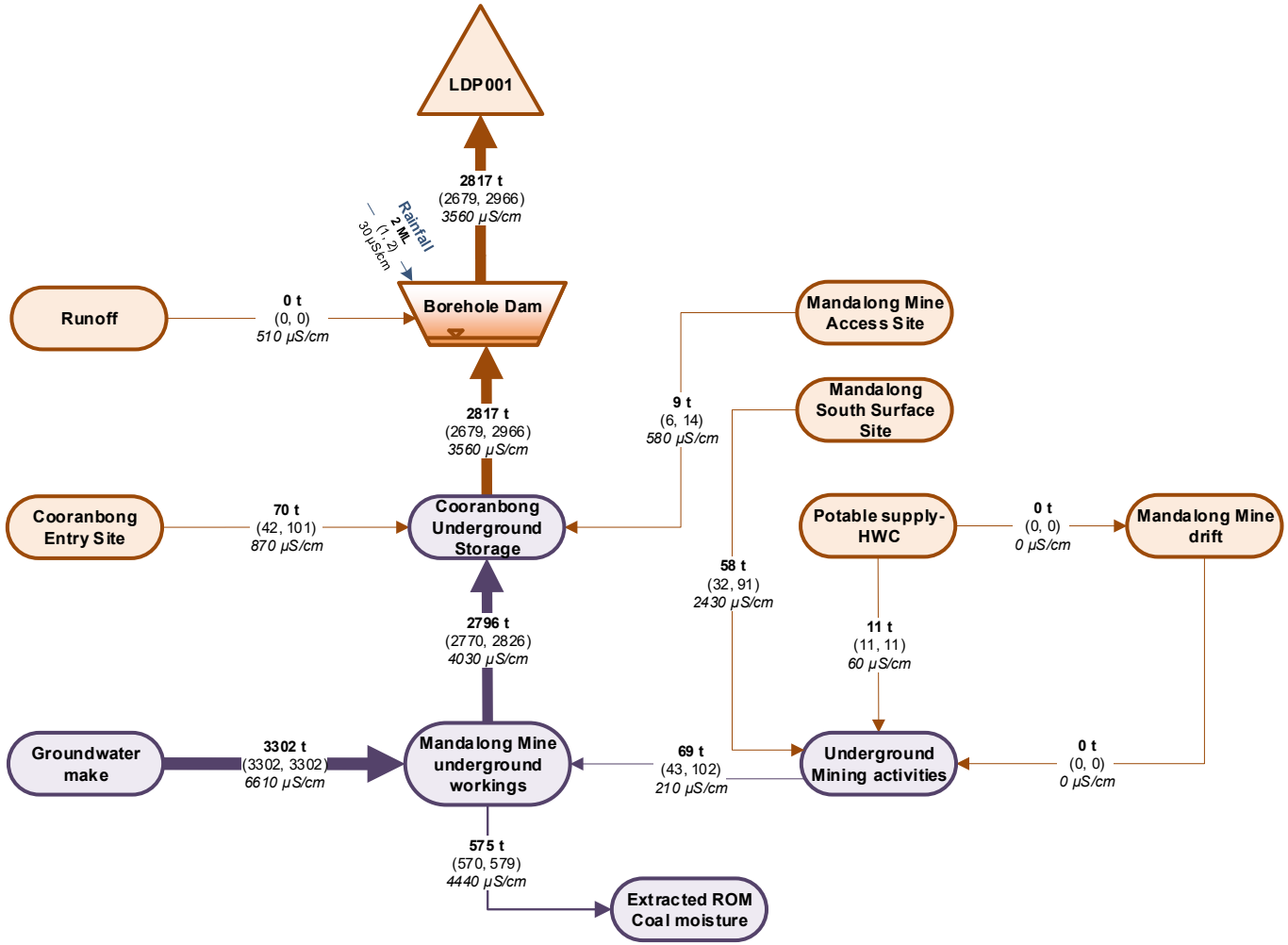
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Salt balance results

As discussed in Section 4.3.1, the salt balance model was developed as an extension of the water balance model with expected concentrations of salt applied to water inflows into the system. The results are presented in Figure 6.5 and Figure 6.6 with a summary presented in Table 6.3.

Table 6.3 Summary of average annual salt balance under future conditions

Water management element	Approved conditions	Proposed conditions
	2035 (tonne/year)	2035 (tonne/year)
INPUTS		
Rainfall and catchment runoff	2	2
Transfer from CES to underground workings	70	70
Transfer from MSSS to underground workings	58	58
Transfer from MMAS to underground workings	9	9
Potable water supply	11	11
Groundwater inflow into underground workings	3302	3260
TOTAL INPUTS (rounded)	**3452**	**3410**
OUTPUTS		
Evaporation	0	0
Discharge to LDP001	2817	2791
ROM moisture loss	575	573
TOTAL OUTPUTS (rounded)	**3392**	**3364**
CHANGE IN STORAGE		
Surface water storage	0	0
Cooranbong underground storage	57	43
TOTAL CHANGE IN STORAGE (rounded)	**57**	**43**
BALANCE		
Inputs – outputs – change in storage	0	0



Legend

- Underground storage
- Underground process
- Surface storage
- Surface process
- Licensed discharge point
- Surface water flow
- Groundwater flow
- X, •(X,X), XX — Mean (10th percentile, 90th percentile) Mean EC

Centennial Coal Company Limited
Mandalong Mine
Modification 10 Water Resources Impact Assessment

Water management schematic
Annual salt transfers
Approved conditions (2035)

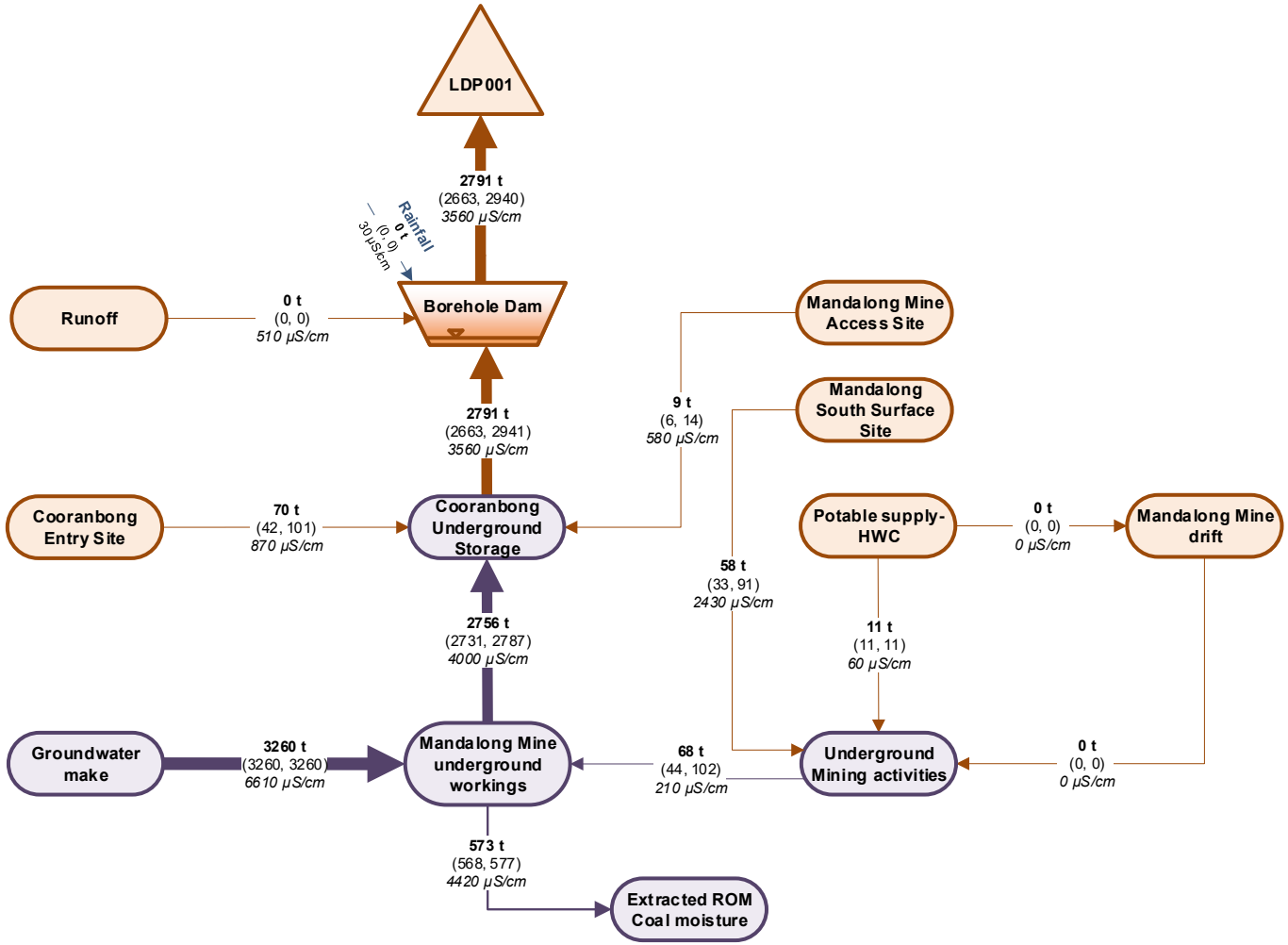
Project No. 12552553
Revision No. A
Date 07/07/2021

FIGURE 6-5

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Legend

- Underground storage
- Underground process
- Surface storage
- Surface process
- Licensed discharge point
- Surface water flow
- Groundwater flow
- X, •(X,X), XX — Mean (10th percentile, 90th percentile) Mean EC

Centennial Coal Company Limited
Mandalong Mine
Modification 10 Water Resources Impact Assessment

Water management schematic
Annual salt transfers
Proposed conditions (2035)

Project No. 12552553
Revision No. A
Date 07/07/2021

FIGURE 6-6

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Similar to the water balance results, Table 6.3 shows that the salt balance is predicted to be essentially unchanged by the proposed modification, with a slight decrease in the mass of salt from groundwater inflows. Due to the timing of groundwater inflow predictions, the results of the water and salt balance modelling indicates a slight reduction in the mass of salt discharged in the peak groundwater inflow year of 2035 via LDP001, corresponding to the slight decrease in salt contained with the underground storage. While this slight decrease in the mass of salt discharge is perhaps counterintuitive, it is considered an artefact of the modelling approach, including the simplifying assumption of instantaneous and complete mixing, rather than an indicator of the potential impact of the proposed modification. In reality the concentration and mass of salt discharges via LDP001 is expected to be essentially unchanged as a result of the proposed modification.

6.3.2 Surface water quality

Ditton 2021) identifies the subsidence effect prediction results for the proposed modification are within the predicted range for the approved longwalls. Unlike LW1-24A, where cracking has not been detected on the steep slopes and ridges, Ditton (2021) predicts that surface cracks ranging from 150 mm to 320 mm width are predicted to occur on the slopes above LW31-32 and the proposed LW34. Subsidence fracturing may expose previously unweathered near-surface rock, which when weathered can release substances such as the metals aluminium, cobalt, iron, manganese, nickel and zinc into surface water or shallow groundwater. Elevated salinity and potentially ecotoxic metal concentrations could be observed downstream of areas with such subsidence fracturing. Baseline surface water quality monitoring has identified some metal species are elevated relative to default guideline values and nearby Morans Creek (refer to Section 5.2.2.1).

Ditton (2021) predicts that changes to surface gradients along creek beds will result in ‘minor’ to ‘negligible’ erosional impacts along the creek, including tributaries of Morans Creek, Buttonderry Creek and Mannering Creek, consistent with the results of the flooding assessment (Umwelt 2021). Therefore, changes to localised subsurface flow diversions and decreased surface water connectivity, which can lead to reduced dissolved oxygen (DO) concentrations (due to decreased re-aeration from turbulent flow) and iron precipitation (Jankowski 2007) are considered unlikely.

6.3.3 Watercourse geomorphology

Subsidence can impact watercourse integrity by changing channel morphology and behaviour due to changes in valley floor tilt and bed cracking. Potential impacts of the proposed modifications are shifts in overall geomorphic behaviour and character, including changes to geomorphic type. Risk from disturbance due to subsidence is dependent on watercourse characteristics including valley confinement, gradient, flow resistance and condition.

6.3.3.1 Subsidence assessment

As the potentially affected watercourses are headwaters with bedrock confinement, this is unlikely to result in significant impact differences between the proposed modification and approved mining layout.

6.3.3.2 Flood impact assessment

The flood impact assessment for the proposed modification (Umwelt 2021) was undertaken to identify the potential impacts on remnant ponding, flooding and watercourse stability in Morans and Buttonderry Creek as a result of the proposed modification. The assessment used a two dimensional hydraulic model and the subsidence contours predicted by Ditton (2020).

Umwelt (2021) found that the addition of LW34 will not change the catchment area, or watercourse stability impacts relative to the already approved operations. For remnant ponding, the total area of remnant ponding was predicted to be similar to but slightly larger than the approved landform.

6.3.3.3 Remnant ponding

As described above, minor increases in remnant ponding are predicted by Umwelt (2021) in Buttonderry Creek. The predicted ponding has the potential to affect the transport of water and sediment, particularly during periods of low flow. Increased sediment accumulation and water retention in these areas of ponding could result in impacts to in-channel vegetation due to longer periods of inundation. These processes could result in a shift in vegetation community over time to favour more water-tolerant species.

As the areas of potential increase in remnant ponding are minor, the velocity of the majority of subsided areas will remain sufficient to transport suspended sediment and are unlikely to result in significant sediment deposition or significant shifts in vegetation community.

6.4 Downstream water users

No potentially impacted downstream surface water users were identified and therefore no impacts are expected. Potential impacts on groundwater receptors are discussed in Section 6.2.

6.5 Cumulative impacts

6.5.1 Groundwater environment

The hydrogeological model considers cumulative impacts to groundwater by including all relevant mine workings in the area in addition to the proposed modification. No baseflow reduction or impacts to GDEs are predicted from mining within the hydrogeological model domain. Therefore, no further groundwater cumulative impact assessment has been undertaken.

6.5.2 Water and salt balance

The proposed modification is expected to result in only slight changes to the volume of groundwater that is intercepted and required to be managed at Mandalong Mine. This change is small compared to the predicted increase in intercepted groundwater volumes over the proposed modification life and therefore the existing and planned future water management system is expected to adequately manage any potential changes to water management as a result of the proposed modification.

6.5.3 Surface water quality

The proposed modification has the potential to affect water quality in Buttonderry Creek. The Buttonderry Waste Management Facility is located downstream of the proposed modification. The potential water quality impacts of mining related subsidence and landfills are typically associated with different water quality parameters and therefore the potential for cumulative impacts are considered to be low.

6.5.4 Watercourse stability

While the potentially affected watercourses are headwaters with bedrock confinement, this is unlikely to result in significant impact differences in subsidence between the proposed modification and approved mining layout (Section 6.3.3); the proposed modification has the potential to affect the watercourse stability of Buttonderry Creek. As noted in Section 6.5.3, the Buttonderry Waste Management Facility is located downstream of the proposed modification. This feature, as well as linear infrastructure such as power line easements, Hue Hue Road and the Pacific Motorway also have the potential to impact watercourse stability of Buttonderry Creek. However, these features are located more than 2 km downstream of the proposed modification area. This is considered sufficiently distant such that watercourse instabilities would be unlikely to propagate such that there would be a potential for cumulative impacts.

6.5.5 Downstream water users

No potentially impacted downstream surface water users were identified and therefore no cumulative impacts are expected.

7. Mitigation, management and monitoring

7.1 Mitigation and management measures

7.1.1 Water management plans

A regional water management plan has been developed to provide an overview of the water management requirements across Centennial's northern operations in the Lake Macquarie catchment. Site-specific management plans for Mandalong Mine and Northern Coal Services have also been developed to address specific water management requirements for each of the operations. In addition, a Discharge Management Plan (DMP) has been developed to outline the requirements for the control and management of mine water discharge from each of Centennial's northern operations. The DMP focuses primarily on the management of discharges of underground mine water from LDPs, including LDP001.

The water management plans ensure that each operation, with respect to water, meets all relevant regulatory requirements. The regional and site-specific water management plans are reviewed every three years or as a result of any regulatory requirements, any significant changes to water management practices or the development of new mining areas.

Trigger action response plans (TARPs) are provided in the site-specific water management plans. Additional TARPs will be developed as required to provide guidance on the immediate actions that should be taken in response to any impacts of the proposed modification identified as part of the monitoring program. Generally, responses include investigation and monitoring, determination of the risk of impact and remedial measures to be implemented.

Following approval of the proposed modification, the site-specific water management plan for Mandalong Mine will be updated to include any changes to water management required by the proposed modification. The DMP will also be reviewed and revised as required to update the necessary discharge management requirements of the proposed modification. These revised management plans will then be implemented.

7.1.2 Extraction plans

An extraction plans will be developed and implemented for LW34 prior to mining. Generally, extraction plans describe the applicable regulatory framework, mine planning and management and monitoring measures to be implemented to ensure the protection of all surface/subsurface natural and built features and the protection of public safety during extraction. The extraction plan for LW34 will include a water management plan to manage potential subsidence-related impacts to water resources.

7.2 Licensing requirements

No changes to the licences held for Mandalong Mine under the WM Act, Water Act 1912 or the POEO Act are required for the proposed modification.

7.3 Monitoring

A comprehensive surface water and groundwater monitoring program has been developed by Mandalong Mine, as detailed in the site-specific WMP (Centennial 2020). Specific monitoring requirements will be developed as part of the extraction water management plan for LW34.

7.3.1 Groundwater monitoring

In accordance with the Statement of Commitments made as part of the Mandalong Southern Extension Project, additional monitoring bores are proposed at locations where depth of cover is less than 250 m. As the depth of cover above LW34 is 300 m to 450 m, no additional groundwater monitoring locations are recommended.

7.3.2 Surface water flow monitoring

The potential for changes to hydrology and watercourse stability in Buttonderry Creek are considered low. Therefore, no additional surface water flow monitoring is recommended.

7.3.3 Surface water quality monitoring

A new surface water monitoring location on Buttonderry Creek, SWMP08 shown in Figure 5.3, was established to develop a baseline dataset for the potential water quality impacts due to subsidence in Buttonderry Creek. Given that there are no additional water quality impacts identified in Buttonderry Creek beyond that already assessed due to approved workings, ongoing monitoring of SWMP08 is not required.

7.3.4 Watercourse stability monitoring

The predicted subsidence related changes to stream channel condition are assessed by flood path monitoring for each reach above longwall panels to define the pre-mining channel condition and subsidence induced changes to stream characteristics. This monitoring will continue for the extraction of LW34 and will be developed as part of the extraction water management plan.

8. References

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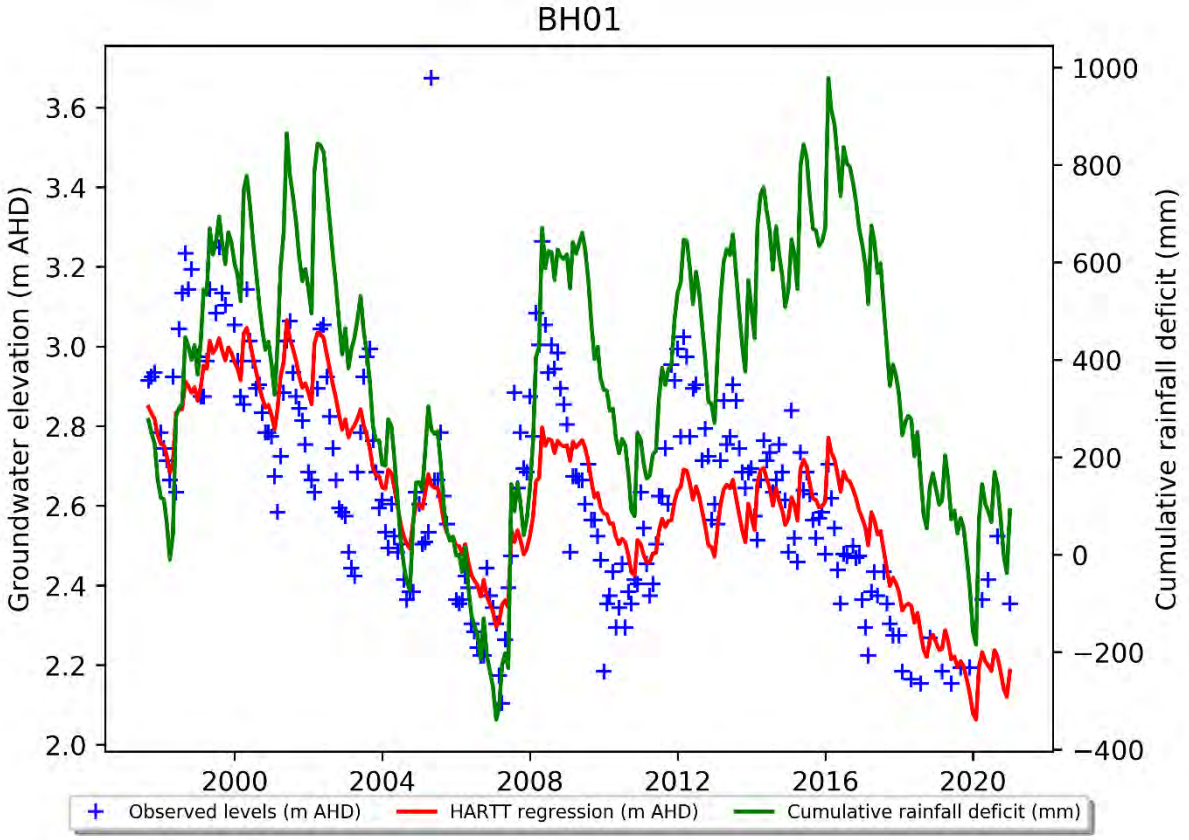
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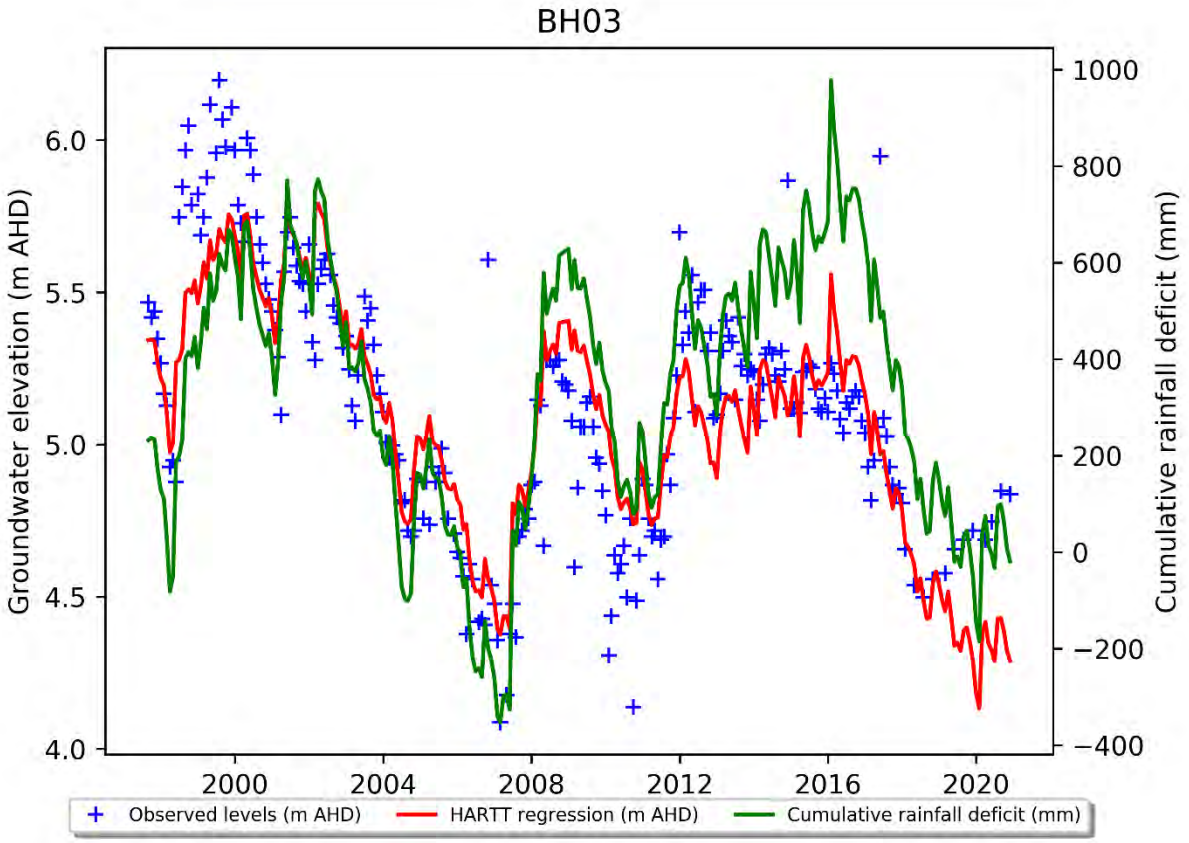
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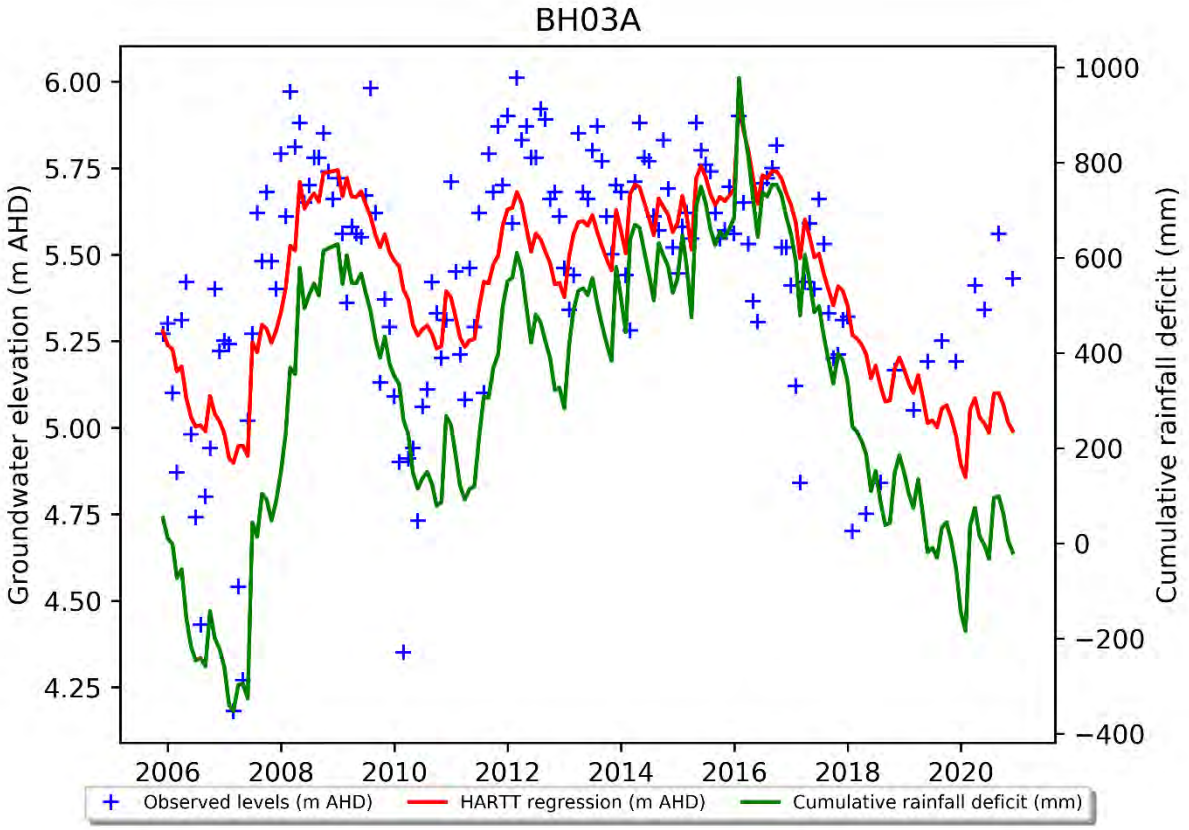
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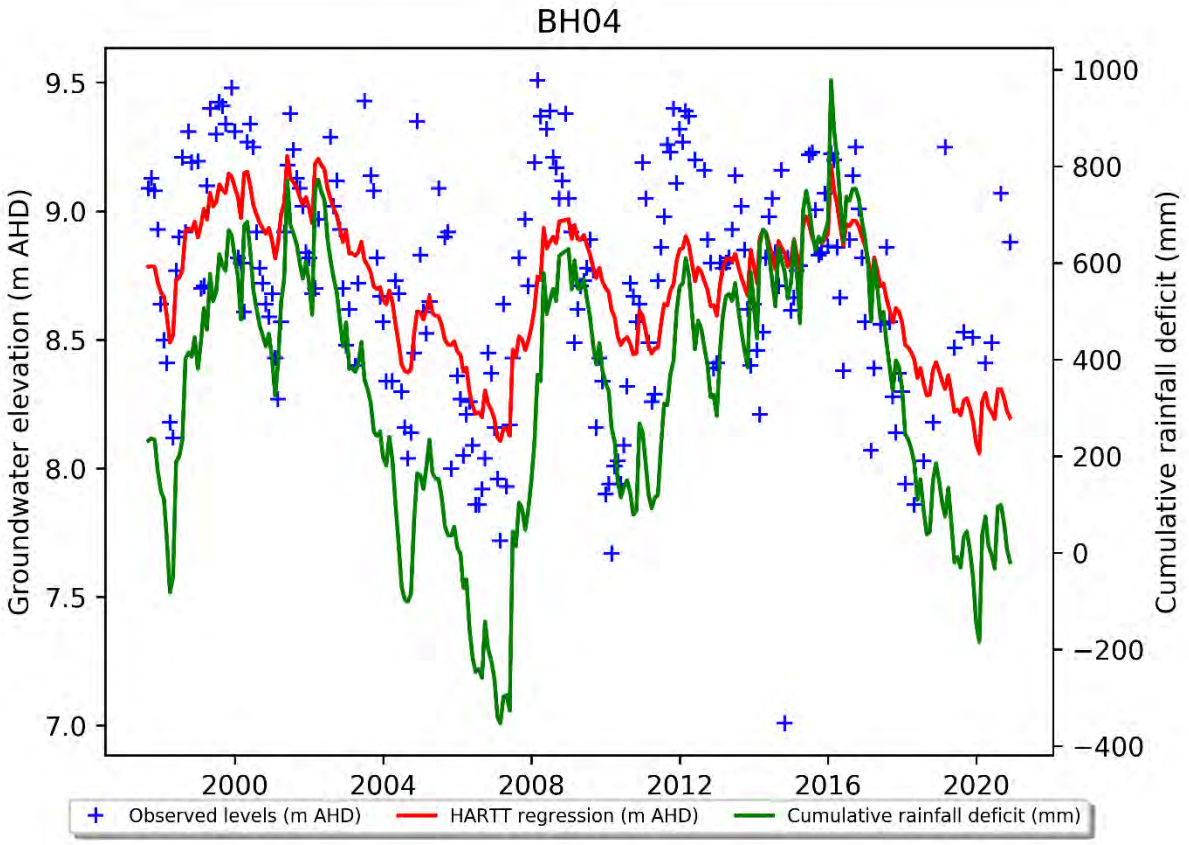
Groundwater hydrographs

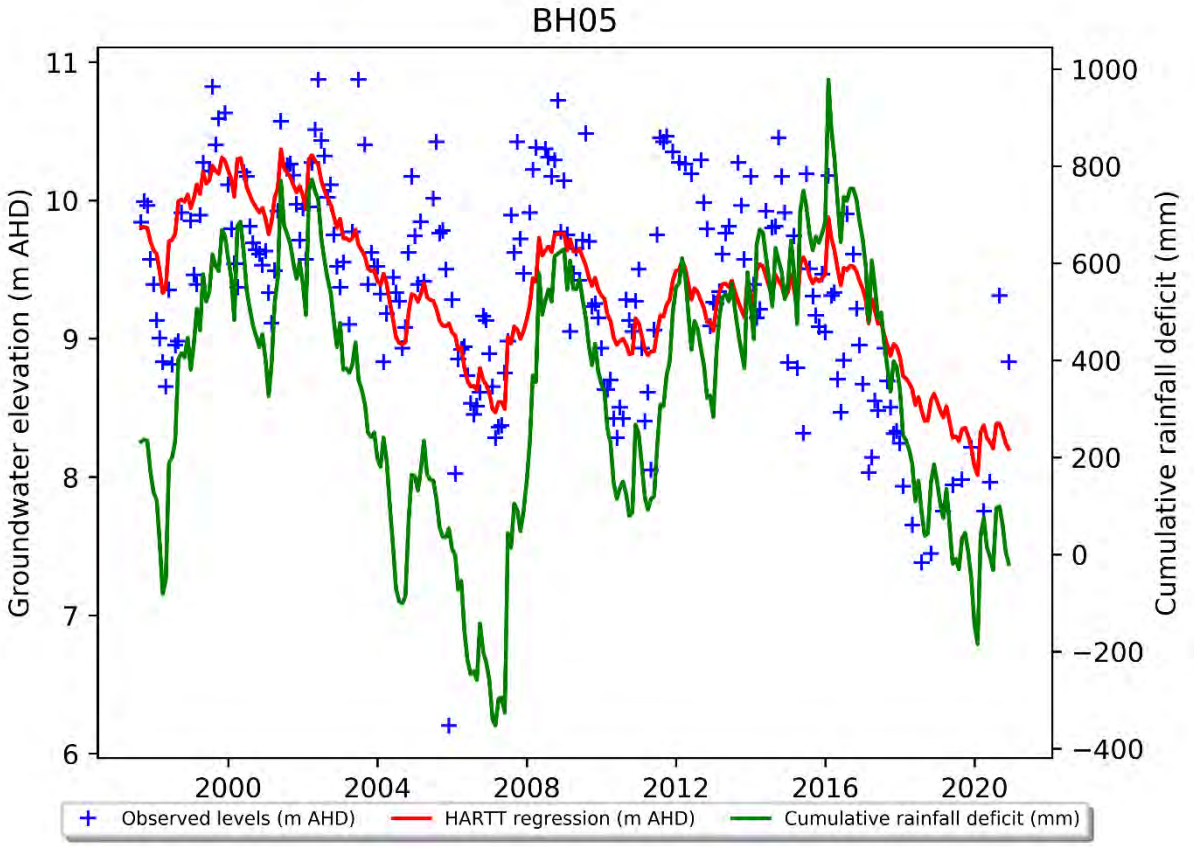
Alluvial groundwater bores

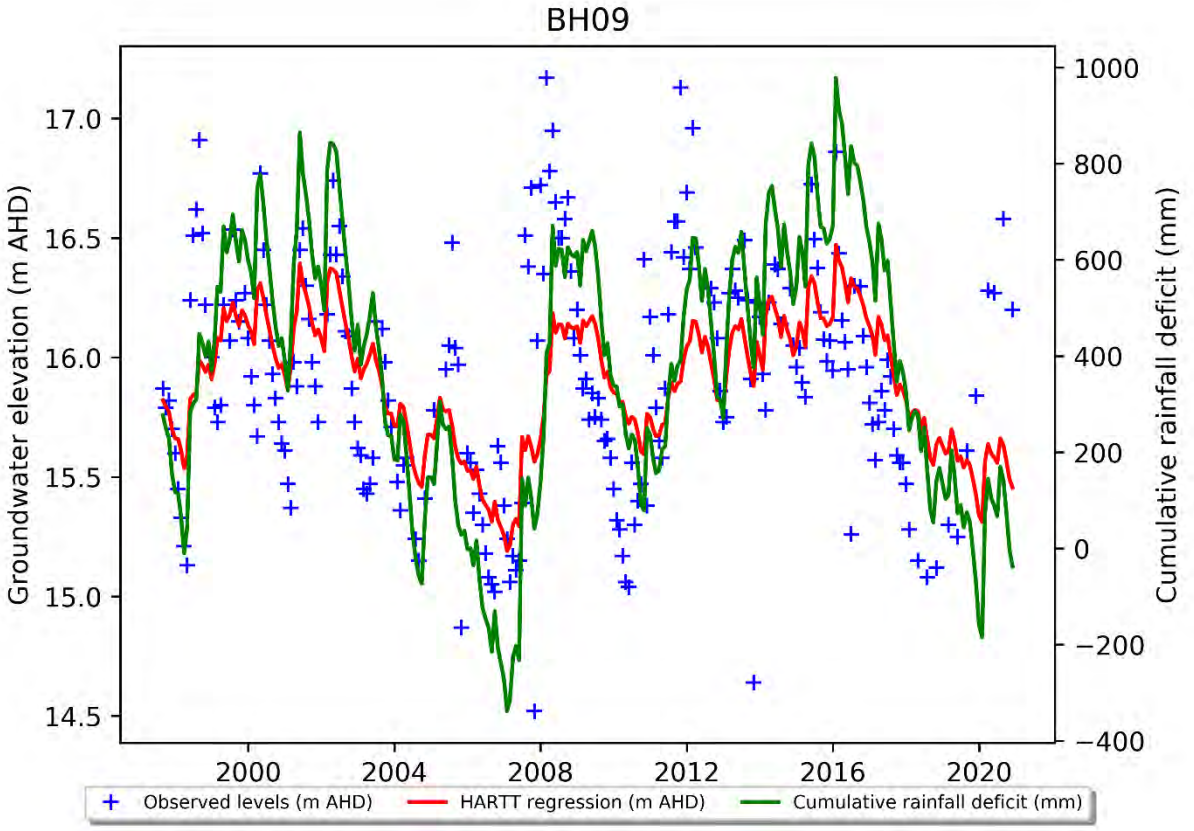


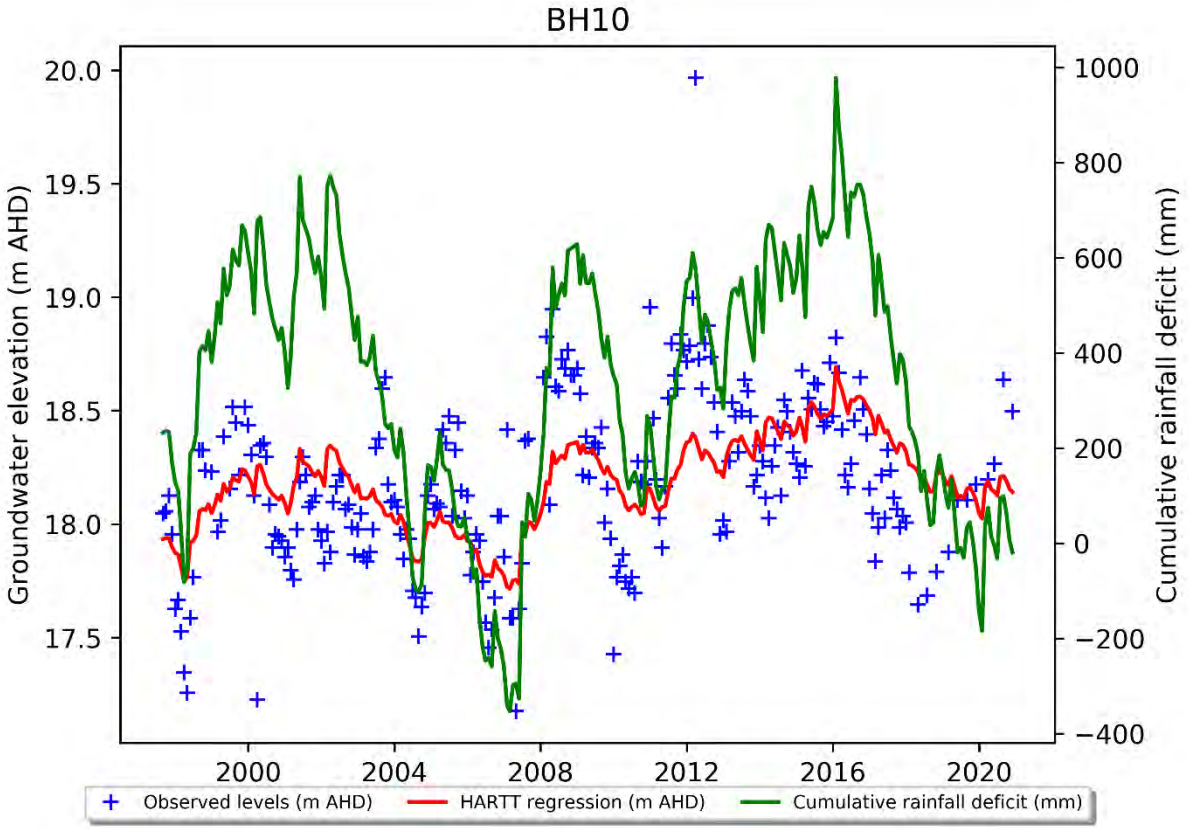


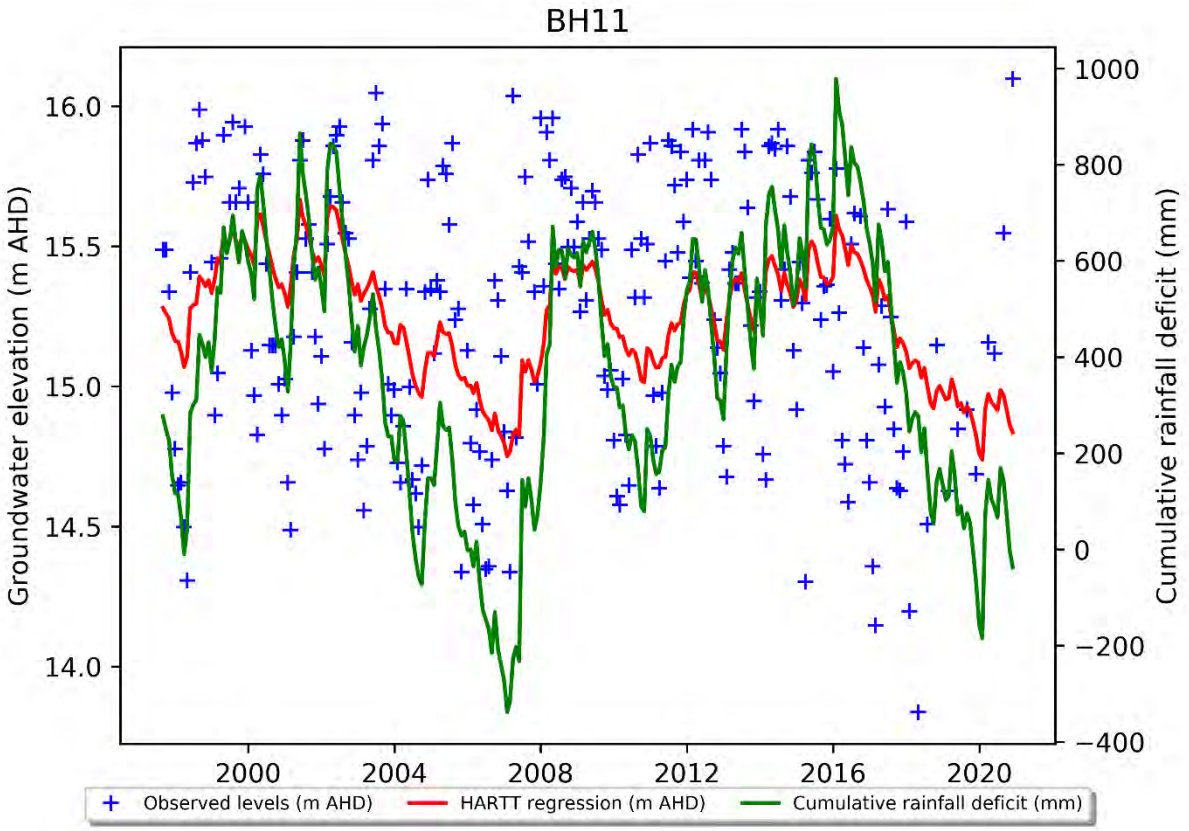

BH03A
Groundwater elevation (m AHD)
Cumulative rainfall deficit (mm)
6.00
5.75
5.50
5.25
5.00
4.75
4.50
4.25
1000
800
600
400
200
0
−200
−400
2006
2008
2010
2012
2014
2016
2018
2020
Observed levels (m AHD)
HARTT regression (m AHD)
Cumulative rainfall deficit (mm)

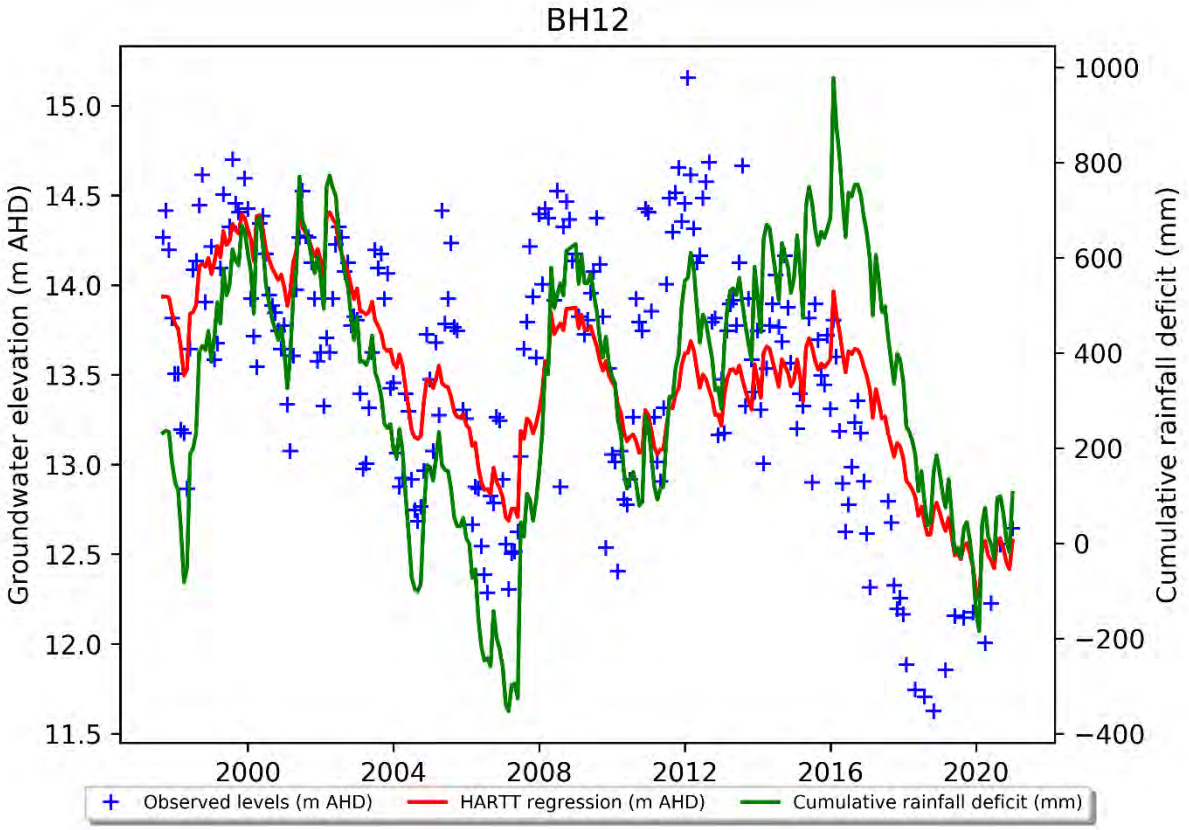

BH04
Groundwater elevation (m AHD)
Cumulative rainfall deficit (mm)
9.5
9.0
8.5
8.0
7.5
7.0
1000
800
600
400
200
0
−200
−400
2000
2004
2008
2012
2016
2020
Observed levels (m AHD)
HARTT regression (m AHD)
Cumulative rainfall deficit (mm)

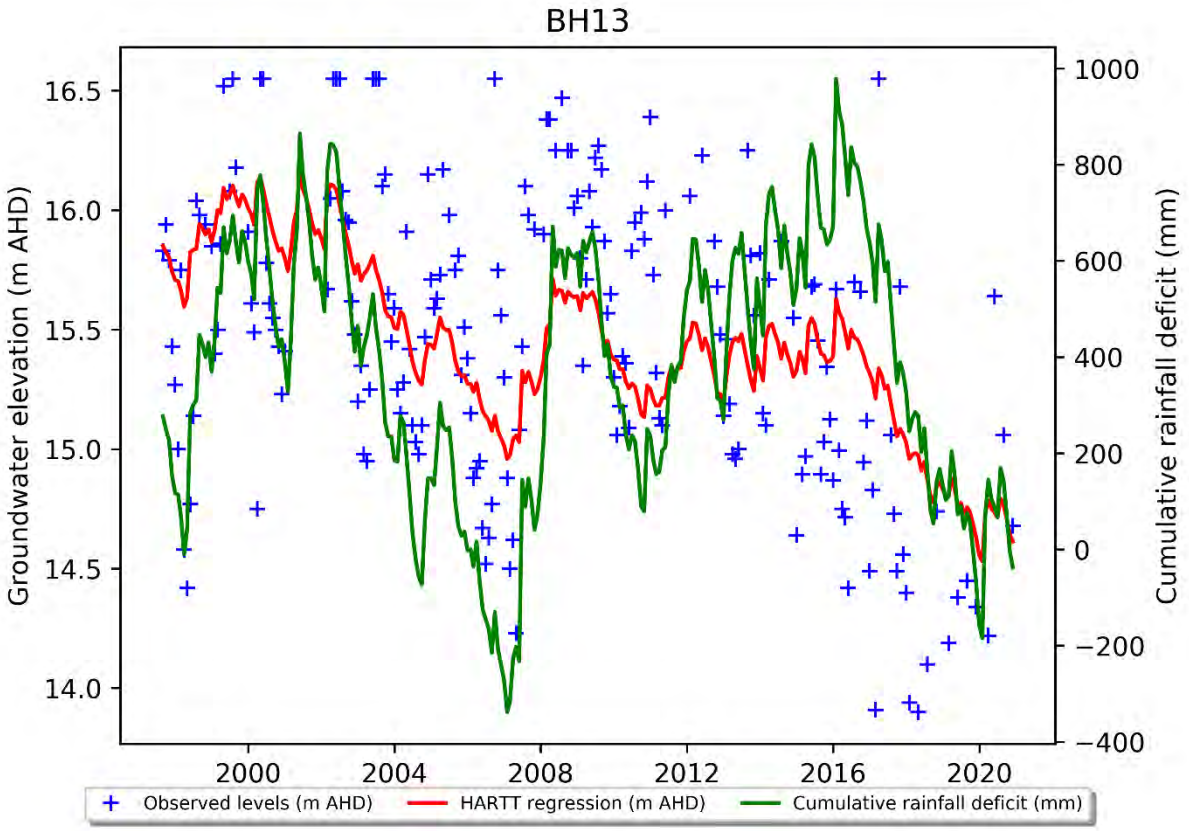

BH05
Groundwater elevation (m AHD)
Cumulative rainfall deficit (mm)
11
10
9
8
7
6
1000
800
600
400
200
0
−200
−400
2000
2004
2008
2012
2016
2020
Observed levels (m AHD)
HARTT regression (m AHD)
Cumulative rainfall deficit (mm)

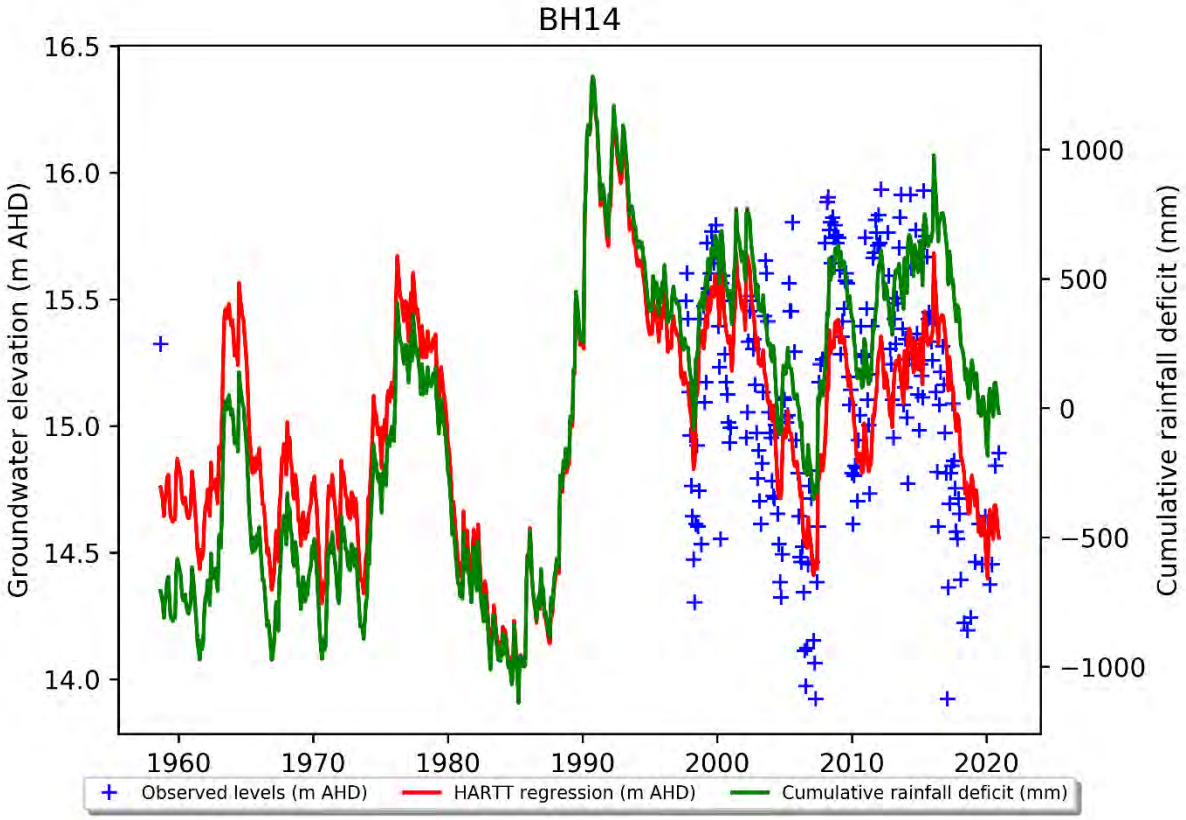

BH09
Groundwater elevation (m AHD)
Cumulative rainfall deficit (mm)
17.0
16.5
16.0
15.5
15.0
14.5
1000
800
600
400
200
0
−200
−400
2000
2004
2008
2012
2016
2020
Observed levels (m AHD)
HARTT regression (m AHD)
Cumulative rainfall deficit (mm)

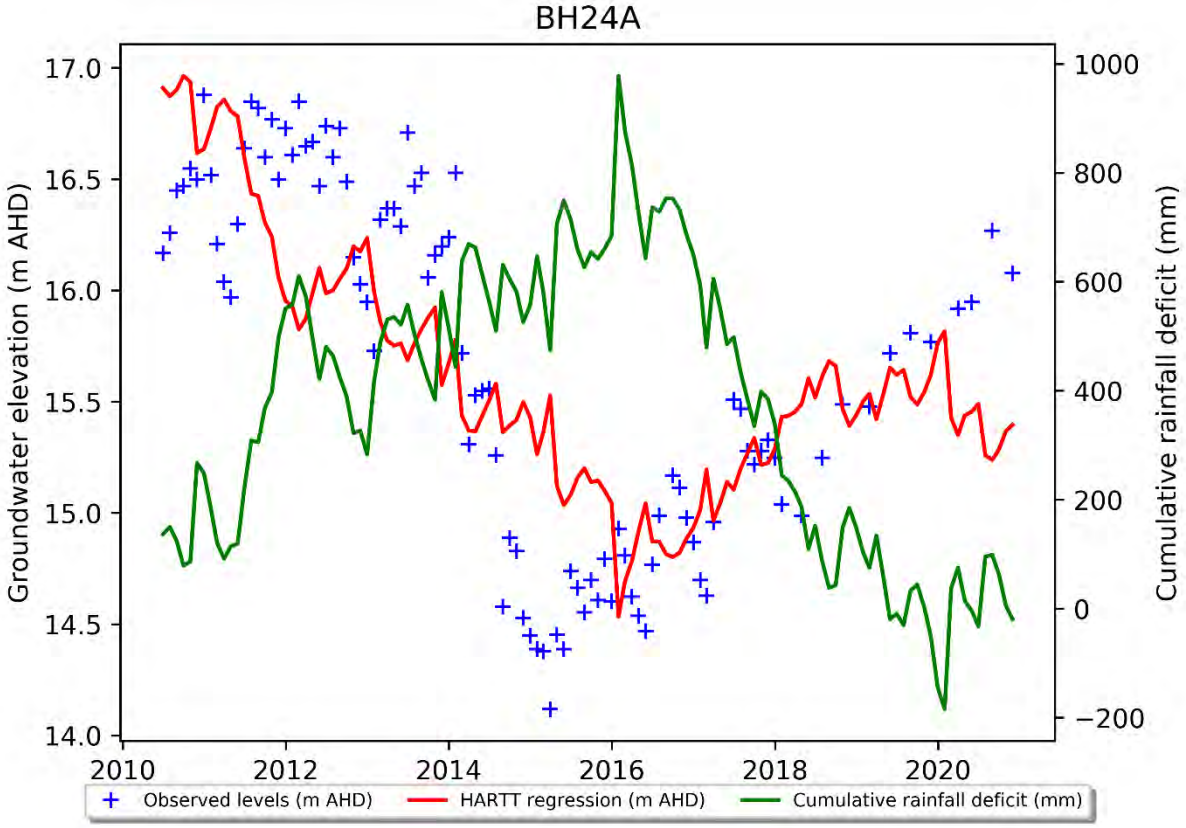

BH10
Groundwater elevation (m AHD)
Cumulative rainfall deficit (mm)
20.0
19.5
19.0
18.5
18.0
17.5
1000
800
600
400
200
0
−200
−400
2000
2004
2008
2012
2016
2020
Observed levels (m AHD)
HARTT regression (m AHD)
Cumulative rainfall deficit (mm)

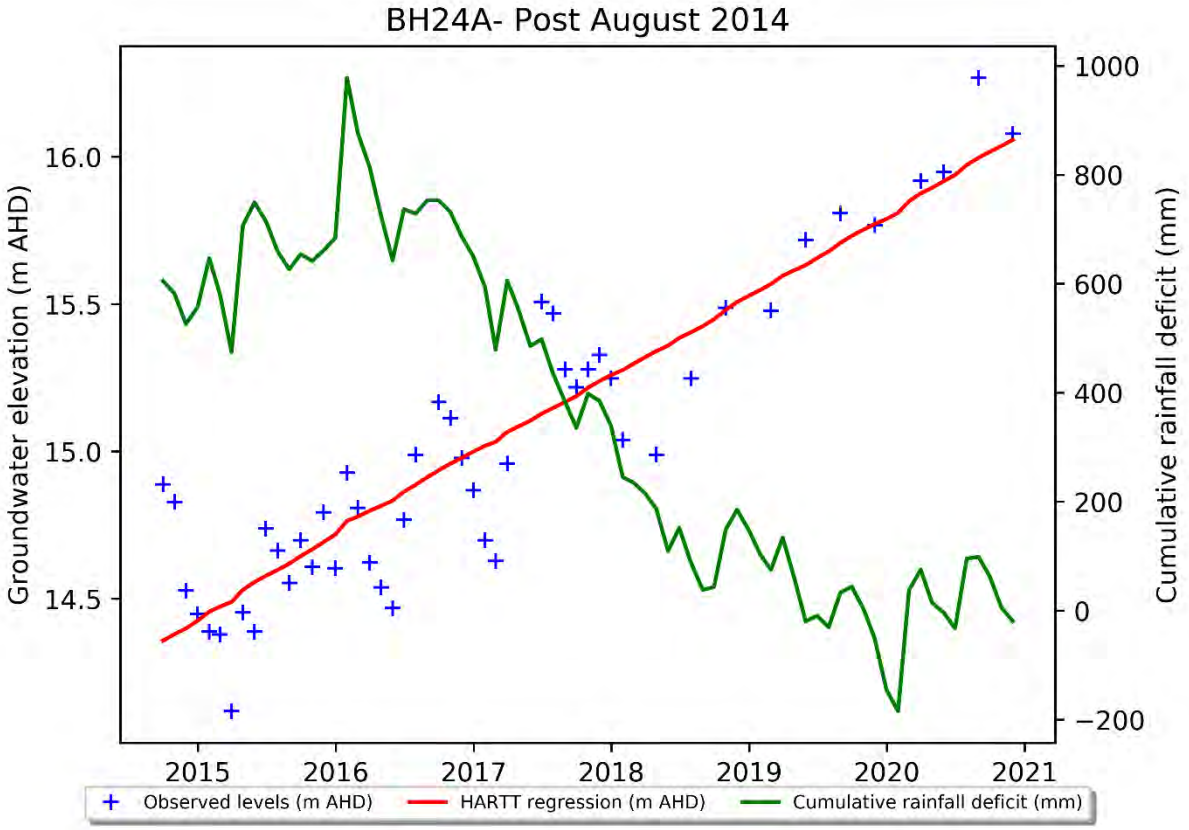

BH11
Groundwater elevation (m AHD)
Cumulative rainfall deficit (mm)
16.0
15.5
15.0
14.5
14.0
1000
800
600
400
200
0
−200
−400
2000
2004
2008
2012
2016
2020
Observed levels (m AHD)
HARTT regression (m AHD)
Cumulative rainfall deficit (mm)

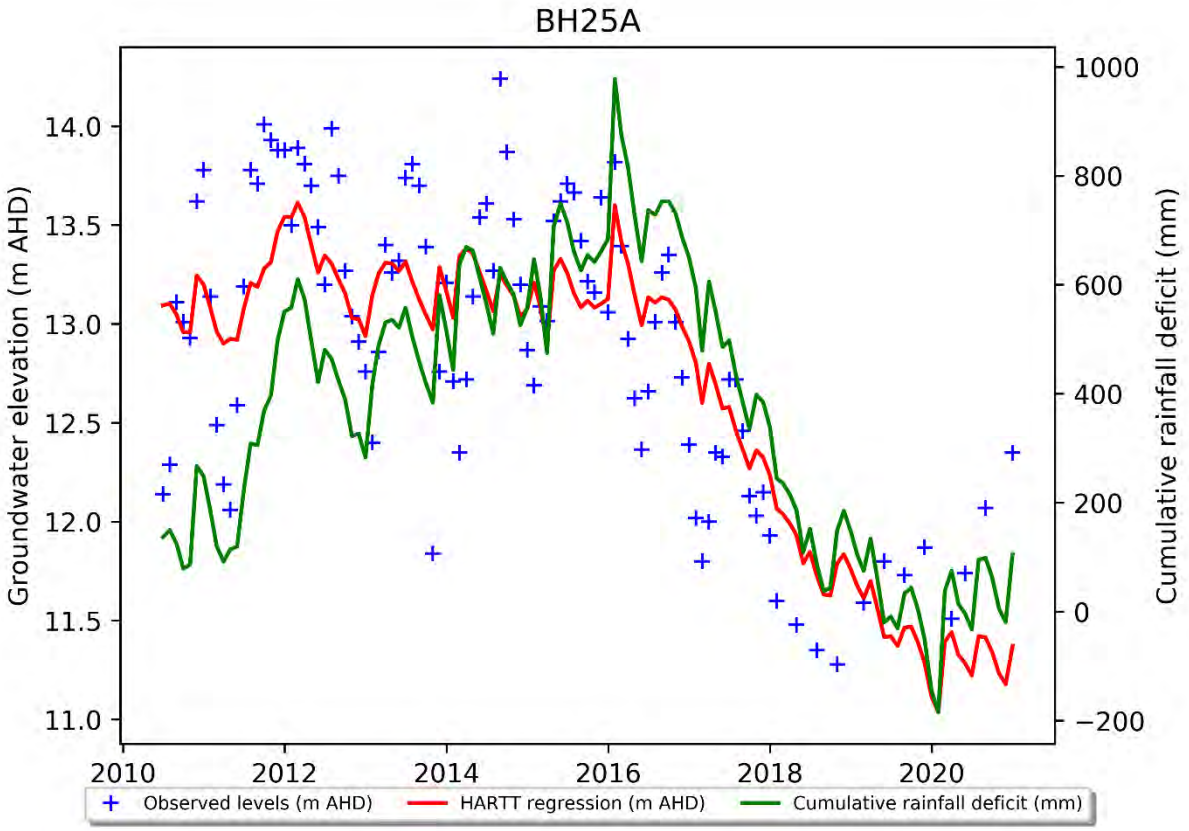

BH12
Groundwater elevation (m AHD)
Cumulative rainfall deficit (mm)
15.0
14.5
14.0
13.5
13.0
12.5
12.0
11.5
1000
800
600
400
200
0
−200
−400
2000
2004
2008
2012
2016
2020
Observed levels (m AHD)
HARTT regression (m AHD)
Cumulative rainfall deficit (mm)

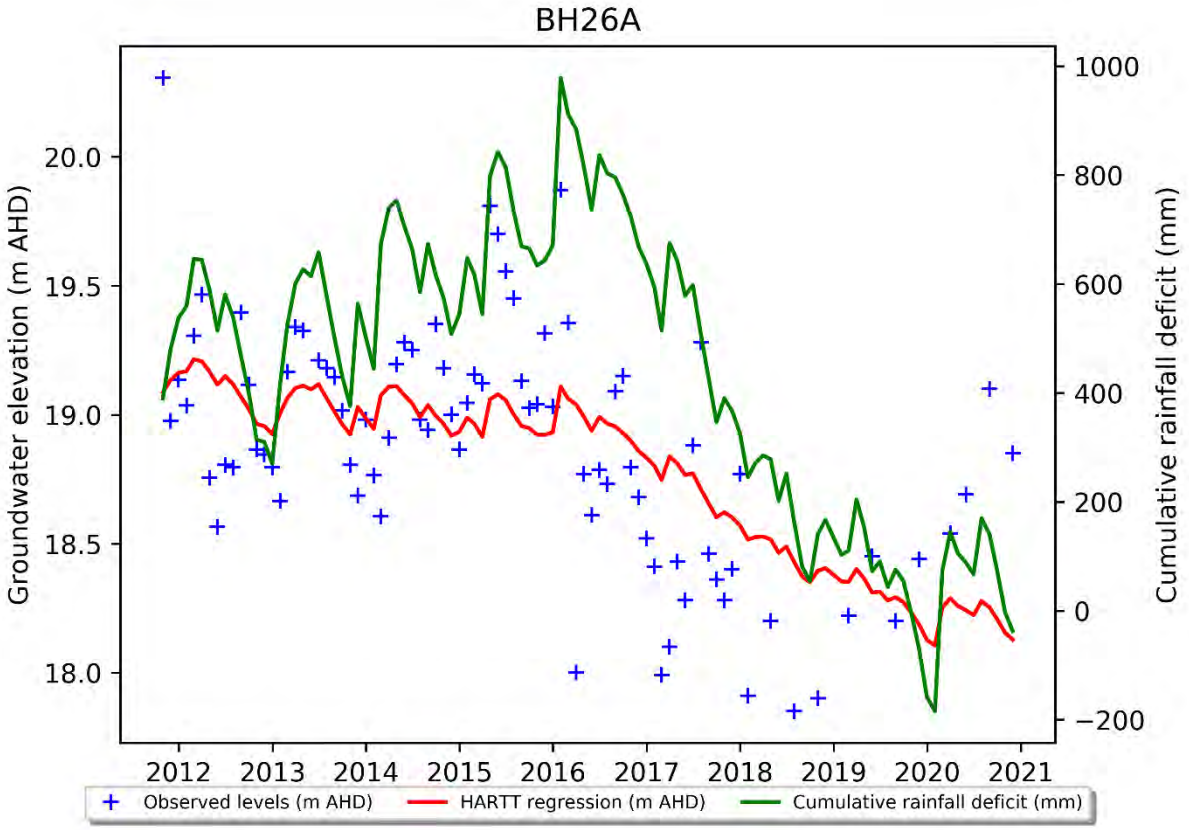

BH13
Groundwater elevation (m AHD)
Cumulative rainfall deficit (mm)
16.5
16.0
15.5
15.0
14.5
14.0
1000
800
600
400
200
0
−200
−400
2000
2004
2008
2012
2016
2020
Observed levels (m AHD)
HARTT regression (m AHD)
Cumulative rainfall deficit (mm)

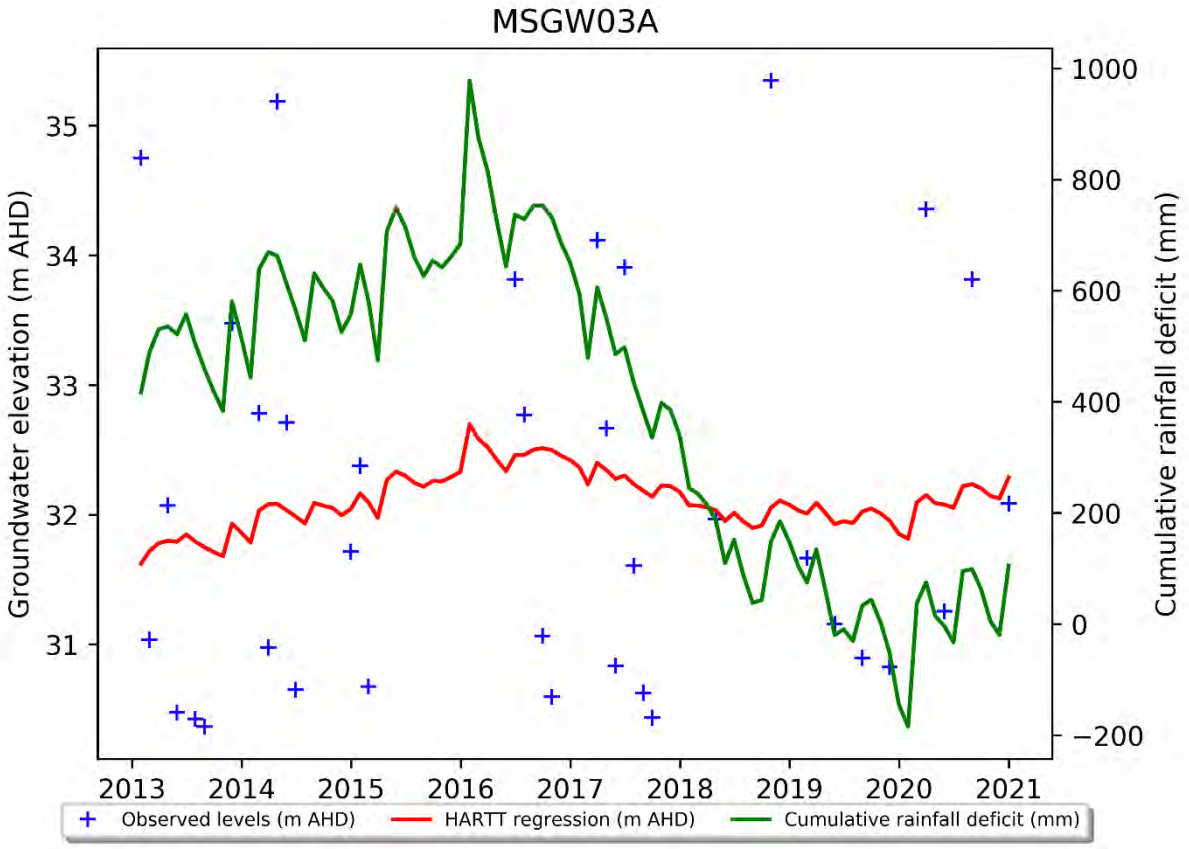

BH14
Groundwater elevation (m AHD)
Cumulative rainfall deficit (mm)
16.5
16.0
15.5
15.0
14.5
14.0
1000
500
0
−500
−1000
1960
1970
1980
1990
2000
2010
2020
Observed levels (m AHD)
HARTT regression (m AHD)
Cumulative rainfall deficit (mm)

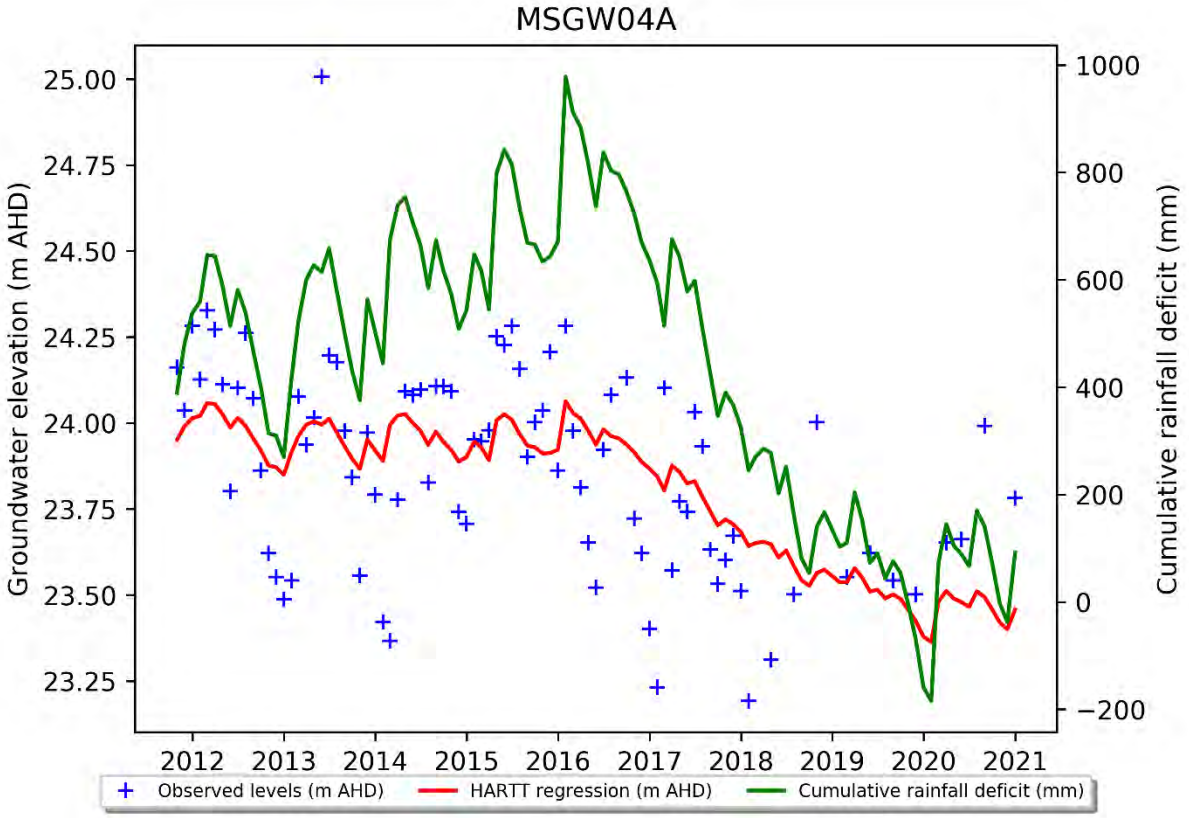

BH24A
Groundwater elevation (m AHD)
Cumulative rainfall deficit (mm)
17.0
16.5
16.0
15.5
15.0
14.5
14.0
1000
800
600
400
200
0
−200
2010
2012
2014
2016
2018
2020
Observed levels (m AHD)
HARTT regression (m AHD)
Cumulative rainfall deficit (mm)


BH24A- Post August 2014
Groundwater elevation (m AHD)
Cumulative rainfall deficit (mm)
16.0
15.5
15.0
14.5
1000
800
600
400
200
0
−200
2015
2016
2017
2018
2019
2020
2021
Observed levels (m AHD)
HARTT regression (m AHD)
Cumulative rainfall deficit (mm)

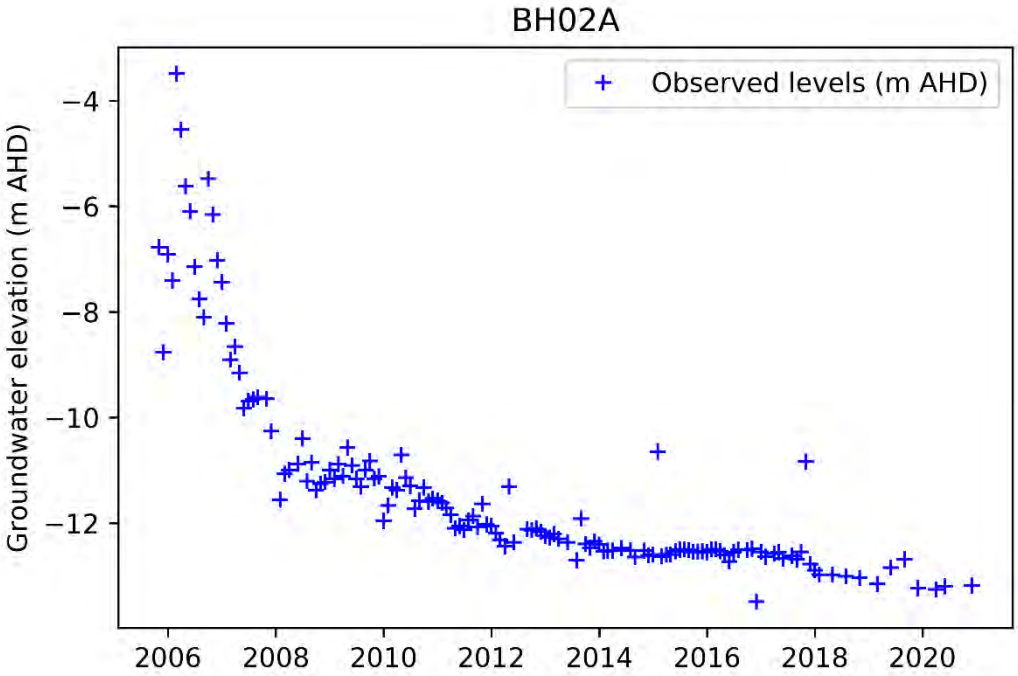

BH25A
Groundwater elevation (m AHD)
Cumulative rainfall deficit (mm)
14.0
13.5
13.0
12.5
12.0
11.5
11.0
1000
800
600
400
200
0
−200
2010
2012
2014
2016
2018
2020
Observed levels (m AHD)
HARTT regression (m AHD)
Cumulative rainfall deficit (mm)

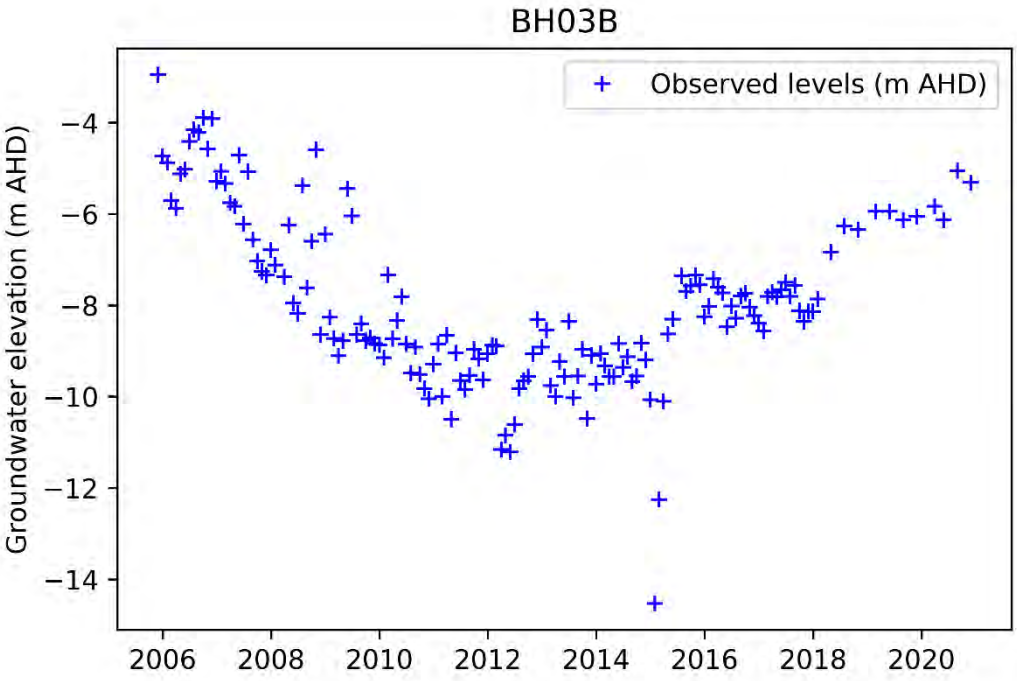

BH26A
Groundwater elevation (m AHD)
Cumulative rainfall deficit (mm)
20.0
19.5
19.0
18.5
18.0
1000
800
600
400
200
0
−200
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
Observed levels (m AHD)
HARTT regression (m AHD)
Cumulative rainfall deficit (mm)

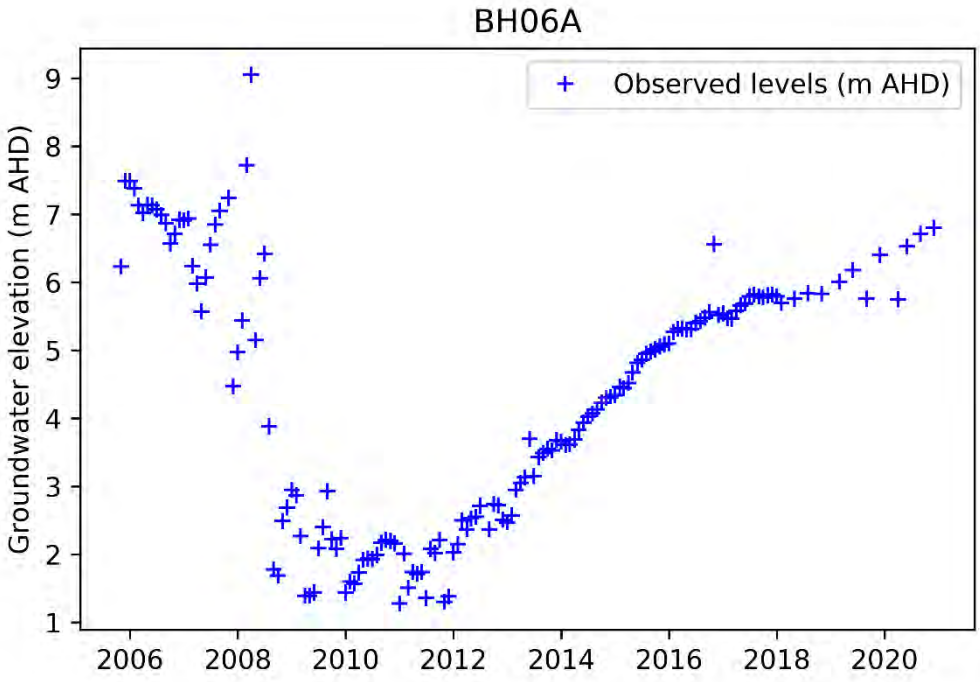

MSGW03A
Groundwater elevation (m AHD)
Cumulative rainfall deficit (mm)
35
34
33
32
31
1000
800
600
400
200
0
−200
2013
2014
2015
2016
2017
2018
2019
2020
2021
Observed levels (m AHD)
HARTT regression (m AHD)
Cumulative rainfall deficit (mm)

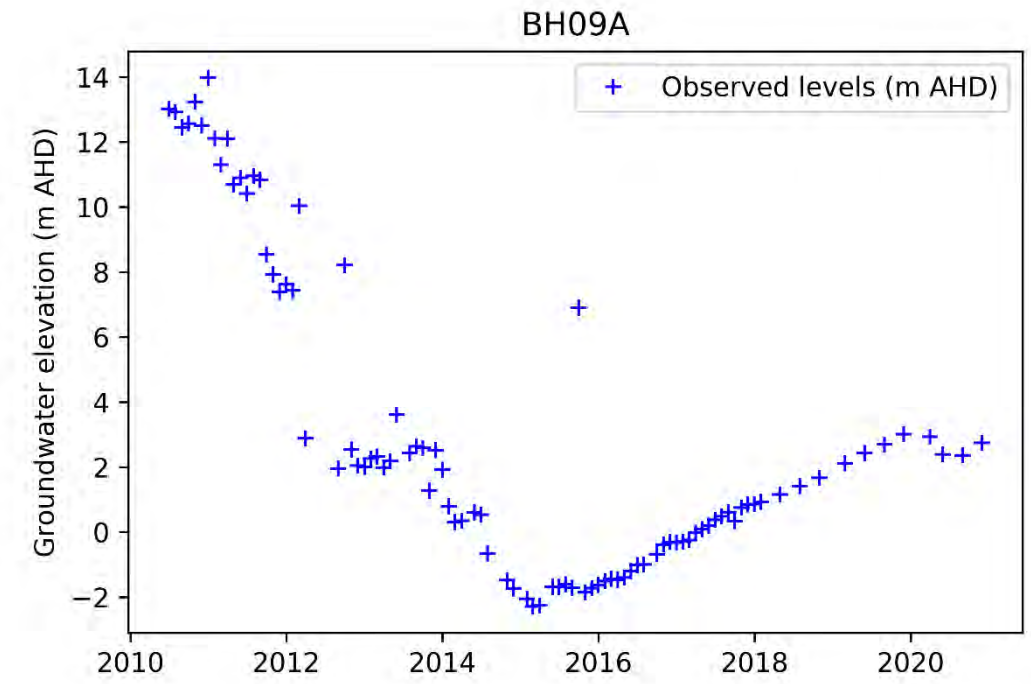


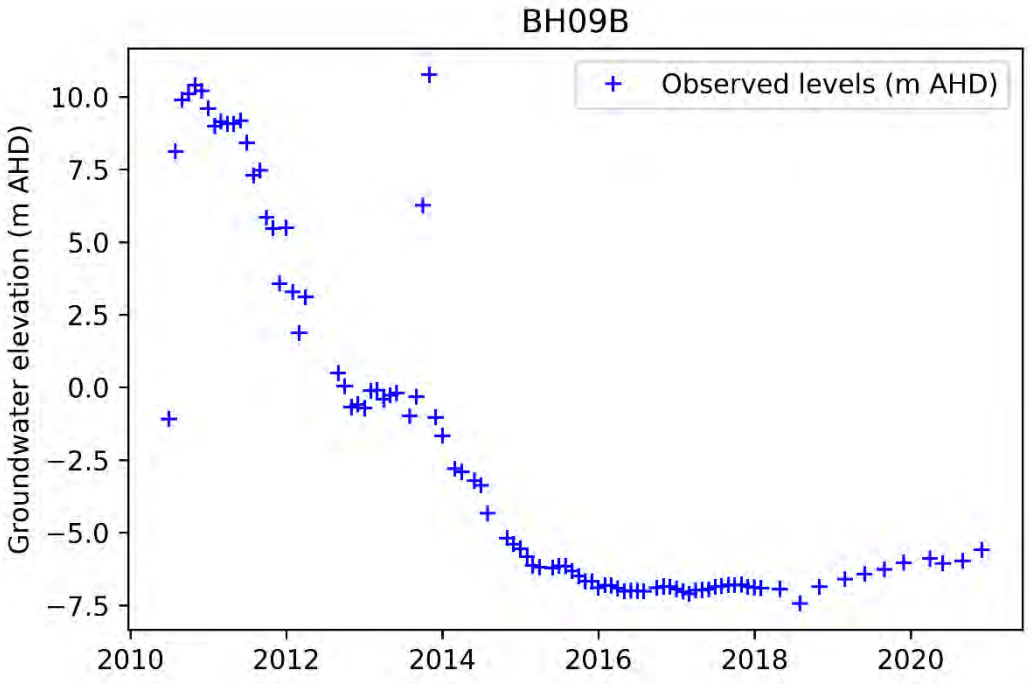
Fractured and porous rock groundwater bores

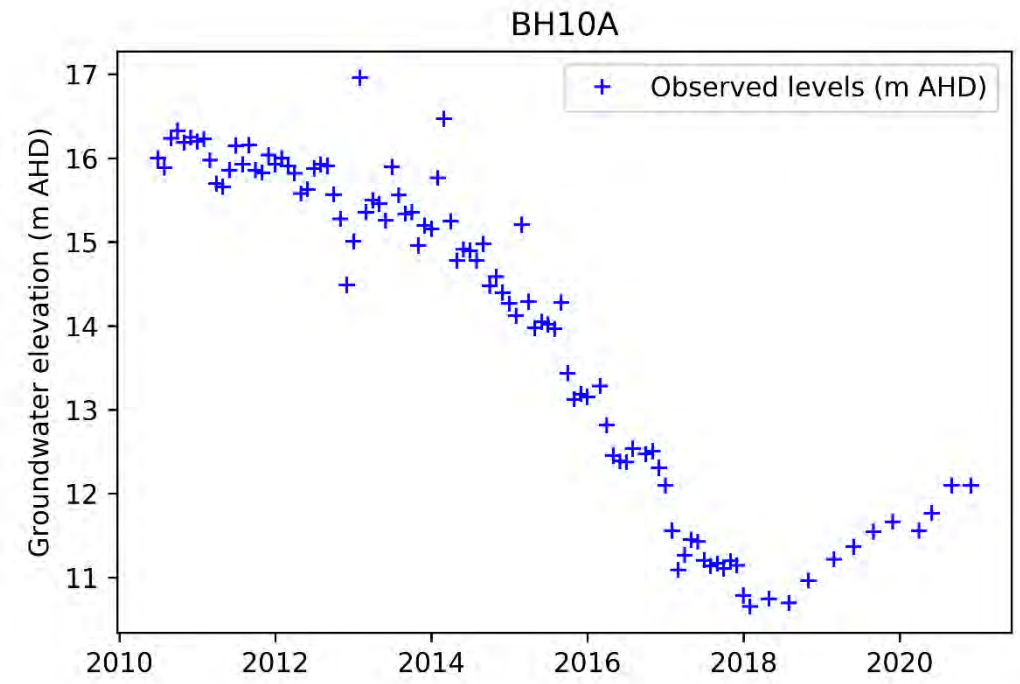


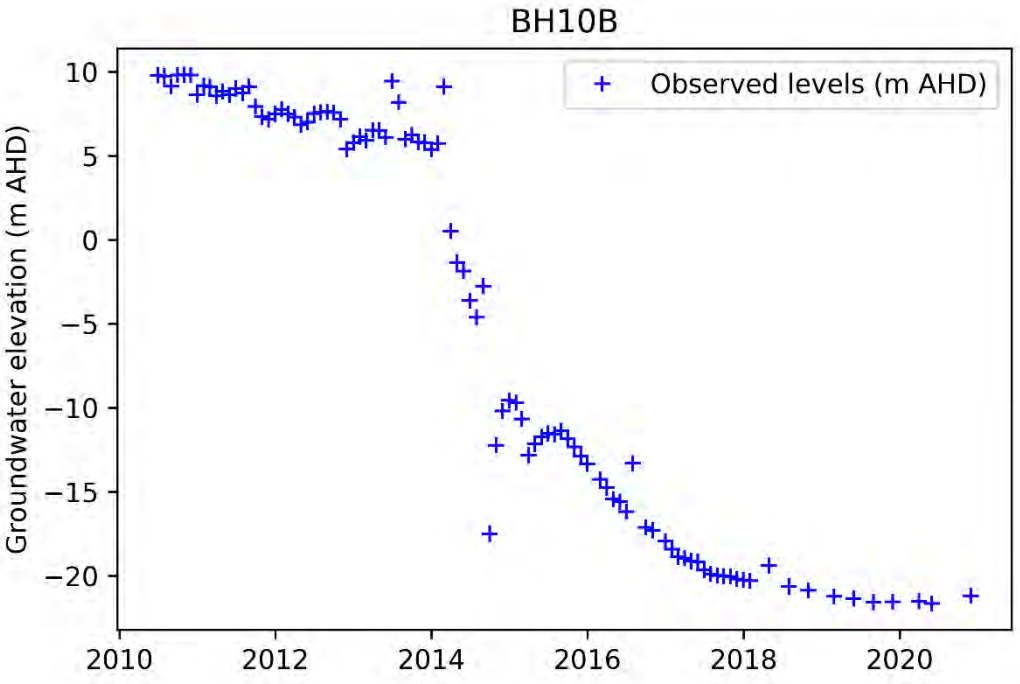

BH03B
Observed levels (m AHD)
Groundwater elevation (m AHD)
−4
−6
−8
−10
−12
−14
2006
2008
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2012
2014
2016
2018
2020

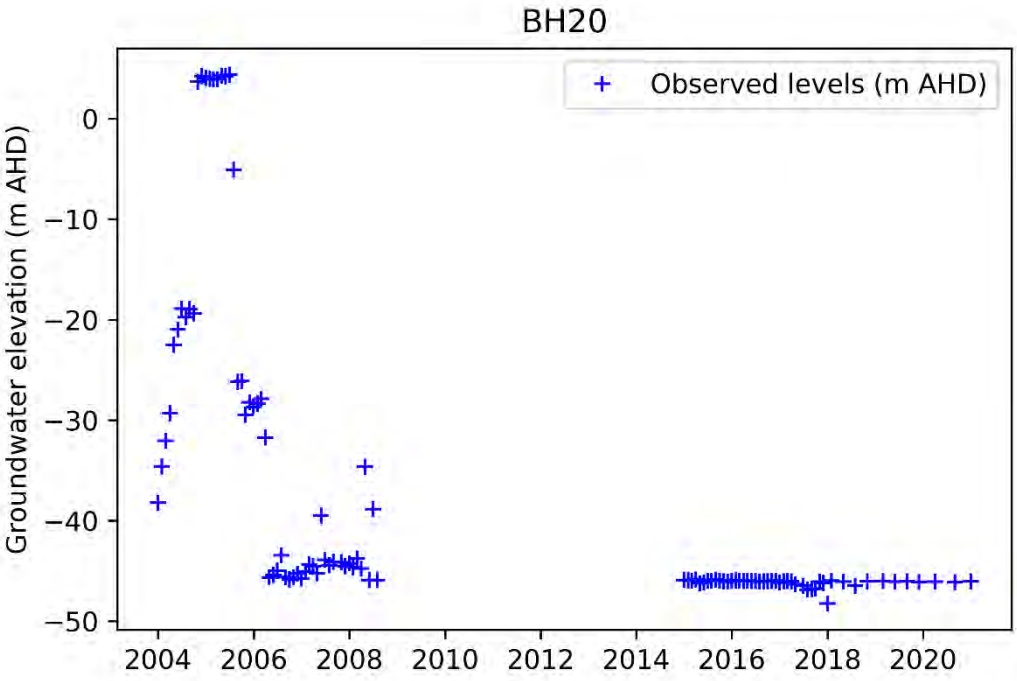

BH06A
Observed levels (m AHD)
Groundwater elevation (m AHD)
9
8
7
6
5
4
3
2
1
2006
2008
2010
2012
2014
2016
2018
2020

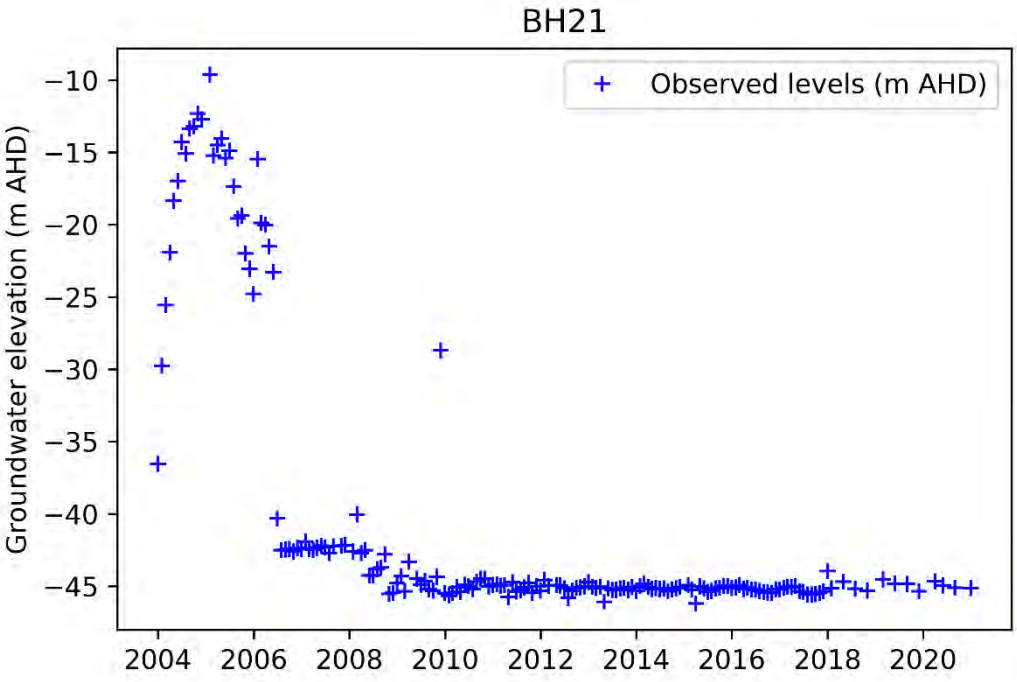

BH09A
Observed levels (m AHD)
Groundwater elevation (m AHD)
14
12
10
8
6
4
2
0
−2
2010
2012
2014
2016
2018
2020

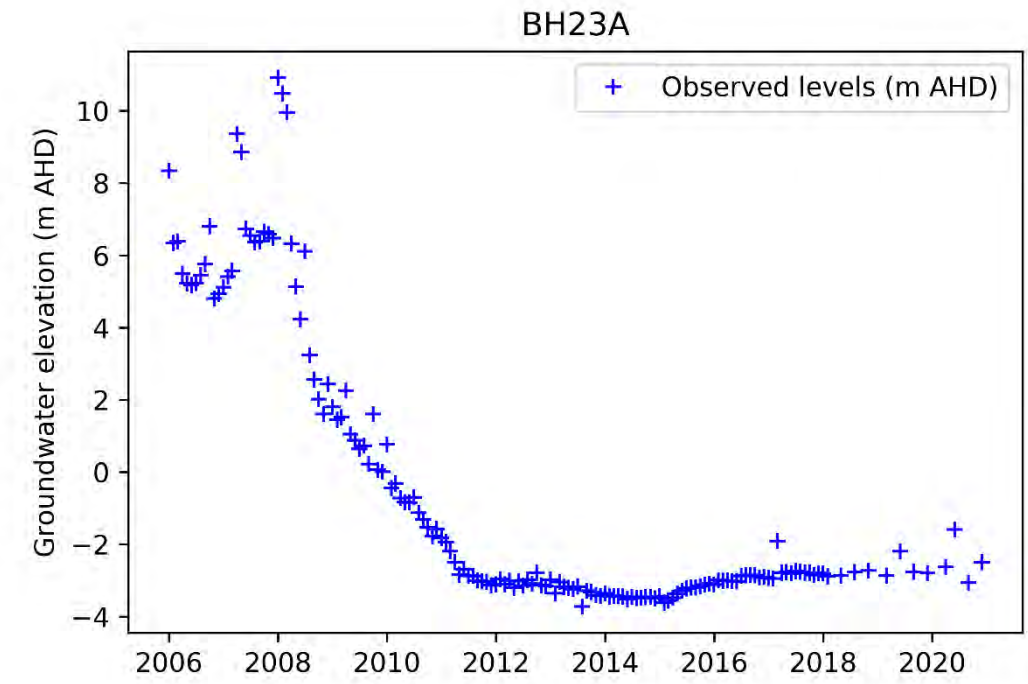

BH09B
Observed levels (m AHD)
Groundwater elevation (m AHD)
10.0
7.5
5.0
2.5
0.0
−2.5
−5.0
−7.5
2010
2012
2014
2016
2018
2020

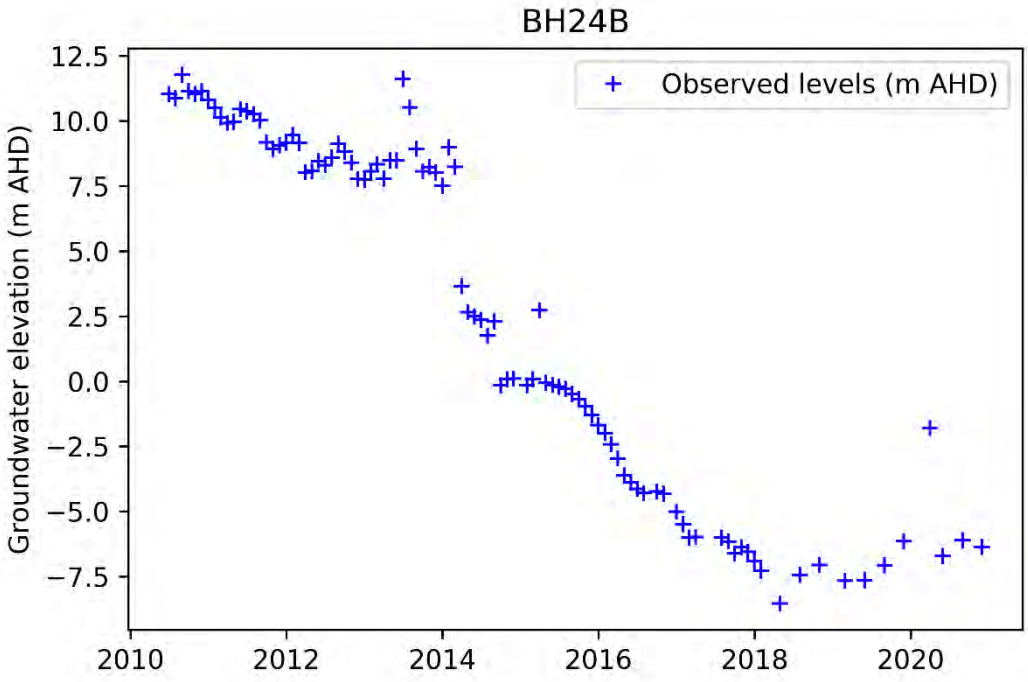

BH10A
Observed levels (m AHD)
Groundwater elevation (m AHD)
17
16
15
14
13
12
11
2010
2012
2014
2016
2018
2020

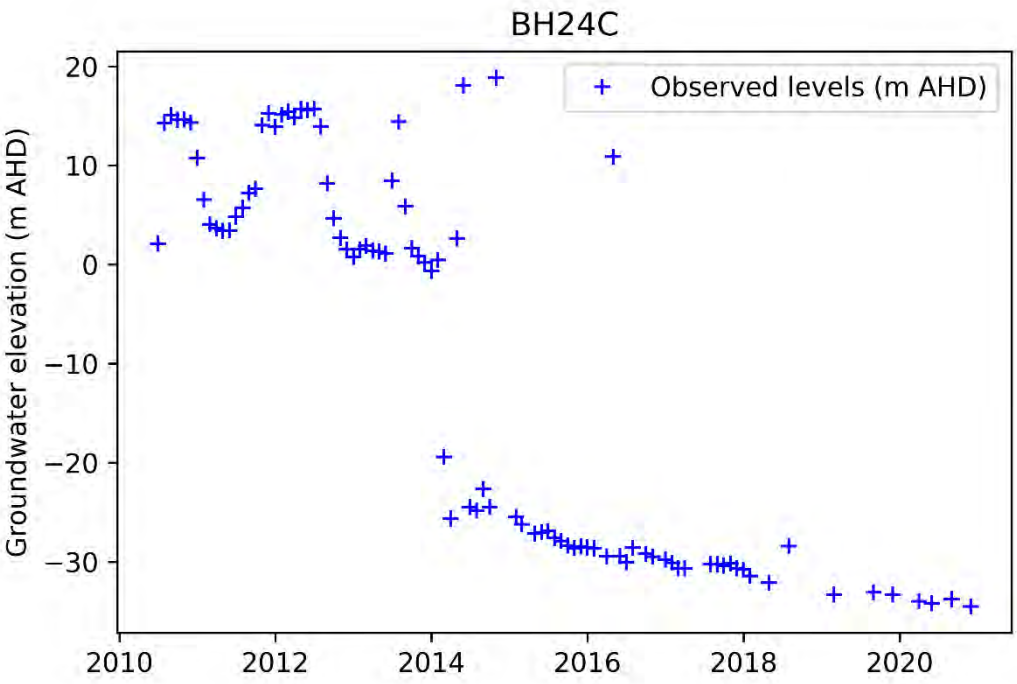

BH10B
Observed levels (m AHD)
Groundwater elevation (m AHD)
10
5
0
−5
−10
−15
−20
2010
2012
2014
2016
2018
2020

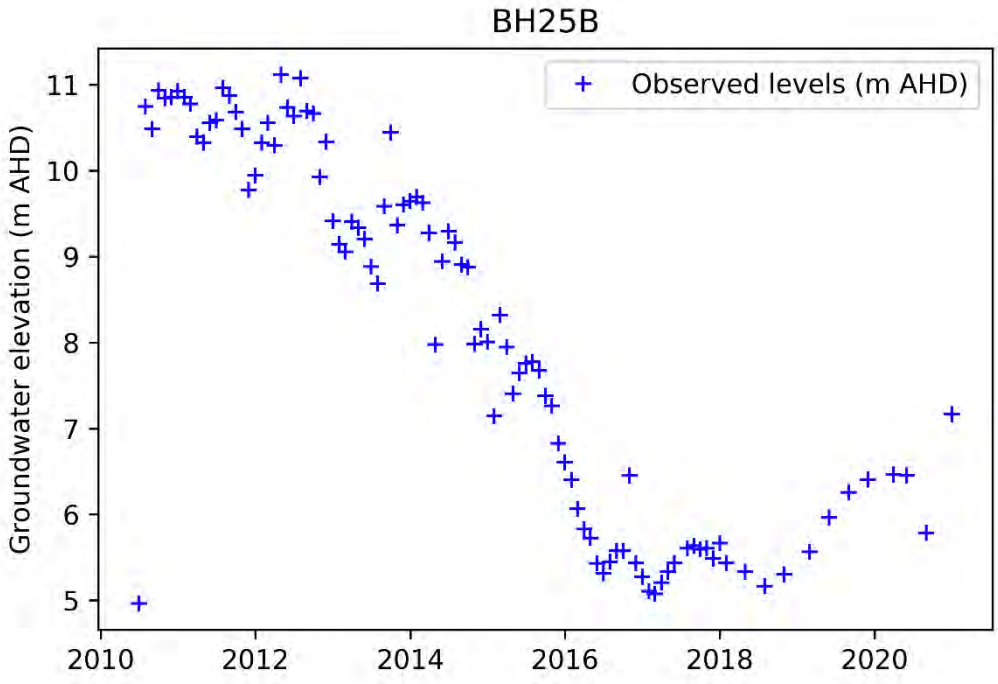

BH20
Observed levels (m AHD)
Groundwater elevation (m AHD)
0
−10
−20
−30
−40
−50
2004
2006
2008
2010
2012
2014
2016
2018
2020

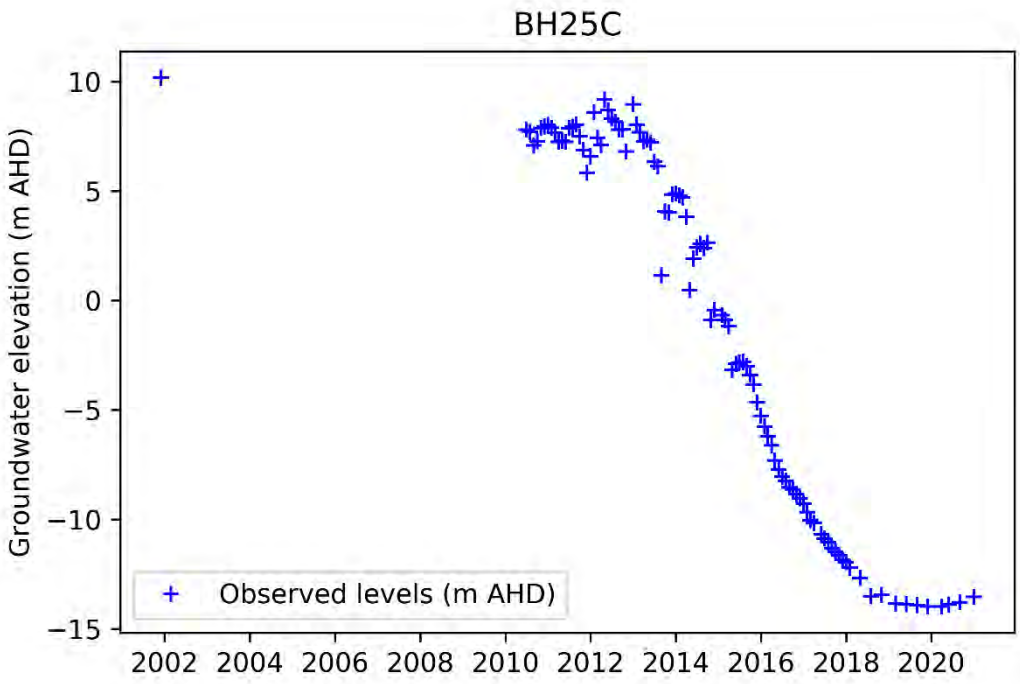

BH21
Observed levels (m AHD)
Groundwater elevation (m AHD)
−10
−15
−20
−25
−30
−35
−40
−45
2004
2006
2008
2010
2012
2014
2016
2018
2020

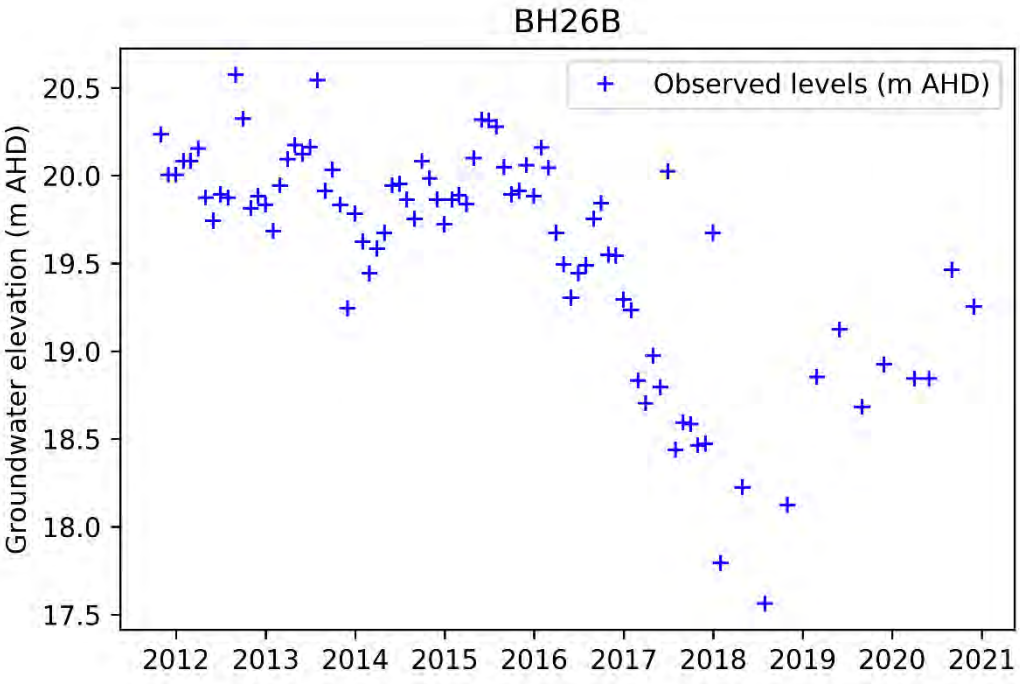

BH23A
Observed levels (m AHD)
Groundwater elevation (m AHD)
10
8
6
4
2
0
−2
−4
2006
2008
2010
2012
2014
2016
2018
2020

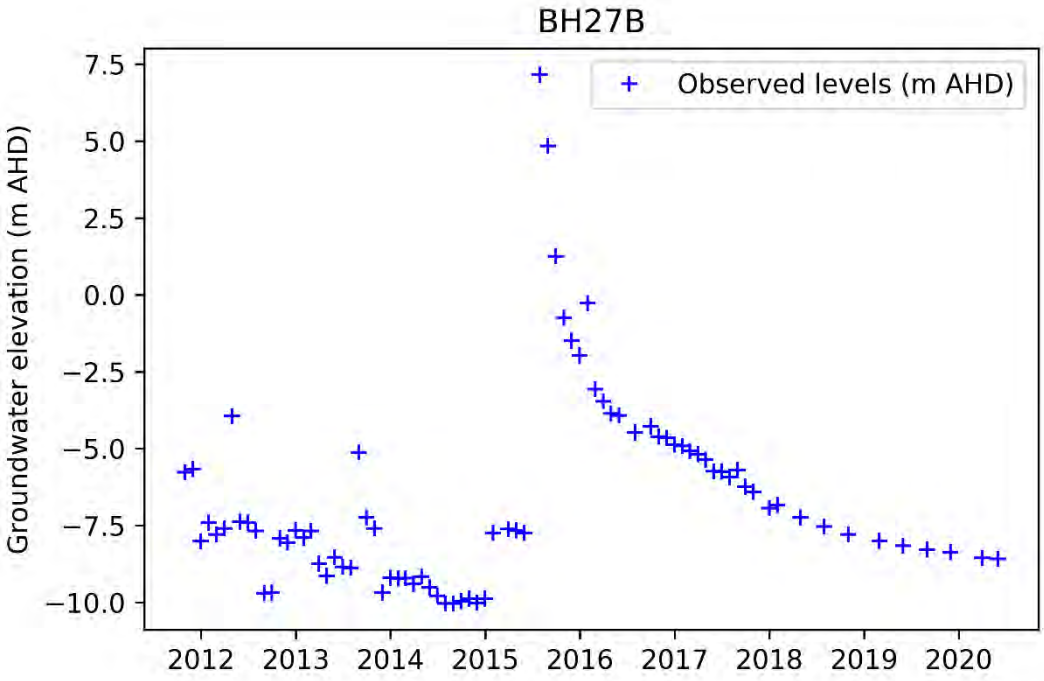

BH24B
Observed levels (m AHD)
Groundwater elevation (m AHD)
12.5
10.0
7.5
5.0
2.5
0.0
−2.5
−5.0
−7.5
2010
2012
2014
2016
2018
2020

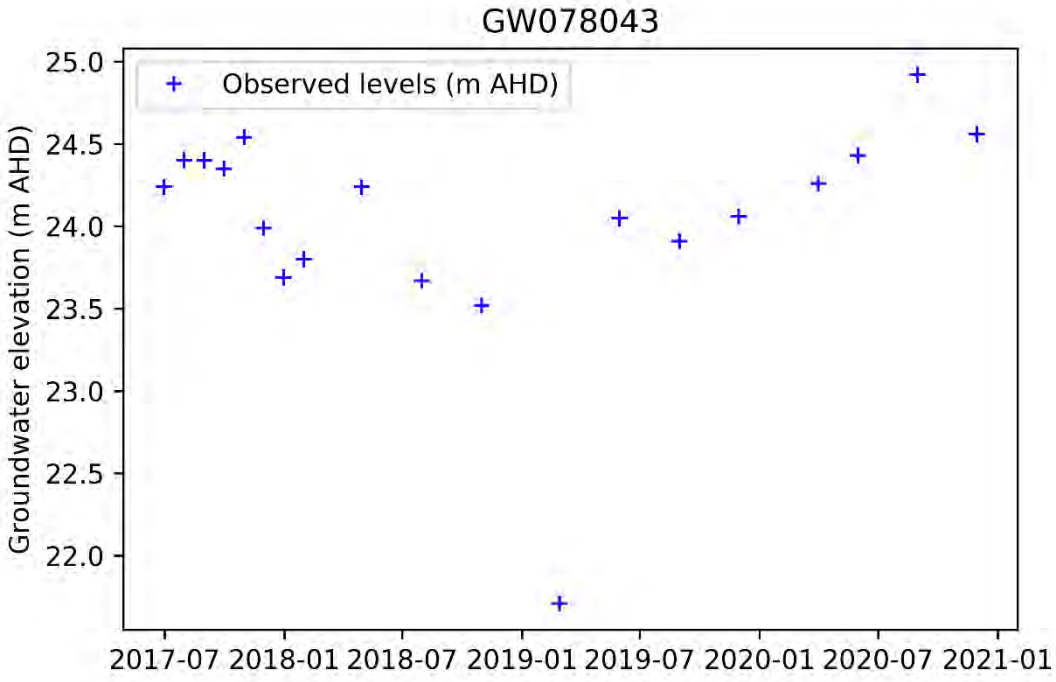

BH24C
Observed levels (m AHD)
Groundwater elevation (m AHD)
20
10
0
−10
−20
−30
2010
2012
2014
2016
2018
2020

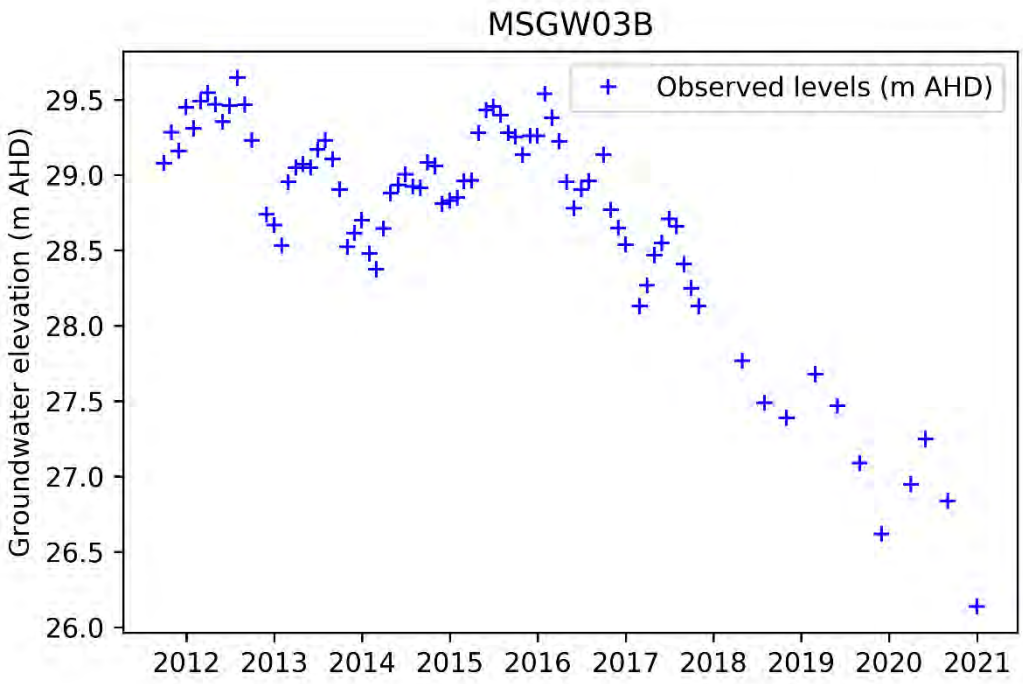

BH25B
Observed levels (m AHD)
Groundwater elevation (m AHD)
11
10
9
8
7
6
5
2010
2012
2014
2016
2018
2020

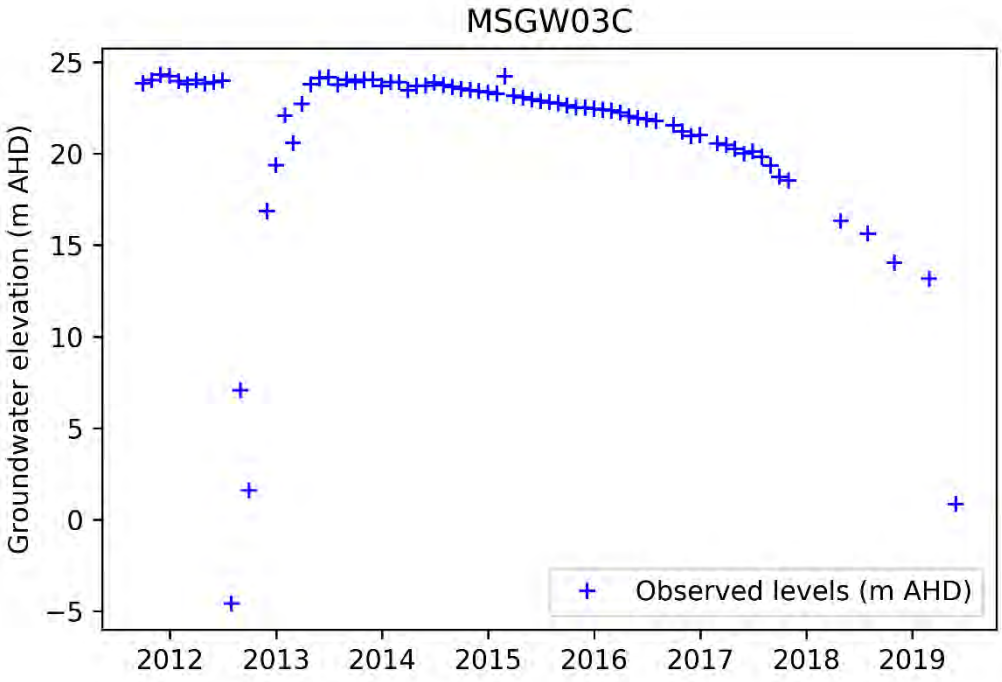

BH25C
Groundwater elevation (m AHD)
10
5
0
−5
−10
−15
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
Observed levels (m AHD)

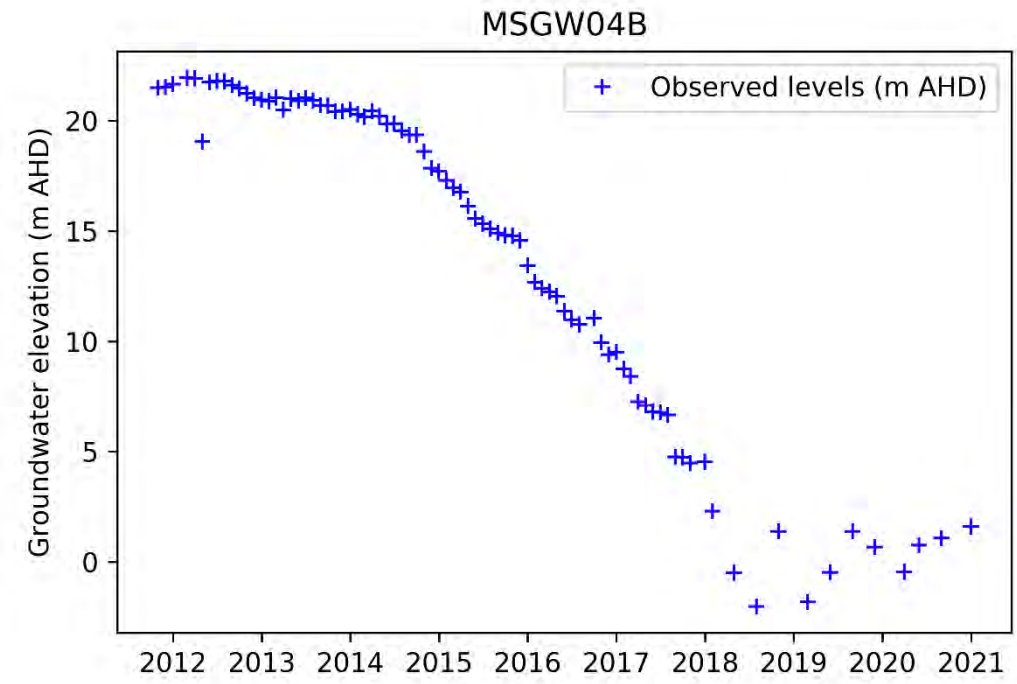

BH26B
Groundwater elevation (m AHD)
20.5
20.0
19.5
19.0
18.5
18.0
17.5
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
Observed levels (m AHD)

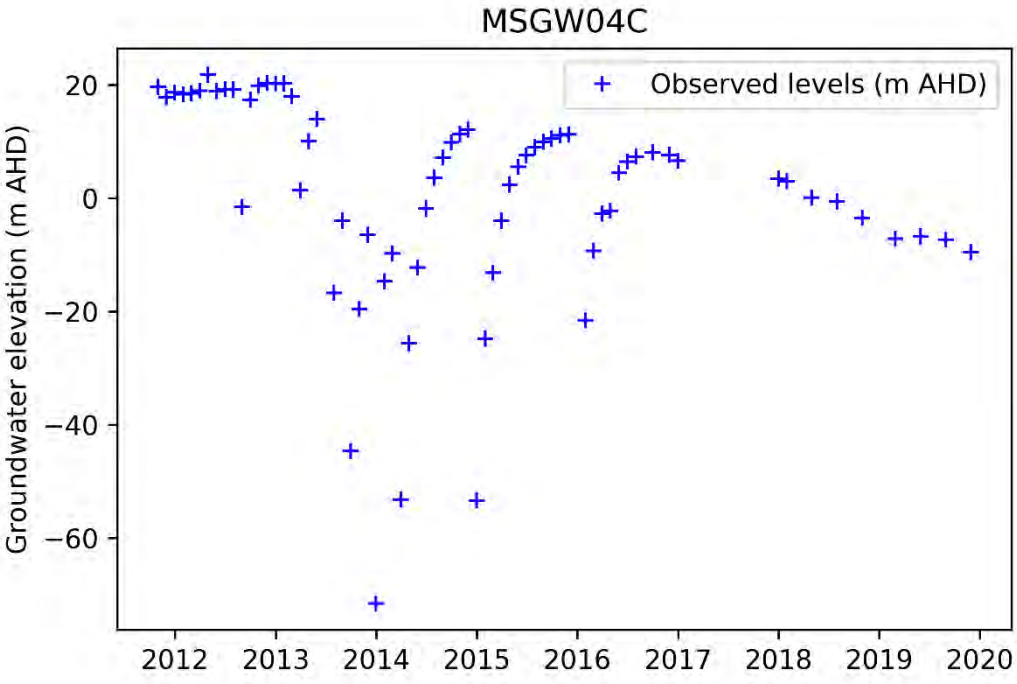

BH27B
Observed levels (m AHD)
Groundwater elevation (m AHD)
7.5
5.0
2.5
0.0
−2.5
−5.0
−7.5
−10.0
2012
2013
2014
2015
2016
2017
2018
2019
2020


GW078043
Observed levels (m AHD)
Groundwater elevation (m AHD)
25.0
24.5
24.0
23.5
23.0
22.5
22.0
2017-07
2018-01
2018-07
2019-01
2019-07
2020-01
2020-07
2021-01


MSGW03B
Observed levels (m AHD)
Groundwater elevation (m AHD)
29.5
29.0
28.5
28.0
27.5
27.0
26.5
26.0
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021


MSGW03C
Observed levels (m AHD)
Groundwater elevation (m AHD)
25
20
15
10
5
0
−5
2012
2013
2014
2015
2016
2017
2018
2019


MSGW04B
Observed levels (m AHD)
Groundwater elevation (m AHD)
20
15
10
5
0
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021


MSGW04C
Observed levels (m AHD)
Groundwater elevation (m AHD)
20
0
−20
−40
−60
2012
2013
2014
2015
2016
2017
2018
2019
2020

Appendix B

Groundwater quality data

Groundwater quality – alluvial monitoring bores

Bore	Conductivity (µS/cm)					pH				
	Min	Max	Median	20th	80th	Min	Max	Median	20th	80th
BH01	178.1	700	490	432.6	525	5.5	9.7	6.3	61.	6.6
BH03	77.6	6130	3268	2200	4736	5.1	8.7	6.2	6.0	6.7
BH03A	280	10130	7140	5948	7682	5.6	8.5	6.1	6.0	6.3
BH04	1235	20170	13710	11950	14800	4.7	7.9	6.1	5.9	6.4
BH05	178	21640	13290	2330	16000	2.5	7.7	4.9	4.3	6.5
BH09	46.8	824	323	2\73	428	5.2	8.7	6.2	6.0	6.5
BH10	1255	4080	2690	2400	2994.8	5.3	7.6	6.0	5.8	6.3
BH11	280	8200	5500	4513	6100	4.9	8.8	5.8	5.6	6.2
BH12	3200	10740	7465	6766	7898	5.6	7.9	6.6	6.4	6.9
BH13	64	10000	2773.5	346	6490	6.0	9.1	6.7	6.4	6.9
BH14	211	20980	13970	10490	15750	5.2	7.8	6.3	6.2	6.6
BH24A	4790	12150	10170	8474	11557.8	3.9	8.0	6.5	6.3	6.9
BH25A	2750	7980	6490	5760	6884	5.5	7.6	6.4	6.2	6.6
BH26A	3420	15770	11605	8458	13532	4.9	10.6	5.9	5.6	6.3
BH27A	-	-	-	-	-	-	-	-	-	-
MSGW01	7070	12370	10430	9768	10886	4.0	5.1	4.4	4.3	4.5
MSGW03A	1592	6370	3689	3184	4736	5.0	6.4	5.8	5.6	6.0
MSGW04A	5780	10760	9286	8520.6	9671.8	5.7	7.2	6.4	6.3	6.5

Note: No data available at BH27A

Groundwater quality – fractured and porous rock monitoring bores

Bore	Conductivity (µS/cm)					pH				
	Min	Max	Median	20th	80th	Min	Max	Median	20th	80th
BH02A	2320	8820	6100	5442	6442	6.2	8.0	7.2	7.1	7.4
BH03B	3070	15570	10440	8743	11210	6.0	7.4	6.8	6.7	7.0
BH06A	4120	11040	7760	6810.2	8340	6.4	8.2	7.3	7.2	7.4
BH09A	5470	11800	6500	6020	7490	9.9	12.8	11.7	11.3	12.4
BH09B	5750	10800	6880	6280	7550	10.0	12.7	12.0	11.7	12.5
BH10A	3990	9568	6660	5940	7050	6.7	9.3	7.5	7.2	7.7
BH10B	3580	7460	5055	4456	5446	9.8	12.9	11.4	11.0	12.1
BH20	664	25583	6520	5686	8004	6.2	9.1	7.0	6.6	7.6
BH21	657	115900	7080	6224	7748	5.4	8.9	7.7	7.3	8.3
BH23A	1120	11200	5890	5210	6248	5.7	8.7	7.4	7.2	7.5
BH24B	590	11850	9510	8406	11074	5.9	12.1	8.4	7.9	10.3
BH24C	2000	13790	9140	7800	10524	5.7	12.8	7.8	7.3	9.3
BH25B	2040	9144	7155	6306	7721.2	6.5	8.3	7.1	7.0	7.3
BH25C	3570	8260	7320	6152	7510	6.6	10.2	8.2	8.0	9.4
BH26B	3160	8066	6710	5944	7124.8	6.6	8.1	7.1	6.9	7.2
BH27B	4450	6350	5410	4866	5772	7.3	8.4	7.7	7.5	7.9
BH27C	3850	5370	4360	4168	4798	7.4	8.8	8.0	7.8	8.1
MSGW03B	4630	7250	6390	5930	6787	5.3	8.0	7.3	7.1	7.5
MSGW03C	5340	8570	6430	5872	7422	6.6	12.0	7.2	7.0	9.1
MSGW04B	5190	8970	7880	7266	8318.8	6.6	7.9	6.9	6.7	7.1
MSGW04C	4770	9960	6460	5222	7772	7.0	12.7	8.0	7.3	11.2
GW078043	3634	5698	4823	4604	4942.4	6.2	7.2	6.3	6.2	6.5



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The Power of Commitment

Appendix C

Flood impact assessment









umwelt
Environmental & Social Consultants

CENTENNIAL MANDALONG

FLOOD IMPACT ASSESSMENT

Mandalong Southern Extension Project
Modification 10

FINAL

September 2021

FLOOD IMPACT ASSESSMENT

Mandalong Southern Extension Project
Modification 10

FINAL

Prepared by
Umwelt (Australia) Pty Limited
on behalf of
Centennial Coal

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Project Manager:	Darren Lyons
Report No.	21540/R01
Date:	September 2021

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	Name	Date	Name	Date
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Appendix 1	Assessment Approach

1.0 Introduction

1.1 Background

Mandalong Mine (Mandalong) is an existing underground coal mine near Morisset, approximately 35 kilometres (km) south-west of Newcastle, predominantly in the Lake Macquarie local government area (LGA) (refer to **Figure 1.1**). Mandalong is operated by Centennial Mandalong Pty Limited (Centennial Mandalong).

Centennial Mandalong has approval to extract run-of-mine (ROM) coal from the West Wallarah and Wallarah-Great Northern seams using a combination of longwall and continuous mining methods. Mandalong operates under State significant development (SSD) consent SSD-5144, which was granted on 12 October 2015 by the NSW Planning Assessment Commission under Part 4, Division 4.1 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act).

As identified in Mandalong's *Mining Operations Plan* (MOP) (Centennial Coal 2018), the progression of underground mining is regularly reviewed dependent on ongoing monitoring and geological conditions. Centennial Mandalong recently encountered poor geological conditions within the Mandalong Southern Extension Area, including a fault zone and igneous sill.

In response to these conditions and in order to maintain coal production, improve mining conditions and improve the financial viability of Mandalong, amendments to the approved mine plan were sought as part of a modification to SSD-5144 (herein referred to as MOD 9). As part of MOD 9, Centennial Mandalong sought approval to amend the approved mine plan, including the reorientation of LW30-LW33.

Since the approval of MOD 9 in April 2021, Centennial Mandalong has continued to review the progression of underground mining within the Mandalong Southern Extension Area. As a result of these investigations, the decision has been made to shorten LW30 and remove LW33 from the mine plan. The shortening of LW30 and removal of LW33 are estimated to result in the sterilisation of approximately 0.4 million tonnes (Mt) and 1.6 Mt of coal, respectively. Consequently, Centennial Mandalong has explored options to optimise the mine plan to access additional coal resources.

Centennial Mandalong is seeking to modify SSD-5144, pursuant to Section 4.55(2) of the EP&A Act, to change Mandalong's approved mine plan to include LW34 (herein referred to as MOD 10 or the proposed modification). The addition of LW34 will maximise resource extraction within the West Wallarah Seam and Mandalong's development consent boundary and improve the continuity of coal extraction and employment at Mandalong. Two updates to Appendix 8 of SSD-5144 are also proposed (**Section 2.2** and **Section 2.3**).

Umwelt prepared the Surface Water Impact Assessment (SWIA) for the Mandalong Southern Extension Project (the Project) in August 2013 (Umwelt, 2013). Approval for the Project was granted in October 2015 (State Significant Development - SSD-5144). Since the 2015 approval, several modifications to SSD-5144 have been approved including Modifications 4 and 5 for which flood impacts were reassessed for LW23 to LW24A. The most recent Flood Impact Assessment was prepared for MOD 9 (Umwelt, 2020).

This Flood Impact Assessment (FIA) has been prepared by Umwelt to support the MOD 10 Modification Report and the Extraction Plan for LW34. For the purpose of this FIA, the assessment of the MOD 10 predicted impacts will be based on a comparison to the approved impacts as of SSD-5144 MOD 9.

1.2 Site Description

Mandalong is an existing underground coal mine approximately 130 km north of Sydney and 35 km south-west of Newcastle near Morisset predominantly within the Lake Macquarie LGA (**Figure 1.1**). The southern extent of the development consent boundary is within the Central Coast LGA (**Figure 1.1**). The development consent boundary encompasses a total area of 11,199 ha (**Figure 1.1**).

The predominant land uses within the development consent boundary include residential and rural-residential, industrial and commercial, utility easements, underground mining and surface operations associated with Mandalong, power generation, agricultural land (predominantly cattle grazing) and production, transport corridors and recreational use.

Surface features above LW34 include:

- AusGrid power poles
- tributaries of Buttonderry Creek, Mannering Creek and Morans Creek
- local roads (including Toepfers Road and Kiar Ridge Road)
- private dwellings, ancillary buildings, fences and driveways
- Aboriginal cultural heritage sites.

1.3 Assessment Guidelines and Requirements

MOD 10 is subject to the relevant requirements of the following water planning policies/plans and legislation regarding flood impacts associated with the Project:

- *Water Management Act 2000*
- *Water Act 1912*
- *Protection of the Environment Operations Act 1997* (POEO Act)
- State Water Management Outcomes Plan (SWMOP) (Department of Natural Resources (DNR), undated)
- Hunter-Central Rivers Catchment Action Plan (CAP)
- Guidelines for Management of Stream/Aquifer Systems in Coal Mining Developments – Hunter Region (Department of Infrastructure Planning and Natural Resources (DIPNR), 2005)
- River Hydrology and Energy Relationships - Design Notes for the Mining Industry (DWE 2007)
- Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009
- Water Sharing Plan for the Central Coast Unregulated Water Sources 2009
- Water Sharing Plan for the Jilliby Creek Water Source 2003.

The relevant requirements of these plans and regulations regarding this FIA are addressed in this report.



Data Source: DFSI (2020), Centennial Mandalong (2020)

0 2.5 5.0 7.5km

1:150 000

Legend

- Development Consent Boundary
- Rail Line
- Road
- Watercourse
- Local Government Area (LGA)
- NPWS Reserve
- State Forest

FIGURE 1.1

Regional Context

File Name (A4): R01/21540_001.dgn
20210707 14.33

1.4 Potential Surface Water Impacts

This FIA has been undertaken for a portion of the Mandalong Southern Extension Project Area (the Project Area) that will be subject to potential impacts from MOD 10. The Project Area is shown in **Figure 3.1**.

The key feature of MOD 10 that can potentially impact on flood behaviour within the catchment is subsidence resulting from underground mining. The potential subsidence impacts on surface water resources in the Project Area relate to vertical subsidence displacement (i.e. differential settlement/ movement) (refer to the Subsidence Assessment Report; Ditton Geotechnical Services (DgS), 2020b and subsidence contours presented in DgS, 2021a). The aim of this FIA is to define the potential impacts on flooding and drainage as a result of MOD 10.

This FIA compares the predicted impacts of MOD 10 on remnant ponding, flooding and watercourse stability to the approved SSD-5144 Modification 9. The FIA prepared for MOD 9 (Umwelt, 2020) assessed the change in impacts from the approved SSD-5144 Modification 5.

1.5 Structure of the Report

This FIA has been prepared for Centennial Mandalong as part of a Modification Report required to support a proposed modification to the development consent (SSD-5144). It compares the potential impacts of MOD 10 on flooding and watercourse stability to the approved SSD-5144 MOD 9.

The report is structured as follows:

- **Section 2.0** outlines the proposed modification
- **Section 3.0** provides information on the existing surface water resources within the Project Area
- **Section 4.0** presents the potential impacts to flooding of MOD 10 and proposed management strategies
- **Section 5.0** provides a discussion of the monitoring and reporting requirements for the MOD 10.

2.0 Proposed Modification

2.1 Proposed Mine Plan

Centennial Mandalong is seeking to modify SSD-5144, pursuant to Section 4.55(2) of the EP&A Act, to include LW34. The previously approved and proposed mine plans for the Mandalong Southern Extension Area are shown in **Figure 2.1**.

LW34 will align with adjacent panels by maintaining the existing panel width of 200 m and all other mining geometry aspects will remain unchanged. Secondary extraction of coal as part of the proposed modification will remain within the currently assessed and approved footprint for secondary extraction.

No changes to the development consent boundary are required.

2.2 Exploration Drilling

Centennial Mandalong is also seeking approval to amend one of the existing commitments in Appendix 8 of SSD-5144 that relates to exploration drilling. Centennial Mandalong is currently not permitted to undertake exploration drilling on total fire ban days. Total fire ban restrictions are typically based on NSW Rural Fire Service (RFS) regional mapping and local conditions may be of lower risk, particularly during certain hours of the day.

Centennial Mandalong propose to amend the commitment that currently reads “no drilling will be conducted on total fire ban days” to better define the activities that can and cannot be undertaken on a total fire ban day. Centennial Mandalong also propose to introduce a risk assessment process that can be undertaken prior to the commencement of any exploration activities on a total fire ban day.

2.3 Annual Contributions

In consultation with Lake Macquarie City Council (LMCC) and in accordance with Centennial Mandalong’s corporate social responsibility objectives, The Lake Macquarie Foundation was established. In accordance with Appendix 8 of SSD-5144, Centennial Mandalong committed to distributing:

a) $50,000 upon the granting of the development consent; and
b) $50,000 on each anniversary of the granting of the development consent until the total amount given by the Donor (ie Centennial Mandalong) is $500,000.

Following consultation with LMCC and the Mandalong Mine Community Consultative Committee (CCC), an amendment to this commitment is proposed to allow the funds to be distributed via the CCC. The income from the fund will still be distributed to the communities of Mandalong and Morisset.

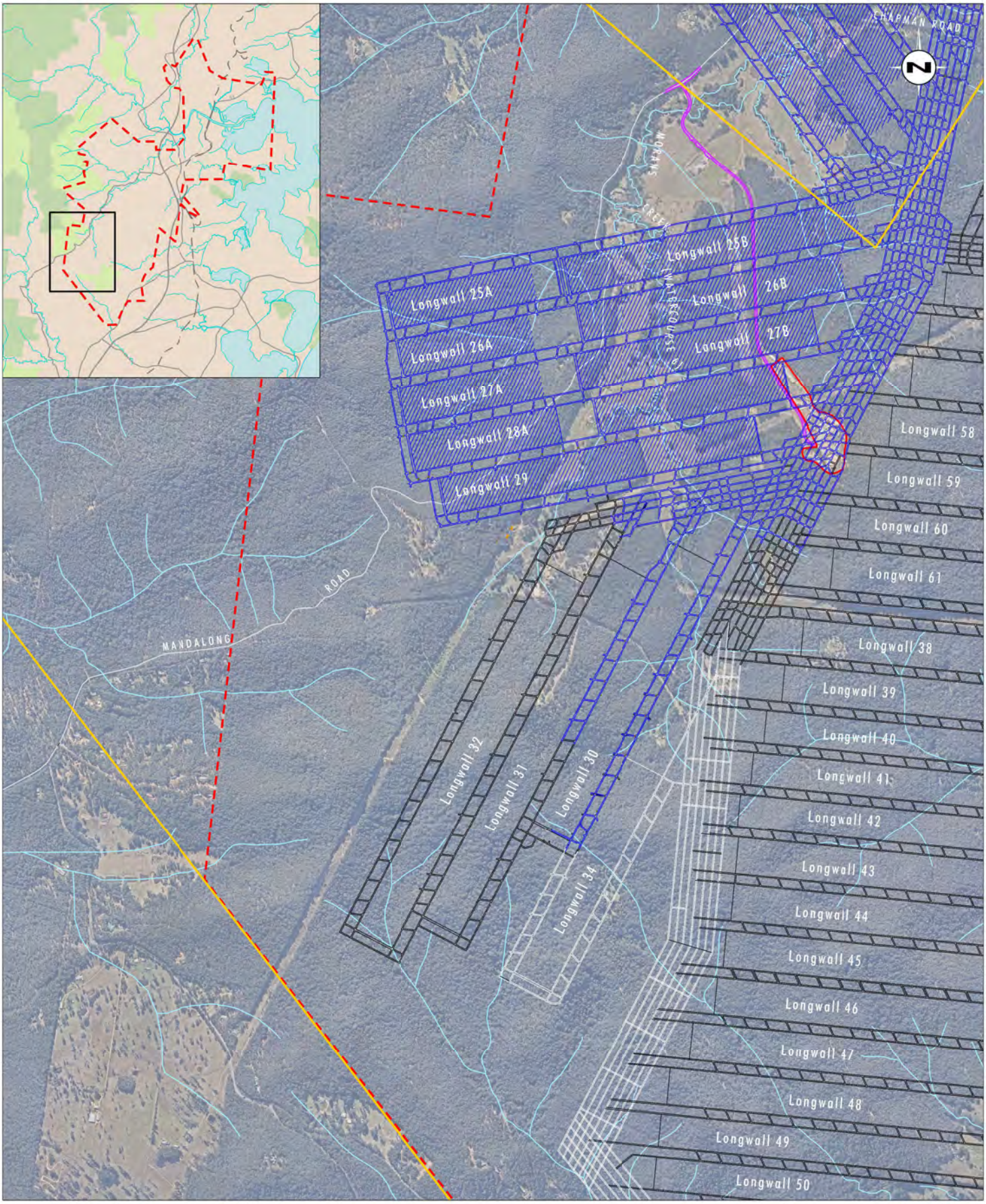


Image Source: Nearmap (Sep 2020)
Data Source: Centennial Mandalong (2021), LPI (2020)

0 0.5 1.0 1.25km
1:25 000

Legend

- Project Area
- Development Consent Boundary
- Surface Infrastructure Site
- Completed Mine Workings
- Approved Workings
- Proposed Workings
- Access Road
- Main Road
- Drainage

FIGURE 2.1

Proposed amendments to Underground Mine Layout at Mandalong Mine

File Name (A4): R01/21540_002.dgn
20210812 14:49

3.0 Existing Surface Water Environment

This section provides information on the existing surface water environment within the Project Area, including catchment areas, watercourses and existing flood regimes to be modelled.

3.1 Strahler Stream Ordering

In characterising the watercourses in the Project Area, consideration was given to the Strahler watercourse ordering system presented in DIPNR guideline documents (DIPNR 2005b, DIPNR undated) (DIPNR is now the NSW Department of Planning, Industry & Environment - DPIE)). Watercourse ordering is a hierarchical numbering system based on the degree of branching within a waterway system and provides an indication of the branching or complexity of creek and river systems.

The Strahler watercourse ordering system begins at the origin of a waterway, the initial watercourse being a first order watercourse. The watercourse remains first order until joining another watercourse. The confluence of two first order waterways results in a second order watercourse and the watercourse remains second order until joining a second order or higher order watercourse. After the confluence of two second order watercourses, the subsequent downstream waterway is designated a third order watercourse and so on moving downstream. Where lower order watercourses join higher order watercourses, the higher order numbering is unaffected, i.e. the watercourse resulting from the confluence of a first or second order watercourse with a third order watercourse will remain a third order watercourse.

The DIPNR guideline documents (DIPNR 2005b, DIPNR undated) classify waterway orders into three schedules linked to their stream ordering. The schedules are as follows:

- Schedule 1 - usually intermittent and consisting of first or second order waterways
- Schedule 2 - third and higher order waterways that drain into primary catchment rivers
- Schedule 3 - these watercourses are major rivers, including their primary tributaries and associated alluvial groundwater zones.

3.2 Catchment Areas and Watercourses

The majority of the Project Area lies within the broader catchment of Lake Macquarie, with the southern portion of the Project Area within the Wyong River catchment (refer to **Figure 3.1**).

The Project Area intersects five sub catchment areas: Morans Creek, Wyee Creek and Mannering Creek catchments which flow to Lake Macquarie; and Buttonderry Creek and Jilliby Creek catchments which flow to the Wyong River (refer to **Figure 3.1**). The watercourse mapping shown in **Figure 3.1** indicates MOD 10 will potentially impact the Project Area over small sections of upper catchment tributaries of Mannering Creek (identified as Watercourse 4 in the 2013 SWIA (Umwelt, 2013) and referred to as such in this assessment for continuity), Buttonderry Creek identified as Watercourse 5 in the 2013 SWIA (Umwelt, 2013) and Morans Creek identified as Watercourse 6 in the 2013 SWIA (Umwelt, 2013).

The upper reaches of first order watercourses within the Jilliby Creek catchment do not extend into the area of LW30-34, which supports the view that MOD 10 will have a negligible (if any) impact on Jilliby Creek.

Key characteristics of each of the catchment areas impacted by MOD 10 within the Project Area are summarised within **Section 3.2.1** for Mannering Creek, **Section 3.2.3** for Morans Creek and **Section 3.2.3** for Buttonderry Creek.

As discussed in **Section 3.4**, watercourses of third order and higher with the potential to be impacted by subsidence are included in the flood modelling.

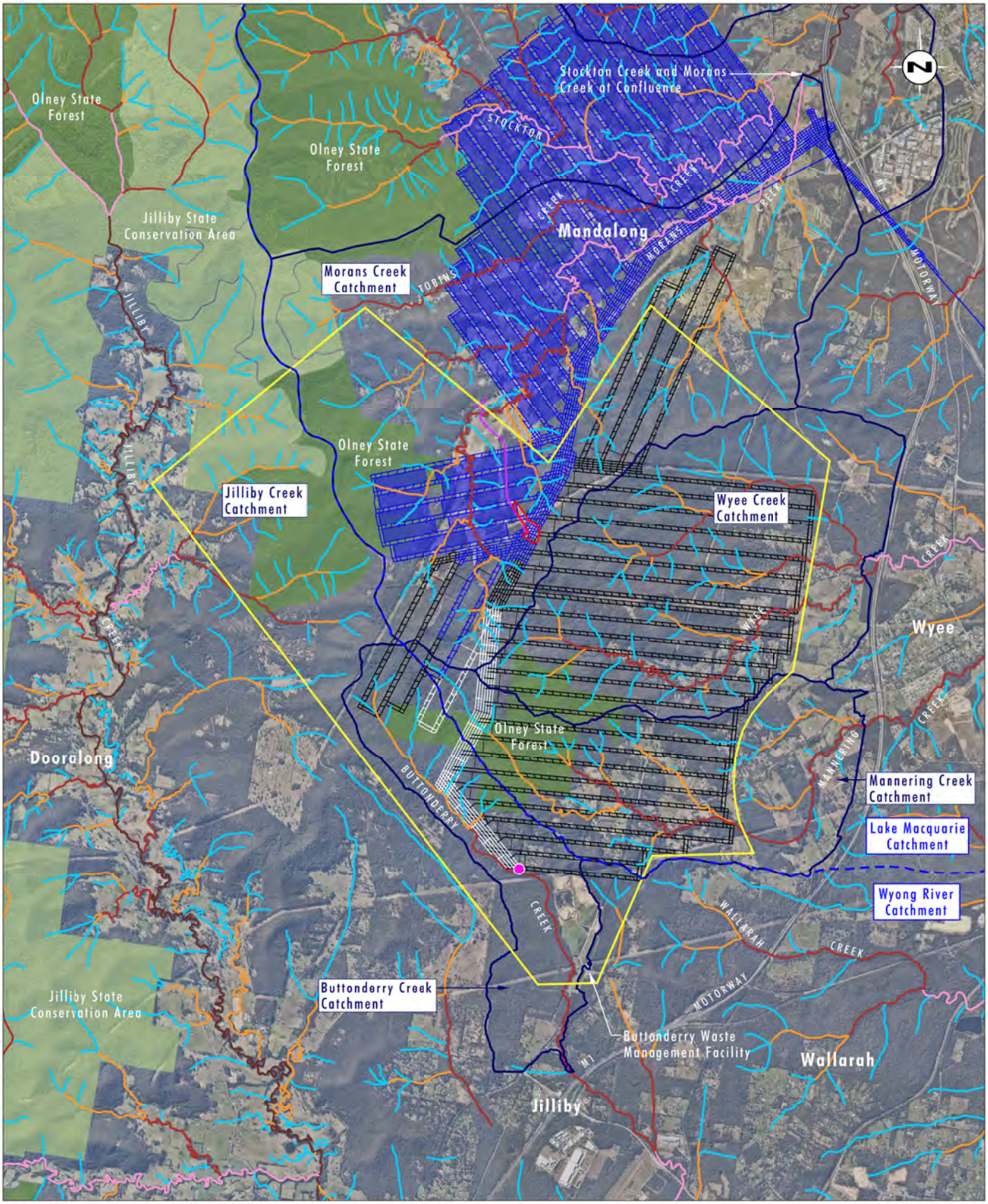


Image Source: Nearmap (Sep 2020)
Data Source: Cenntenial Mandalong (2021), LPI (2019)

0 1 2 3km
1:70 000

Legend

- Project Area
- Sub-catchment Boundary
- Completed Mine Workings
- Approved Longwalls
- Proposed Longwalls
- Surface Infrastructure
- Access Road
- State Forest
- Conservation Area
- Catchment Boundary
- Approximate Location of Observed Ponding

Stream Order:

- 1st Order
- 2nd Order
- 3rd Order
- 4th Order
- 5th Order

FIGURE 3.1

Watercourses and Catchments

File Name (A4): R01/21540_003.dgn
20210812 13.50

3.2.1 Mannering Creek

Mannering Creek, a third order watercourse within the Project Area (refer to **Figure 3.1** and **Figure 3.2**; Watercourse 4), is located in the Lake Macquarie catchment and generally flows in an easterly direction (refer to Figure 3.1) before being intercepted upstream of Mannering Dam east of Wyee and diverted into Wyee Creek to the north by way of a diversion drain. The diversion is intended to prevent the flow of clean water into the Mannering Lake, which is currently used as an ash dam for Vales Point Power Station.

Approximately 639 ha (65% of the total catchment area) of Mannering Creek lies within the Project Area (Umwelt, 2013). Catchment elevations range from 260 metres Australian Height Datum (mAHD) within the southern sections of the catchment to 30 mAHD in the east of the Project Area.

The catchment of Mannering Creek ranges from well forested with medium to large trees, thin under scrub and minimal groundcover to areas largely cleared for use as livestock pasture. The forested areas are generally located within the upper catchment areas, including the location of the proposed MOD 10 LW34. Mannering Creek typically consists of well graded sands and gravels overlaying clays with occasional rock bars and minimal vegetation. Soil landscapes for Mannering Creek are discussed further in **Section 3.3**.

The headwaters of Mannering Creek (1st order watercourses) are generally above the mid-section of the proposed MOD 10 LW34. These 1st order streams are typically small and steep with very limited channel and overbank areas. The proposed LW34 will undermine a short reach of first order tributaries of Mannering Creek – refer to **Figure 2.1** and **Figure 3.1**.

There is a third order section of Mannering Creek within the Project Area to the east of LW34. At its nearest point, this third order section is 1.8 km east of the proposed LW34. As was the case in within the EIS prepared in 2013, Mannering Creek was not included in the hydraulic modelling, with assessment of watercourse impacts based on subsidence predictions.

3.2.2 Morans Creek

Morans Creek, a third order watercourse within the Project Area (refer to **Figure 3.1** and **Figure 3.2**; Watercourse 6), is located in the Lake Macquarie catchment and flows in an approximately north-easterly direction through the Project Area, before flowing into Stockton Creek approximately 4 km north of the Project Area and 0.3 km upstream of the Pacific Motorway (M1). Stockton Creek flows into Dora Creek west of Morisset, which flows into Lake Macquarie.

Approximately 1274 ha (43% of the total catchment area) of Morans Creek lies within the Project Area (Umwelt, 2013). Catchment elevations range from 260 metres mAHD within the southern sections of the catchment to 30 mAHD at the northern end of the Project Area.

Ponding areas, which occur after prolonged rainfall and/or flooding, were observed during a field survey in June 2011, primarily within second order tributaries of Morans Creek (refer to Umwelt, 2013 for further information). No scouring was observed along surveyed sections of Morans Creek during the June 2011 survey conducted by Umwelt as preparation for the 2013 EIS.

In contrast to the sections of Morans Creek in the vicinity of the approved Mandalong Mine to the north of the Project Area, the portion of the Morans Creek catchment area within the Project Area is predominantly well forested, with sandy soils and some rocks ranging in size up to approximately 200 mm in diameter (refer to Umwelt, 2013 for further information). Soil landscapes for Morans Creek are discussed further in **Section 3.3**.

The headwaters of Morans Creek (1st and 2nd order watercourses) are generally above the northern half of the proposed MOD 10 LW34. These 1st and 2nd order streams are typically small and steep with very limited channel and overbank areas. The proposed LW34 will undermine a short reach of first order tributaries of Morans Creek – refer to **Figure 2.1** and **Figure 3.1**.

There is a third order section of Morans Creek within the Project Area to the north of LW34 that is included the flood model domain, however, LW34 is outside the extent of the flood model domain - refer to **Figure 3.1** and **Figure 4.1**. The flood model domain is further discussed in **Section 4.1**.

3.2.3 Buttonderry Creek

Buttonderry Creek is a second order watercourse within the Project Area, (refer to **Figure 3.1** and **Figure 3.2**; Watercourse 5). Within the Project Area Buttonderry Creek flows in a southerly direction to the west of the Buttonderry Waste Management Facility, and then flows into the Wyong River approximately 6 km south of the Project Area. Approximately 505 ha (80% of the total catchment area) of Buttonderry Creek lies within the Project Area (Umwelt, 2013). The Buttonderry Creek catchment ranges in elevation from approximately 260 mAHD in the north to approximately 20 mAHD at the southern boundary of the Project Area, adjacent to the Buttonderry Waste Management Facility. Within the Project Area, the catchment is predominantly forested with a thick canopy of medium sized trees with minimal underbrush (refer to Umwelt, 2013 for further information).

Sections of Buttonderry Creek displayed evidence of scouring, including bank erosion and deposition of sandy sediments within the creek bed during the field survey in June 2011 conducted by Umwelt. Ponding was also observed within the main channel of Buttonderry Creek in the south of the Project Area during the June 2011 survey (refer to **Figure 3.1** and Umwelt, 2013 for further information). Soil landscapes for Buttonderry Creek are discussed further in **Section 3.3**.

The headwaters of Buttonderry Creek (1st order watercourses) are generally above the southern half of the proposed MOD 10 LW34. These 1st order streams are typically small and steep with very limited channel and overbank areas. The proposed LW34 will undermine a first and second order tributaries of Buttonderry Creek – refer to **Figure 2.1** and **Figure 3.1**.

There is a third order section of Buttonderry Creek near the southern limit of the Project Area approved workings - refer to **Figure 3.1** and **Figure 3.2**. At its nearest point, this third order section is 1.3 km south-east of the proposed LW34. As was the case in within the EIS prepared in 2013, Buttonderry Creek was not included in the hydraulic modelling, with assessment of watercourse impacts based on subsidence predictions.

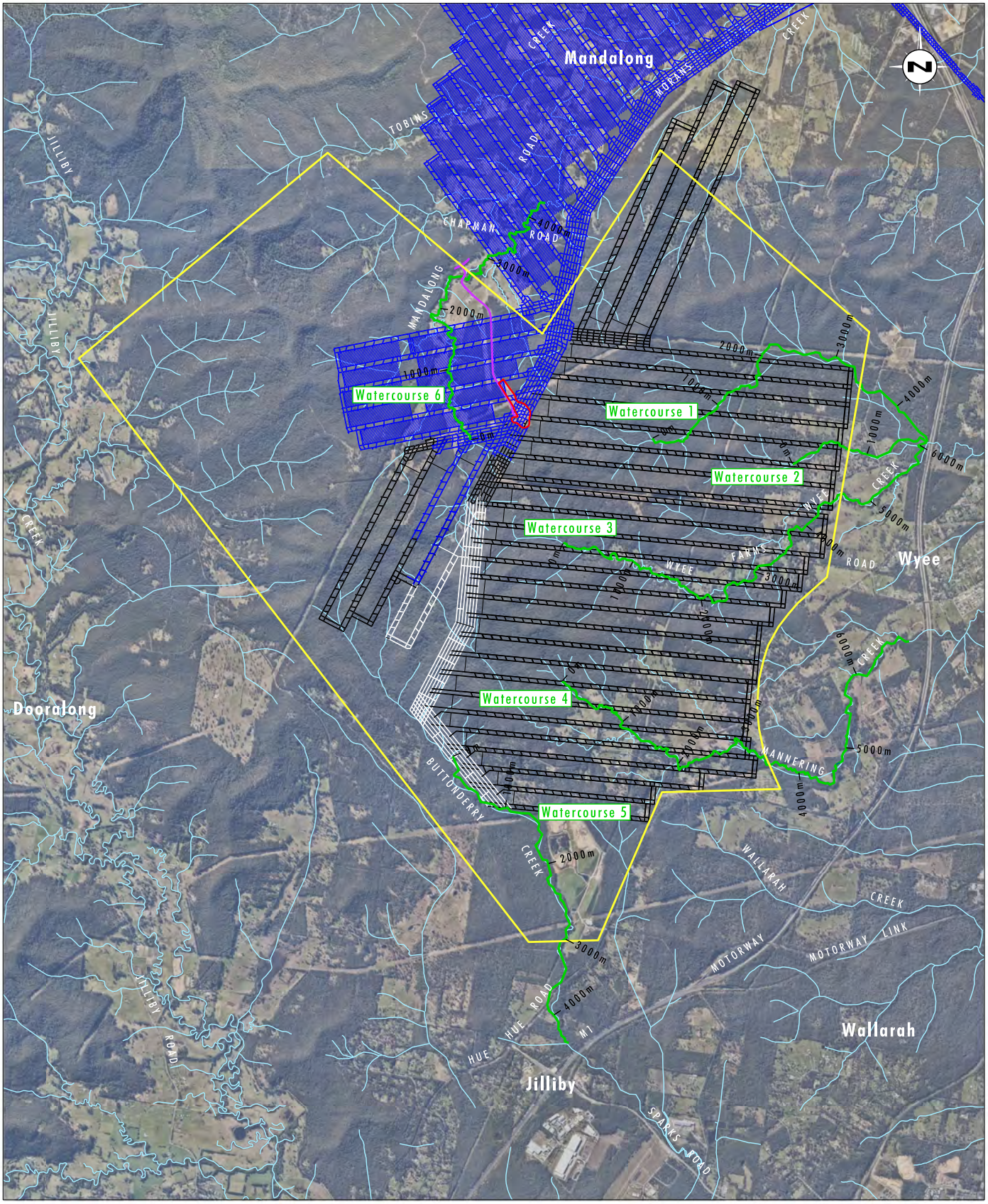


Image Source: Nearmap (Sep 2020)
Data Source: Centennial Mandalong (2021), LPI (2019)

0 1.0 2.0 2.5km
1:60 000

Legend

- Project Area
- Surface Infrastructure
- Completed Mine Workings
- Approved Longwalls
- Proposed Longwalls
- Access Road
- Drainage Line
- Watercourse Longsection Locations

FIGURE 3.2

Watercourse Extents and Locations within the Project Area

File Name (A4): R01/21540_004.dgn
20210812 13.21

3.3 Soil Landscapes

The Project Area typically includes seven soil landscapes (Department of Land and Water Conservation (DLWC) 1993), with the extents shown in **Figure 3.3** and the typical soil landscape properties summarised in **Table 3.1**. The upper slopes of the Project Area are predominantly Mandalong and Woodburys Bridge soil landscapes, with the footslopes predominantly Gorokan soil landscapes. The floodplain areas are typically Yarramalong, Wyong and Doyalson soil landscapes. All of the soils landscapes within the Project Area typically exhibit between moderate and very high erodibility, with a corresponding erosion hazard between slight to moderate and extreme (refer to **Table 3.1**). Erodibility describes the susceptibility of soil to mobilise as a result of rainfall and runoff, while erosion hazard describes the likelihood for erosion to occur within a given area.

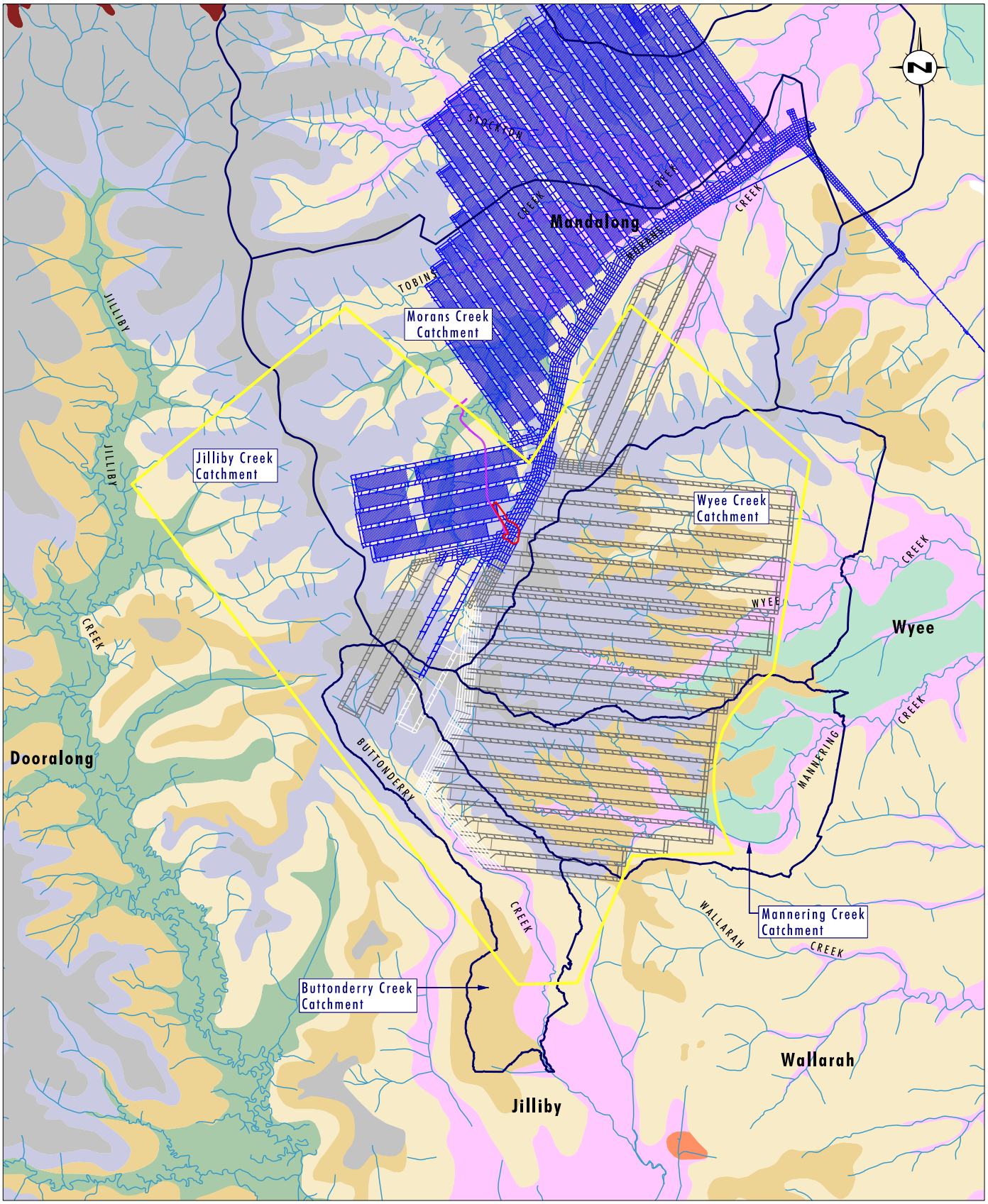
Table 3.1 Soil Landscapes in the Mandalong Southern Extension Project Area

Soil Landscape	Typical Terrain	Dominant Topsoil	Erodibility	Erosion Hazard[1]
Watagan	Hill tops	Friable dark brown loam (WN1[2]) Hardsetting yellowish brown sandy clay loam (WN2[2])	Very high	Extreme
Mandalong	Upper slopes	Hardsetting stony brown sandy clay loam (ML1[2])	Moderate to High	Very High
Woodburys Bridge		Dark brown pedal fine sandy loam (WO1[2])	Moderate	Moderate
Gorokan	Footslopes	Loose dark brown loamy sand (GK1[2])	High	Moderate to High
Yarramalong	Floodplains	Loose brown sands (YA1[2])	Moderate to High	Slight to High
		Brown pedal loam (YA2[2])	Moderate	Slight to High
Wyong		Brownish black pedal loam (WY1[2])	Moderate	Slight to Moderate
Doyalson		Brown loose loamy sand (DO1[2])	Moderate to High	Moderate

Note: [1]Erosion Hazard category for grazing conditions
[2]Source: Soil Landscapes for Gosford – Lake Macquarie, DLWC (1993)

The soil landscapes within the Morans Creek catchment include Watagan and Mandalong soil landscapes within upper slope areas, Gorokan soil landscapes within the footslope areas and Yarramalong and Wyong soil landscapes within the floodplain area (refer to **Figure 3.3**). The proposed northerly extension of LW33 is in an area that exhibits the Mandalong soil landscape within the upper slopes of the Morans Creek catchment.

The soil landscapes within the Buttonderry Creek catchment include Watagan, Mandalong and Woodburys Bridge soil landscapes within upper slope areas, Gorokan soil landscapes within the footslope areas and Wyong soil landscapes within the floodplain area (refer to **Figure 3.3**). The proposed LW34 is in an area that predominantly exhibits the Mandalong and Watagan soil landscapes.



Legend

- Project Area
- Sub-catchment Boundary
- Surface Infrastructure
- Completed Mine Workings
- Approved Longwalls
- Proposed Longwalls
- Access Road
- Drainage Line

Soil Landscapes:

- Disturbed Terrain
- Doyalson Soil Landscape
- Gorokan Soil Landscape
- Mandalong Landscape
- Sydney Town Landscape
- Watagan Landscape
- Woodburys Landscape
- Wyong Landscape
- Yarramalong Landscape

FIGURE 3.3

Soil Landscapes

File Name (A4): R01/21540_005.dgn
20210812 13.24

3.4 Flood Model Background and Pre-Mining Flood Regime

Hydrodynamics is the study of fluids in motion, and for this FIA an RMA-2 two-dimensional (2D) hydrodynamic flood model (also referred to as a 2D hydraulic flood model) has been employed to assess flood behaviour and watercourse stability for several design storm events (refer to **Appendix 1**).

This RMA-2 flood model was developed originally for the EIS in 2013 '*Surface Water Assessment – Mandalong Southern Extension Project*', Umwelt, August 2013).

The RMA-2 model was also employed in subsequent FIAs for the Mandalong South MOD 4 (Umwelt, 2016) and MOD 5 (Umwelt, 2017) associated with changes to longwalls 22 to 24A. Also the model was used for the FIA prepared for the Extraction Plan for LW25 to 31 (Umwelt, 2018). The most recent FIA using this model was for MOD 9 (Umwelt, 2020).

Watercourses of third order (as defined in Schedule 2) and higher with the potential to be impacted by subsidence are included in the RMA-2 model. In relation to MOD 10, Morans Creek has a third order section within the Project Area just north of the northern end of LW34 (refer to **Figure 3.1**). The upper reaches of Mannering Creek and Buttonderry Creek in the vicinity of LW34 are first order watercourses (i.e. Schedule 1) (refer to **Figure 3.1**). As such, Mannering Creek and Buttonderry Creek were not included in the hydraulic modelling, with assessment of watercourse impacts based on subsidence predictions, as was the case for these watercourses within the EIS prepared in 2013.

Morans Creek joins Stockton Creek about 0.3 km upstream of the Pacific Motorway (M1), as shown on **Figure 3.1**. The downstream limit of the Morans Creek hydraulic model domain is on Stockton Creek at the M1 motorway, approximately 1 km downstream of the most downstream Mandalong longwall LW1 (refer to **Figure 3.1**). The upstream boundary of the Morans Creek hydraulic model domain extends approximately 50 m into to the northern end of LW30 (refer to **Figure 4.1**).

The pre-mining landform serves as a reference for the approved and proposed landforms where appropriate. For the Mandalong Southern Extension Project, the pre-mining landform is defined as mining being completed for the original Centennial Mandalong operation (LW1 to 24A) with the landform fully subsided, and prior to mining in the Project Area (LW25 to 64).

Based on the adopted 2D hydrodynamic model, **Figure 3.4** illustrates the modelled peak 100 year Average Recurrence Interval (ARI) flood depths for pre-mining conditions in Morans Creek and **Figure 3.5** illustrates the modelled peak 1 year ARI flood depths for pre-mining conditions in Morans Creek. Flood hazard categories for pre-mining conditions within Morans Creek for the 100 year ARI flood event are included in **Figure 3.6**.

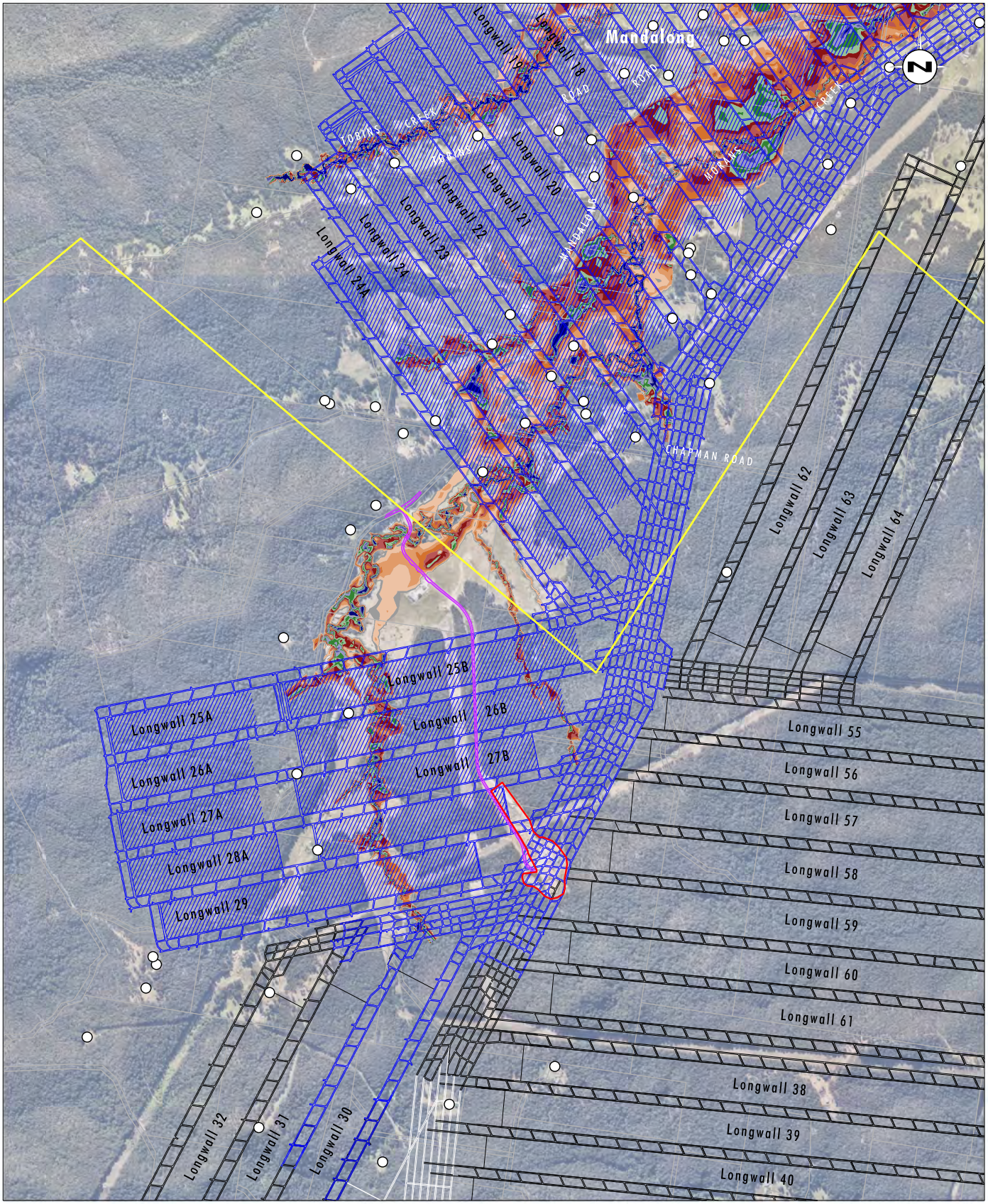


Image Source: Nearmap (Sep 2020)
Data Source: Centennial Mandalong (2021), LPI (2020)

0 0.5 1.0 1.25km
1:25 000

Legend

- Project Area
- Dwelling
- Surface Infrastructure Site
- Completed Mine Workings
- Approved Workings
- Proposed Workings
- Access Road
- Cadastre

Water Depth (metres)

- Range [0.001 : 0.100]
- Range [0.100 : 0.300]
- Range [0.300 : 0.500]
- Range [0.500 : 0.700]
- Range [0.700 : 0.900]
- Range [0.900 : 1.100]
- Range [1.100 : 1.300]
- Range [1.300 : 1.500]
- Range [1.500 : 1.700]
- Range [1.700 : 1.900]
- Range [>1.900]

FIGURE 3.4

100 year ARI Storm Event
Maximum Flood Depths for Morans Creek
(Pre-mining Landform)

File Name (A4): R01/21540_006.dgn
20210707 16.51

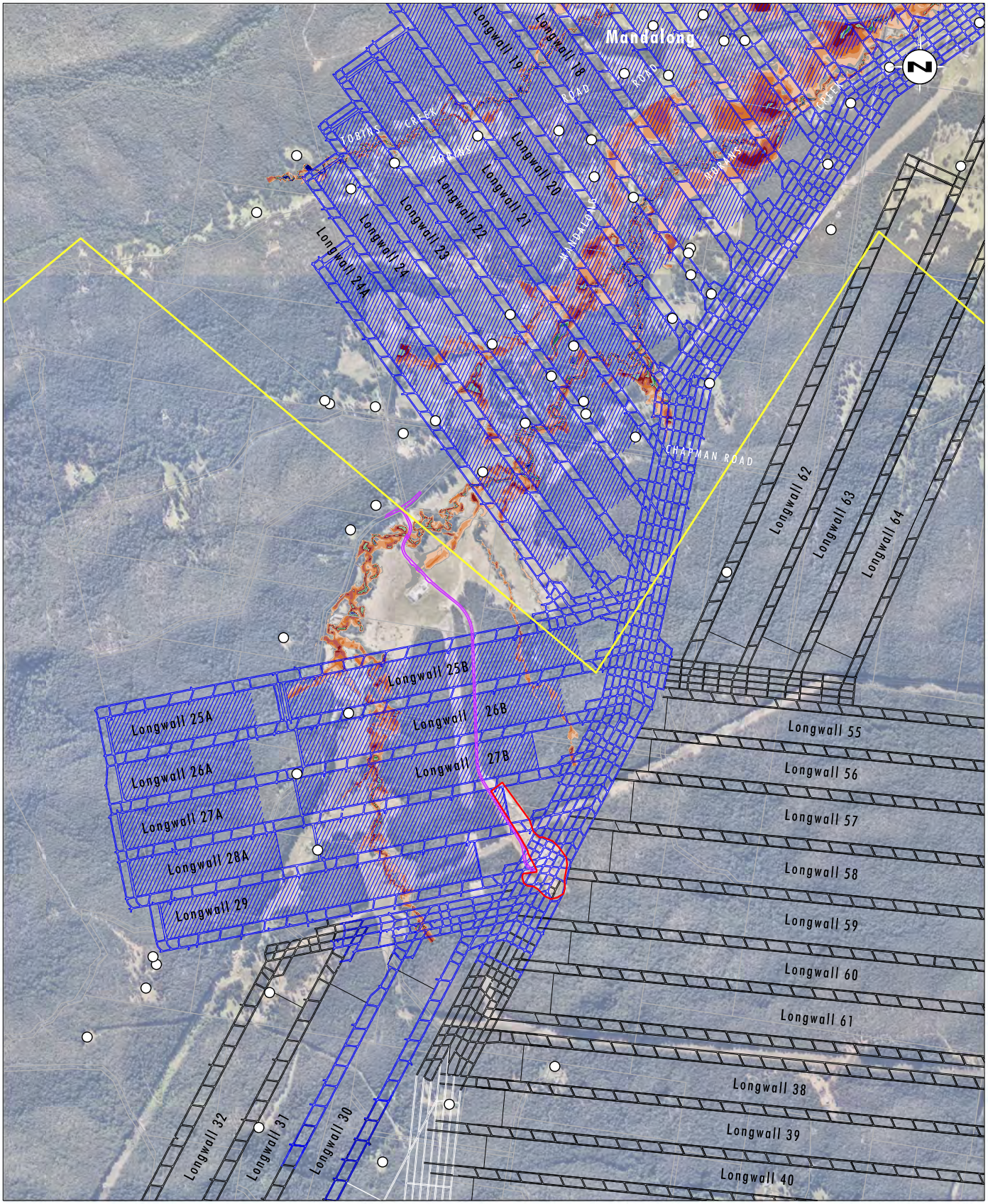


Image Source: Nearmap (Sep 2020)
Data Source: Centennial Mandalong (2021), LPI (2020)

0 0.5 1.0 1.25km
1:25 000

Legend

- Project Area
- Dwelling
- Surface Infrastructure Site
- Completed Mine Workings
- Approved Workings
- Proposed Workings
- Access Road
- Cadastre

Water Depth (metres)

- Range [0.001 : 0.100]
- Range [0.100 : 0.300]
- Range [0.300 : 0.500]
- Range [0.500 : 0.700]
- Range [0.700 : 0.900]
- Range [0.900 : 1.100]
- Range [1.100 : 1.300]
- Range [1.300 : 1.500]
- Range [1.500 : 1.700]
- Range [1.700 : 1.900]
- Range [>1.900]

FIGURE 3.5

1 year ARI Storm Event
Maximum Flood Depths for Morans Creek
(Pre-mining Landform)

File Name (A4): R01/21540_007.dgn
20210707 16.54

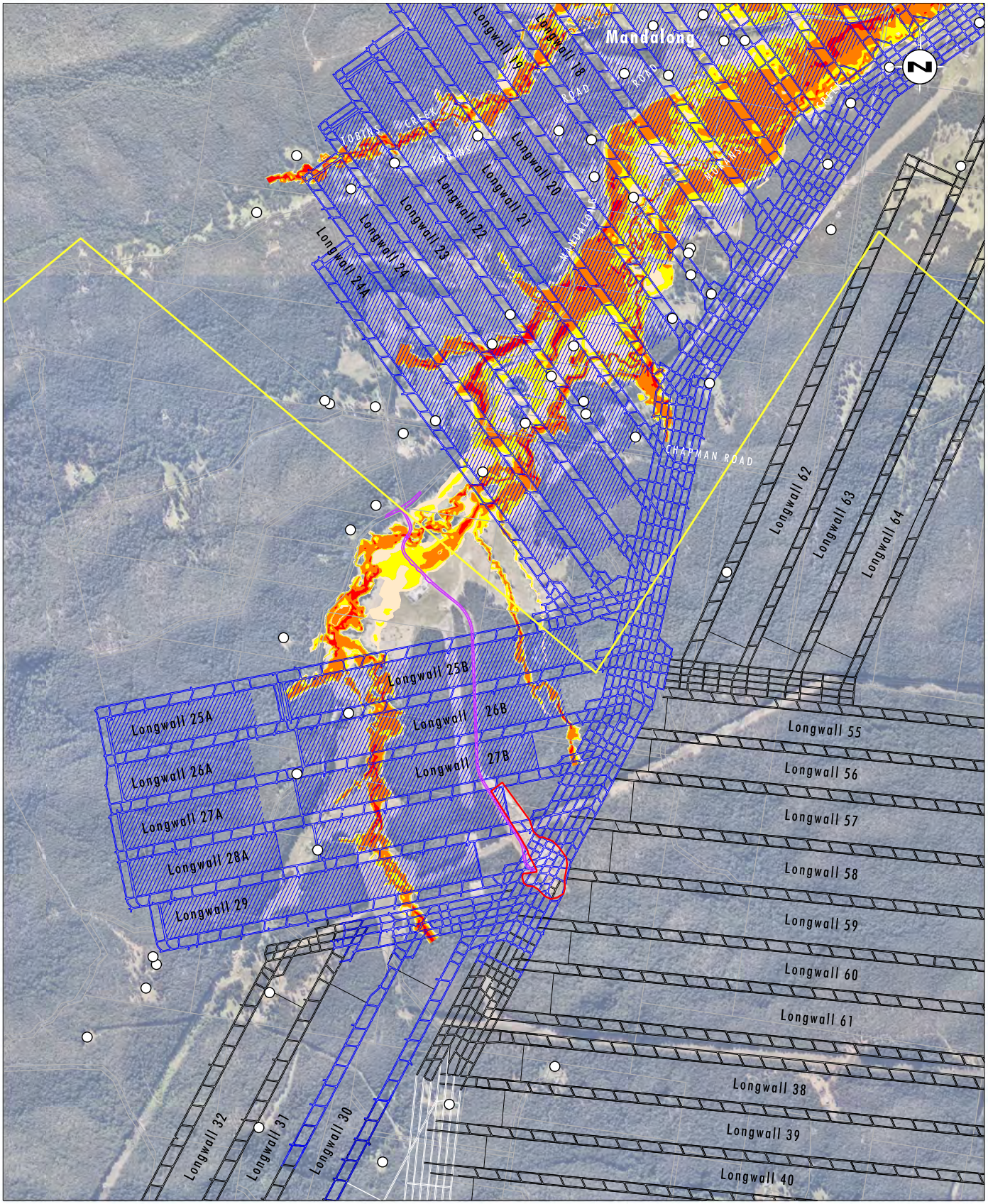


Image Source: Nearmap (Sep 2020)
Data Source: Centennial Mandalong (2021), LPI (2020)

0 0.5 1.0 1.25km
1:25 000

Legend

- Project Area
- Dwelling
- Surface Infrastructure Site
- Completed Mine Workings
- Approved Workings
- Proposed Workings
- Access Road
- Cadastre

Hazard Category

- Low Hazard - Unclassified hazard
- Low Hazard - Vehicles unstable
- High Hazard - Wading unsafe
- High Hazard - Damage to light structures

FIGURE 3.6

100 year ARI Storm Event
Maximum Flood Hazard Categories for Morans Creek
(Pre-mining Landform)

File Name (A4): R01/21540_008.dgn
20210708 10.20

4.0 Surface Water Impacts and Management Methods

This section of the FIA reviews the potential impacts of MOD 10 on surface water resources and the proposed management of any identified potential impacts. The assessment approach and methodology are discussed in **Appendix 1**.

The proposed landform has the potential to impact on the following:

- catchment area boundaries
- watercourse stability and associated water quality
- remnant ponding
- flood regimes.

The potential of each of these impacts and any proposed management methods are outlined in **Sections 4.1** to **4.7**.

4.1 RMA-2 Hydraulic Model – Relevant Factors

The RMA-2 hydraulic model is used to predict flood impacts and watercourse stability impacts related to the proposed MOD 10 mining operations and comparing these impacts to the approved MOD 9 to SSD-5144.

In relation to the RMA-2 hydraulic model domain, the potential impacts of MOD 10 relate to Mannering Creek, Morans Creek and Buttonderry Creek, as discussed below:

- **Mannering Creek** in the Lake Macquarie catchment. The headwaters of Mannering Creek (1st order watercourses) are generally above the mid-section of the proposed MOD 10, and these 1st order streams are typically small and steep with very limited channel and overbank areas.

  As shown in Umwelt (2013), the upstream limit of the Mannering Creek hydraulic model domain (3rd order watercourses and higher) is approximately 1.8 km east of the nearest point on the proposed longwall LW34. Given the 1.8 km distance, LW34 will not change the flood regime impacts for Mannering Creek identified in the MOD 9 FIA.

  As the watercourse (long section) analysis on Mannering Creek covers a 4 km length of 3rd order watercourse within the uppermost reach of the hydraulic model domain, LW34 will not change the watercourse stability impacts for Mannering Creek identified in the MOD 9 FIA.

- **Morans Creek** in the Lake Macquarie catchment. The headwaters of Morans Creek (1st and 2nd order watercourses) are generally above the northern half of the existing LW30-33, and these 1st and 2nd order streams are typically small and steep with very limited channel and overbank areas.

  For the RMA-2 model, the upstream limit of the Morans Creek hydraulic model domain (3rd order watercourses and higher) extends approximately 50 m into the northern end of LW30. However, LW34 is outside the RMA-2 hydraulic model domain (refer to **Figure 4.1**). A similar situation existed for the MOD 9 FIA. This indicates that MOD 10 will not change the flood regime impacts for Morans Creek identified in the MOD 9 FIA.

As the watercourse stability (long section) analysis on Morans Creek covers a 3.1 km length of 3rd order watercourse within the uppermost reach of the hydraulic model domain, LW34 will not change the watercourse stability impacts for Morans Creek identified in the MOD 9 FIA.

- **Buttonderry Creek** in the Wyong River catchment. The headwaters of Buttonderry Creek (1st order watercourses) are generally above the southern half of the proposed MOD 10, and these 1st order streams are typically small and steep with very limited channel and overbank areas.

  As shown in Umwelt (2013), the upstream limit of the Buttonderry Creek hydraulic model domain (3rd order watercourses and higher) is approximately 1.2 km east of the nearest point on the proposed longwall LW34. Given the 1.2 km distance, LW34 will not change the flood regime impacts for Buttonderry Creek identified in the MOD 9 FIA.

  As the watercourse (long section) analysis on Buttonderry Creek covers a 3.5 km length of 3rd order watercourse within the uppermost reach of the hydraulic model domain, LW34 will not change the watercourse stability impacts for Buttonderry Creek identified in the MOD 9 FIA.

  NOTE: Within the Project Area boundary, there is a 3rd order tributary of Jilliby Creek (in the Wyong River catchment) that is approximately 1.6 km west of the nearest point on the boundary of longwall LW33.
  This tributary was not examined in the MOD 9 FIA, and given the 1.6 km distance, it is also not considered necessary to examine this tributary in this assessment.

As described above, the MOD 10 proposal for LW34 does not materially impact the RMA-2 hydraulic model domain and associated model mesh. Accordingly, MOD 10 will not materially change the flood regime impacts nor the watercourse stability impacts for Mannering Creek, Morans Creek and Buttonderry Creek as approved under SSD-5144MOD 9.

4.2 Landform Changes

The proposed MOD 10 landform changes due to the proposed LW34 can potentially alter catchment boundaries and remnant ponding relative to the approved SSD-5144MOD 9.

For comparison to the proposed MOD 10 landform, the pre-mining landform in this FIA is unchanged from the Modification 9 FIA, and the approved landform is now based on the approved SSD-5144 Modification 9. In the MOD 9 FIA, the approved landform was based on the approved SSD-5144 Modification 5.

Further detail on the pre-mining, approved and proposed landforms used in this FIA is given below:

1. *Pre-mining landform* – refers to completed mining within the original Centennial Mandalong operations (LW1 to 24A) and prior to mining commencing in the Project Area (Mandalong Southern Extension Project).

   NOTE: As in the MOD 9 FIA, the pre- mining landform is based on observed subsidence for Longwalls 1 to 17 (captured in 2015 LiDAR) and previously predicted subsidence for Longwalls 18 to 24A. There is no subsidence for LW25 to 64 within the Project Area.

2. *Approved landform* – refers to approved predicted subsided landform for the Project Area applicable to SSD-5144 MOD 9, i.e. the pre-mining landform with predicted subsidence for the Project Area (LW25 to LW64) as approved for SSD-5144 MOD 9.

   NOTE: The approved mining landform is based on observed total subsidence for LW1 to 25 (using 2020 LIDAR). As the 2020 LIDAR reflected partial subsidence for LW26 to 29, the pre-mining scenario was modified with the MOD 9 predicted subsidence for these longwalls. As the 2020 LIDAR reflected a non-subsided landform for LW30 to 33, the 2020 LIDAR was modified with the MOD 9 predicted subsidence for these longwalls. For areas outside the longwalls (i.e. not undermined), the 2020 LIDAR was used to define the proposed landform.

3. *Proposed landform* – refers to the predicted subsided landform as a result of MOD 10, i.e. the approved subsidence impacts as of SSD-5144 MOD 9 revised to include the longwall modifications listed in **Section 2.0**.

   NOTE: The proposed mining landform is based on observed total subsidence for LW1 to 25 (using 2020 LIDAR). As the 2020 LIDAR reflected partial subsidence for LW26 to 29, the pre-mining scenario was modified with the MOD 10 predicted subsidence for these longwalls. As the 2020 LIDAR reflected a non-subsided landform for LW30 to 33, the 2020 LIDAR was modified with the MOD 10 predicted subsidence for these longwalls. For areas outside the longwalls (i.e. not undermined), the 2020 LIDAR was used to define the proposed landform.

4.3 Catchment Areas

The predicted subsidence associated with the proposed landform has the potential to alter catchment boundaries that overlap the predicted subsidence area. Subsidence predictions for MOD 10 (Ditton Geotechnical Services, 2021a) indicate that the proposed underground mining will result in maximum predicted vertical subsidence of approximately 1.2 m in areas above LW34. The locations for the maximum subsidence of 1.4m are at LW30.

Catchment analysis for the proposed subsided landform indicates that the proposed MOD 10 catchment boundaries of the creek systems to be undermined will not change significantly relative to the existing approved subsided landform.

4.4 Watercourse Stability

Longwall subsidence within the Project Area has the potential to impact the physical characteristics and hydraulic response of flows within a watercourse. Subsidence can cause changes to the longitudinal grades which can impact flow velocities and tractive stresses at various locations.

An increase in longitudinal grade in the direction of flow (i.e. steeper grade) has the potential to promote scouring while a decrease in grade has the potential to promote ponding.

Changes to flow velocity and tractive stress during flood events can impact the stability of a watercourse, causing scouring, changes to channel geometry and/or rerouting of the watercourse. The potential for changes to velocity and tractive stress can be examined to identify locations that may require monitoring and ongoing management as mining progresses.

As discussed in **Section 4.1**, the MOD 10 proposal to include LW34 does not materially impact the RMA-2 hydraulic model domain nor the third order watercourses used for previous watercourse (long section) analysis on Mannering Creek, Morans Creek and Buttonderry Creek. Accordingly, MOD 10 will not materially change the watercourse stability impacts for Mannering Creek, Morans Creek and Buttonderry Creek identified for the approved SSD-5144 MOD 9.

Notwithstanding, the location of potential scouring and ponding identified previously in the MOD 9 FIA should be included in any ongoing watercourse monitoring program and may require remediation works. This typically applies to Morans Creek, as the MOD 9 FIA indicates that proposed changes in the Mannering Creek and Buttonderry Creek longitudinal grade are negligible compared to the pre-mining landform.

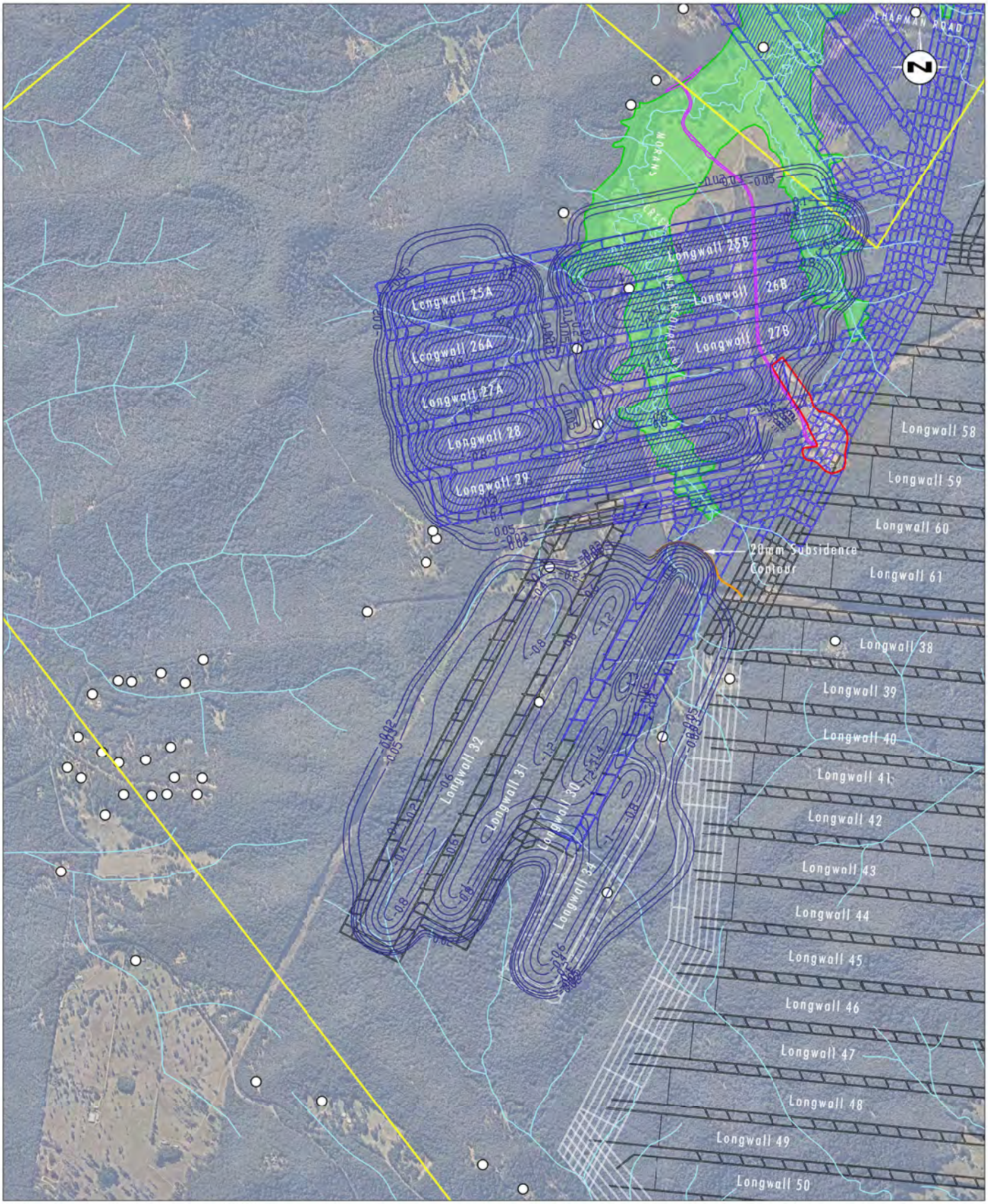


Image Source: Nearmap (Sep 2020)
Data Source: Centennial Mandalong (2021), LPI (2020)

0 0.5 1.0 1.25km
1:25 000

Legend

- Flooding Assessment Project Area
- Dwelling
- Surface Infrastructure Site
- Completed Mine Workings
- Approved Longwalls
- Proposed Longwalls
- Access Road
- Predicted Subsidence Contours
- RMA2 Model Extent
- Drainage

FIGURE 4.1

Predicted Subsidence Extent

File Name (A4): R01/21540_009.dgn
20210708 10.42

4.5 Remnant Ponding

The proposed landform has the potential to cause or increase remnant ponding (ponding that occurs after prolonged rainfall and/or flooding) within the area affected by subsidence. **Figure 4.2** shows remnant ponding for the proposed landform compared to the approved landform and the pre-mining landform.

> *NOTE: In **Figure 4.2**, the proposed scenario is the bottom layer in the drawing, with the pre-mining scenario being on a layer above, and the approved scenario is the top layer.*

Remnant ponding for the proposed landform is based on the predicted subsided landform associated with the new mine plan that includes proposed LW34. As discussed in **Section 4.2**, subsidence impacts to remnant ponding for the approved (MOD 9) and proposed (MOD 10) landforms use observed total subsidence for LW1 to LW25 (based on recent LIDAR dated 5 April 2020) and the relevant predicted subsidence for LW26-34 (MOD 9 - DGS, 2020a; MOD 10 – DGS, 2021a).

> *NOTE: Mining of LW25 was completed on 17 September 2019, and recent LIDAR captured on 5 April 2020 will therefore reflect full subsidence for all LW1 to LW25. LW26 mining was completed on 6 March 2020 and the recent LIDAR will exhibit partial subsidence for LW26, hence predicted subsidence has been used for LW26 to LW34 (MOD 9 and MOD 10). Previously predicted subsidence for the higher numbered longwalls within the Project Area is unchanged.*

Analysis of remnant ponding for the proposed landform compared with remnant ponding for the approved landform indicates:

- Remnant ponding is typically confined to existing flow paths (refer to **Figure 4.2**)
- Negligible change in remnant ponding:
  - Along Mannering Creek and Morans Creek.
- Minor increases in remnant ponding:
  - Along Buttonderry Creek.

As discussed in the SWIA Umwelt (2013), analysis indicates that the total remnant ponding area for the pre-mining landform within the Project Area is approximately 128 ha. Of this total area, the remnant ponding area for the pre-mining landform within the catchments of Mannering Creek, Morans Creek and Buttonderry Creek is 16 ha. Within LW30 to 34, the remnant ponding for the pre-mining landform is 4.88 ha. **Table 4.1** presents a comparison of the remnant ponding within the subsidence affected area for the pre-mining, approved and proposed landforms.

Table 4.1 Changes in Remnant Ponding for Mannering Creek, Morans Creek and Buttonderry Creek within the Subsidence Affected Area

Landform	Total area of predicted remnant ponding within LW25-34 (ha)	Change in area from Approved – within LW25-34 (ha)
Approved – Modification 9	9.28	-
Proposed - Modification 10	9.29	0.01 (<1%)

As can be seen in **Table 4.1**, an assessment of the proposed landform indicates changes to remnant ponding in the area to be undermined as follows:

- Compared to the approved scenario, a slight increase in total remnant ponding area of 0.01 ha is predicted (i.e. less than 1%)

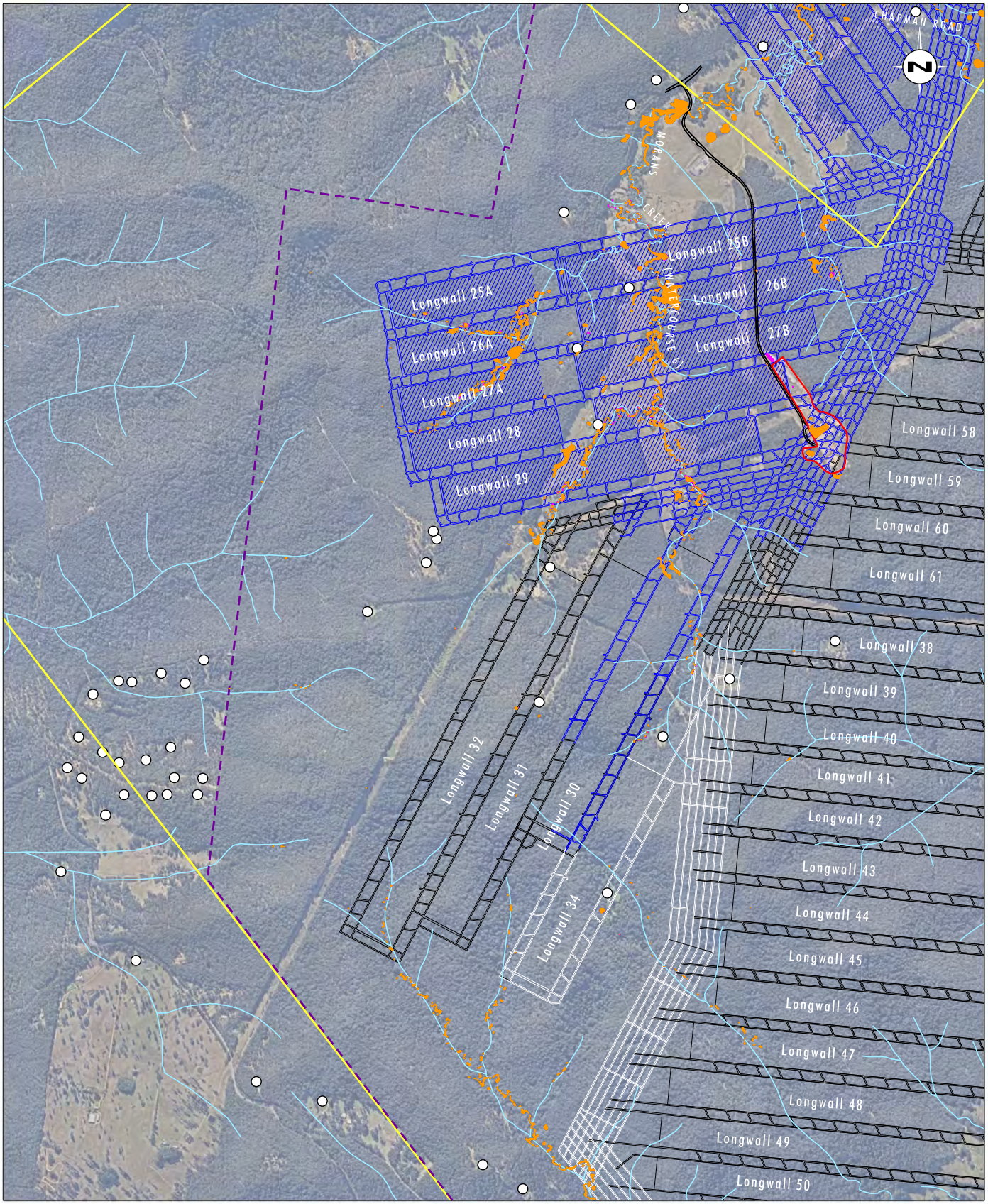


Image Source: Nearmap (Sep 2020)
Data Source: Centennial Mandalong (2021), LPI (2020)

0 0.5 1.0 1.25km
1:25 000

Legend

- Flooding Assessment Project Area
- Dwelling
- Surface Infrastructure Site
- Completed Mine Workings
- Approved Longwalls
- Proposed Longwalls
- Limit of 2020 LiDAR Extent
- Access Road
- Ponding Areas (Approved Mining Scenario)
- Ponding Areas (Proposed Mining Scenario)
- Drainage

FIGURE 4.2

Proposed Remnant Ponding (Modification 10)

File Name (A4): R01/21540_010.dgn
20210812 13.33

The analysis indicates that potential impacts on remnant ponding are confined to existing flow paths, with no predicted impact on access routes to, or within, properties (and residences) within the Project Area. Slight increases to remnant ponding areas are predicted compared to the approved scenario in the area where LW34 has been revised (refer to **Figure 4.2**).

Compared to the pre-mining scenario, the majority of the change in the area of remnant ponding is a result of the different LiDAR dataset and extent used for the approved and proposed mining landforms (relative to the pre-mining landform).

As discussed in **Section 4.2**, the pre-mining landform is based on observed subsidence for Longwalls 1 to 17 (captured in 2015 LiDAR) and previously predicted subsidence for Longwalls 18 to 24A. There is no subsidence for LW25 to 64 within the Project Area. Further, the approved mining landform (MOD 9) and the proposed mining landform (MOD 10) are based on observed total subsidence for LW1 to 25 (using 2020 LIDAR), and the relevant predicted subsidence for LW26 to 34. Hence, the different LiDAR dataset and extent used for the approved and proposed mining landforms is responsible for a majority of the change in the area of remnant ponding (relevant to the pre-mining landform).

4.6 Summary of Watercourse Impacts

As discussed in **Section 4.1**, it is predicted that MOD 10 will not materially change the watercourse stability impacts for Morans Creek and Buttonderry Creek identified for the approved SSD-5144 Modification 9.

Notwithstanding, the location of potential scouring and ponding identified previously in the MOD 9 FIA should be included in any ongoing watercourse monitoring program. Watercourse stabilisation works should be undertaken if increased bed and bank scouring is observed during monitoring of subsidence and watercourse stability (refer to **Sections 5.1** and **5.2**).

For the proposed subsided landform, compared to the approved landform, there will be a negligible change to remnant ponding. Overall, the total area of remnant ponding is predicted to be similar to the approved landform, and over LW30 to 34 there is a predicted to be a slight increase in the predicted remnant ponding areas – refer to **Table 4.1**.

Drainage mitigation works should be undertaken if increases in remnant ponding are identified during monitoring of subsidence and watercourse stability (refer to **Sections 5.1** and **5.2**).

4.7 Flood Regime

A potential consequence of the predicted subsidence is a change to the flood regime (flood behaviour and flood extent), both within the Project Area and the surrounding areas. **Section 3.4** describes the pre-mining flood regime.

As discussed in **Section 4.1**, MOD 10 subsidence is not expected to impact the RMA-2 hydraulic model domain and associated model mesh. Accordingly, it is predicted that MOD 10 will not materially change the flood regime impacts (depth, extent, velocity, duration or hazard) for Morans Creek and Buttonderry Creek identified for the approved SSD-5144 MOD 9. This includes there being no change to 100 year ARI flood depths for the four (4) dwellings identified in the MOD 9 FIA as having a footprint that is wholly or partially within the 100 year ARI flood extent (Dwelling IDs 70A, 85, 90, 219).

As discussed in **Section 4.1**, it is predicted that MOD 10 will not materially change the flood regime impacts (depth, extent, velocity, duration or hazard) for Morans Creek and Buttonderry Creek identified for the approved SSD-5144 MOD 9. Consequently, no impacts to the functionality of roads and transport are expected as a result of the proposed landform.

4.8 Annual Flows, Environmental Flows and Downstream Users

The watercourses within the Project Area do not have a long-term persistent baseflow. Their ephemeral nature is reflected in small flows during dry periods and cease to flow during drought periods.

As discussed in **Sections 0** and **4.7**, MOD 10 does not materially impact the RMA-2 hydraulic model domain and associated model mesh. Accordingly, it is predicted that MOD 10 will not materially change the flood regime impacts nor the watercourse stability impacts for Morans Creek and Buttonderry Creek identified for the approved SSD-5144 MOD 9. As such, MOD 10 is not expected to impact streamflow conditions within these watercourses (flow rates, annual flow volumes and baseflows).

As a result of the very limited potential for changes to water quantities, including annual flow volumes, baseflows and environmental flows, downstream users are unlikely to experience significant changes to water availability due to MOD 10.

Overall, it is considered that MOD 10 will not result in adverse cumulative impacts on water use or flows within the Project Area or surrounding areas.

4.9 Proposed Monitoring and Remediation Protocols

It is not expected that MOD 10 will materially change the flood regime impacts nor the watercourse stability impacts for Mannering Creek, Morans Creek and Buttonderry Creek identified for the approved SSD-5144 MOD 9.

Taking into consideration the existing surface water regime, associated topography and previous experience at Mandalong, it is considered likely that only minor remediation works will be required in the future, consisting essentially of standard erosion protection/remediation measures (refer to **Section 4.9.1**).

As outlined in the MOD 9 FIA, a comprehensive monitoring regime should be implemented to monitor major drainage lines for potential subsidence impacts. The location of potential scouring and ponding identified previously in the MOD 9 FIA should be included in any ongoing watercourse monitoring program.

Watercourse stabilisation works should be undertaken if increased bed and bank scouring is observed during monitoring of subsidence and watercourse stability (refer to **Sections 5.1** and **5.2**).

Due to the steepness of the catchment areas and surrounding topography, as well as the substantial vegetation, it is not considered practical to divert runoff from upstream catchment areas around potentially impacted areas of streams. As such, it is proposed that all remediation works are managed in stream.

Remediation measures and procedures for drainage lines within the Project Area will be detailed in the Extraction Plan and will be implemented as required and refined where necessary based on performance experience. These measures and procedures may include, but are not limited to:

- monitoring of vertical and horizontal subsidence along second and third order drainage lines as determined in consultation with DPIE, formerly Department of Industry (Water) (DOI - Water)
- visual inspection and recording (including photographic records at least every 50 m) of stream bed and bank condition and riparian vegetation along second and third order drainage lines, including collection of baseline data and monitoring during mining and in the post- mining phase
- erosion and sediment controls
- soil stabilisation measures, where appropriate

- revegetation techniques and maintenance
- velocity reduction controls

4.9.1 Erosion and Sediment Controls

Any necessary subsidence remediation works will require suitable erosion and sediment controls, both as remediation and as future protection. All erosion and sediment control measures should be carried out in accordance with the relevant guidelines for erosion and sediment control, including:

- Managing Urban Stormwater Soils and Construction (the Blue Book) Volume 1 (Landcom 2004) and Volume 2C Unsealed Roads (Department of Environment and Climate Change (DECC) 2008)
- where relevant, to a standard consistent with Draft Guidelines for the Design of Stable Drainage Lines on Rehabilitated Mine Sites in the Hunter Coalfields (DIPNR, undated).

Where subsidence remediation works associated with MOD 10 are required, the general erosion and sediment control principles to be incorporated into the construction of the works include:

- construction of relevant erosion and sediment controls prior to the commencement of any substantial construction works
- construction and regular maintenance of sediment fences downslope of disturbed areas
- use of soil amelioration/stabilisation methods where appropriate
- repair to or replacement of riparian vegetation along second and third order drainage lines where required
- seeding and controlled fertilising of disturbed areas to provide for rapid grass cover. Areas will be seeded with a grass mix specific to the needs of the area to be grassed
- regular inspection of all works and immediately following rainfall events of a magnitude sufficient to generate runoff to ensure erosion and sediment controls are performing adequately
- provision for the immediate repair or redesign of erosion and sediment controls which are identified as not performing adequately.

In addition to the above erosion and sediment control measures, construction plans will detail the specific inspection, maintenance and revegetation requirements for each work area where subsidence remediation works are required.

4.10 Summary of Impacts

The potential impacts of the Mandalong Southern Extension Project on flooding have been minimised by the iterative process Centennial Mandalong has undertaken over time to develop mine designs that minimise potential impacts on surface waters, including catchment areas, watercourse impacts, flood regimes, regional infrastructure and annual flows.

An assessment of the predicted MOD 10 subsidence impacts, as described in **Section 3** indicates that the catchment boundaries of the creek systems to be undermined will not change significantly for the proposed landform relative to the approved SSD-5144 MOD 9 landform.

The existing environment has already undergone scouring and sediment transport as a result of constructed features, including culverts and bridges, however any further scouring may further increase sediment transport and degrade water quality. Monitoring of watercourses within the impacted area and the implementation of appropriate mitigation measures is proposed to reduce the potential for additional scouring. If subsidence remediation works are required, erosion and sediment control measures should be included to assist in remediation and to minimise impact to downstream water quality. As discussed in **Section 4.4**, it is not expected that MOD 10 will materially change the watercourse stability impacts for Mannering Creek, Morans Creek and Buttonderry Creek identified for the approved SSD-5144 MOD 9.

The potential for change to remnant ponding or storage of surface runoff is considered minimal for MOD 10. In fact, as shown in **Table 4.1** and discussed in **Section 4.5**, the MOD 10 proposed landform remnant ponding is essentially unchanged relative to the approved SSD-5144 MOD 9. There is a negligible change in remnant ponding area associated with LW34

Although MOD 10 is not expected to result in any material change to potential scouring and ponding relative to the SSD-5144 Modification 9 approved landform, as outlined in the MOD 9 FIA, a comprehensive monitoring regime should be implemented to monitor major drainage lines for potential subsidence impacts. The location of potential scouring and ponding identified previously in the MOD 9 FIA should be included in any ongoing watercourse monitoring program. These locations should be monitored in addition to those identified within the 2013 SWIA for all six watercourses within the Project Area (Umwelt, 2013).

It is not expected that the predicted MOD 10 subsidence will materially change the flood regime impacts (depth, extent, velocity, duration or hazard) for Morans Creek and Buttonderry Creek identified for the approved SSD-5144 Modification 9. No changes are anticipated to 100 year ARI flood depths for the four (4) dwellings identified in the MOD 9 FIA as having a footprint that is wholly or partially within the 100 year ARI flood extent (Dwelling IDs 70A, 85, 90, 219).

As discussed in **Section 4.8**, there is not expected to be any change to the functionality of roads and transport as a result of the MOD 10 proposed landform relative to the SSD-5144 MOD 9 approved landform.

The watercourses within the Project Area do not have a long-term persistent baseflow. Their ephemeral nature is reflected in small flows during dry periods and cease to flow during drought periods. As discussed in **Section 4.8**, MOD 10 is not expected to change streamflow conditions within these watercourses (flow rates, annual flow volumes and baseflows) relative to the SSD-5144 MOD 9 approved landform.

As a result of the very limited potential for changes to water quantities, including annual flow volumes, baseflows and environmental flows, downstream users are unlikely to experience significant changes to water availability due to MOD 10.

Overall, it is considered that MOD 10 will not result in adverse cumulative impacts on water use or flows within the Project Area or surrounding areas.

5.0 Monitoring, Licensing and Reporting

5.1 Subsidence Monitoring

Centennial Mandalong will develop and implement an Extraction Plan for LW34 and will include inspections of second order and higher watercourses proposed to be undertaken on a regular basis to assess whether watercourses within the subsidence affectation zone are adversely impacted by remnant ponding and scouring, and to thereby determine appropriate remediation works.

Relative to the SSD-5144 MOD 9 approved landform, it is considered that the MOD 10 proposed subsided landform will have only a minor impact on predicted remnant ponding or drainage realignment within the Project Area.

The MOD 9 FIA identified locations where drainage line grades will increase relative to the pre-mining landform, and monitoring locations were identified. If monitoring identifies that remediation works are required, remediation works should consider channel characteristics, including channel grades, and channel stabilities.

If remediation works are necessary, they have the potential to generate short term impacts on water quality while the remediation works are being undertaken and stable vegetated landforms are being established. Potential water quality impacts for downstream water users and ecosystems relate to increased sediment generation and export of sediment off site. To mitigate the potential impact, erosion and sediment control measures should be implemented as required (refer **Section 4.9.1**), as part of the ongoing monitoring and remediation works.

5.2 Watercourse Stability Monitoring

Centennial Mandalong proposes to monitor watercourses within and near to the undermined area.

Monitoring will commence immediately prior to the undermining of the areas and continue through the post-mining period, with additional inspection of the monitoring locations following rainfall events of a magnitude sufficient to generate runoff (an appropriate rainfall trigger will be identified during the preparation of the monitoring program). Annual watercourse stability reports are to be prepared with the key findings reported in Mandalong's Annual Review. Monitoring will include:

- monitoring of any bed control points
- monitoring of areas where subsidence may increase the erosive potential above the determined threshold limits potentially causing channel erosion/instability
- the use of long section and cross section surveys, photographic records and/or methods outlined in Australian Rivers Assessment System (AUSRIVAS) (eWater CRC, 1994).

5.3 Erosion and Sediment Controls for Remediation Works

Where subsidence remediation works are required, the design and implementation of such works should incorporate erosion and sediment controls that will be monitored during the works period in accordance with the Blue Book (Landcom 2004 and DECC 2008), including regular inspections and inspection after rainfall events causing runoff (refer **Section 4.9.1**).

5.4 Reporting

Results from the proposed monitoring programs (refer **Sections 5.1** to **5.3**) are to be reported in the Annual Review and made available to the public on the Centennial Mandalong website.

6.0 References

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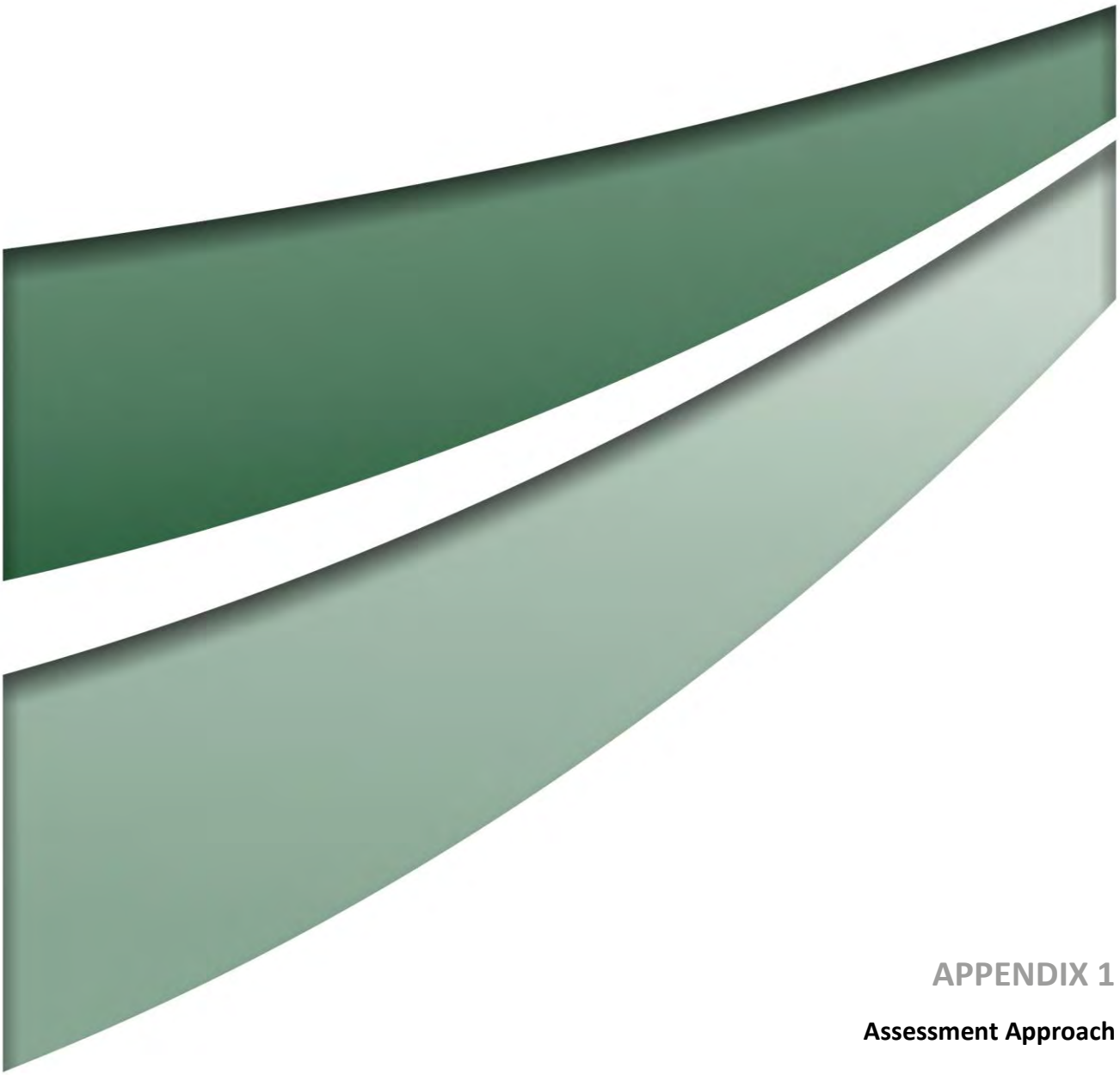
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APPENDIX 1

Assessment Approach

A1.1 Subsidence Predictions

Subsidence predictions for the mine plan applicable to the proposed modification (MOD 10) were provided by Ditton Geotechnical Services Pty Ltd. The predicted subsidence was used to 'subside' the digital terrain model (DTM) that was developed for the Project Area using aerial LiDAR survey (ALS) data. The subsided DTM then reflects the potential subsidence for the local terrain (proposed landform). Similarly, relevant subsidence predictions and DTMs reflect the local terrain for the approved landform and pre-mining landform. Relevant DTMs incorporate total observed (actual) subsidence where suitable LIDAR topographic data is available for previously undermined areas.

A1.2 Modelling Methodology

Two dimensional (2D) hydrodynamic modelling (RMA-2 software) is used where it is necessary to estimate the potential surface water impacts of underground mining and the related subsidence of the ground surface. Typically, the modelling compares flood behaviour for the pre-mining landform, approved landform and proposed landform.

The 2D hydrodynamic RMA-2 model uses a finite element mesh to describe the terrain of the modelled area at a variable resolution, suitable to capture the hydraulically important details. The finite element mesh typically consists of nodes (points) that describe a detailed network of triangular elements. The nodes are locations where the various 2D hydraulic equations are computed for each time step, which can then be interpolated across the mesh elements to provide a highly detailed estimate of the flood response of a floodplain. The RMA-2 software package is typically applied to large and broad floodplains.

A 2D hydrodynamic RMA-2 model was previously developed for Morans Creek (and other creeks) as part of the *Mandalong Valley Flood Study* (Hughes Truman 2004). That 2D model has been used for subsequent surface water assessments and ongoing subsidence management plans covering these creeks (e.g. Umwelt 2012, 2013, 2016, 2017, 2018 and 2020). The latest modelling (Umwelt, 2020) assessed potential subsidence impacts on the flood flows within Morans Creek for Modification 9.

A high resolution DTM provides the essential information to define the topography across the model mesh for the different landform scenarios (i.e. pre-mining, approved and proposed). The 2D hydrodynamic model is used to estimate the flood response for pre-mining conditions and to also predict the flood response for the approved subsided landform and the proposed subsided landform.

Specifically, the 2D hydrodynamic model is used to estimate the flood response of watercourses within the Project Area and to identify any potential downstream impacts, typically for four design flood events, including:

- approximate bank-full event, typically the one or two year average recurrence interval (ARI) design event (1 year ARI event is normally used);
- 10 year ARI design event
- 20 year ARI design event, and
- 100 year ARI design event.

ARI refers to the long term average interval (in years) between occurrences of a design storm of a specific magnitude or greater. For example, a 10 year ARI storm is expected to occur on average every 10 years assuming a sufficiently long observation period (of the order of several hundred years). This does not mean the event will occur once every 10 years, and in fact such events tend to cluster within flood dominated periods as a result of large-scale climate cycles.

The bank full flood event, defined as the design flood event that results in flow depths that are approximately equal to the top of bank of a watercourse, are used for the estimation of the potential changes to velocities and tractive stresses (largely dependent on velocity) within the main watercourse channel sections. The estimation of tractive stress within the modelled watercourses allows for the determination of locations which have the potential to undergo increased erosion or scouring as a consequence of the changes to the watercourses.

The outputs of the flood model are used to generate flood maps and graphs, which allow for comparison of the pre-mining, approved and proposed landform flood depths, velocities and flood hazard categories. The flood model also allows for the estimation of potential changes to tractive stresses within each watercourse during approximately bank full flows.

A1.2.2 Remnant Ponding

Remnant ponding refers to the areas which retain surface water for an extended period following a rainfall event. They are typically local depressions which do not gravity drain, i.e. not free draining. Subsidence has the potential to alter the existing pattern of remnant ponding, potentially impacting on the existing amenity of properties, including farm dams, pasture areas and access routes. The changes to remnant ponding can also impact existing ecosystems.

The potential changes to the pattern of remnant ponding are estimated using a high resolution DTM and predicted subsidence for the relevant landform scenario, as well as Geographic Information System (GIS) tools that identify areas within the DTMs that are not free draining. It should be noted that the remnant ponding analysis does not include minor drainage structures, such as subsurface drains, that may be in place to alleviate local ponding issues.

A1.2.3 Watercourse Stability

The 2D hydrodynamic model results provide information to assess potential changes to the bed and bank stability of the modelled watercourses in response to the predicted subsidence. Changes to the landform as a result of predicted subsidence can result in changes to flow velocities and tractive stresses within a watercourse, which can change the existing pattern of erosion and deposition within a watercourse.

The potential impact of changes to modelled velocities and tractive stresses on the stability of a watercourse are estimated using stability thresholds. The stability thresholds allow for flows to be categorised as stable, marginally stable or unstable. The thresholds depend on bed and bank material and vegetation coverage.

Based on the observations from previous field inspections (Umwelt, 2013), bed materials appear to range from graded loam to fine gravels and cobbles. The thresholds for tractive stress and flow velocity shown in **Table A1.2** have therefore been selected as indicative thresholds for determining the stability state of relevant watercourses.

Table A1.2 Permissible Tractive Stress and Velocity Thresholds for graded loam to fine gravels to cobbles, Adapted from Fischenich (2001)

Flow Metric	Stable	Marginally Stable	Unstable
Velocity	< 0.75 m/s	0.75 m/s to 1.15 m/s	> 1.15 m/s
Tractive Stress	< 3.6 N/m^2	3.6 N/m^2 to 18.2 N/m^2	> 18.2 N/m^2

The results from 2D hydrodynamic modelling allow tractive stress to be plotted *per unit width,* typically at the channel centre line.



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Appendix D

Aboriginal cultural heritage assessment









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MODIFICATION 10 – ADDITION OF LONGWALL 34, MANDALONG MINE

Aboriginal Cultural Heritage Assessment

FINAL

September 2021

MODIFICATION 10 – ADDITION OF LONGWALL 34, MANDALONG MINE

Aboriginal Cultural Heritage Assessment

FINAL

Prepared by
Umwelt (Australia) Pty Limited
on behalf of
Centennial Mandalong

Project Director: Nicola Roche
Project Manager: Ashley O'Sullivan
Report No. 20133
Date: September 2021

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Document Status

Rev No.	Reviewer		Approved for Issue	
	Name	Date	Name	Date
1	Nicola Roche	17 February 2021	Nicola Roche	17 February 2021
2	Nicola Roche	26 February 2021	Nicola Roche	26 February 2021
3	Nicola Roche	5 May 2021	Nicola Roche	5 May 2021
4	Nicola Roche	3 August 2021	Nicola Roche	9 August 2021
5	Nicola Roche	15 September 2021	Nicola Roche	15 September 2021

Acknowledgement

Umwelt (Australia) Pty Ltd (Umwelt) and Centennial Mandalong Pty Limited (Centennial Mandalong) would like to acknowledge the traditional custodians of the Mandalong area and pay respect to their cultural heritage, beliefs and continuing relationship with the land.

Umwelt and Centennial Mandalong would also like to acknowledge the post-contact experiences of Aboriginal people who have attachment to the Mandalong area.

We pay our respect to the Elders – past, present and future – for they hold the memories, traditions, culture and hopes of Aboriginal people in the area.

Statements of Aboriginal Cultural Significance

As discussed throughout this document, the key objective of this document is to recognise and assess Aboriginal cultural values associated with the Modification Area. In recognition of this, the following section documents previous statements provided by registered Aboriginal parties regarding the Aboriginal cultural significance of the Mandalong area. These statements have been extracted from a previous assessment for the Mandalong Southern Extension Project (RPS 2013).

The registered Aboriginal parties were provided with the opportunity to revisit or supplement these statements of significance in relation to the specifics of the current Modification. An updated statement of significance was received on 3 March 2021 from the Awabakal Traditional Owners Aboriginal Corporation and the Awabakal and Guringai Pty Ltd, as provided unedited below.

Awabakal Traditional Owners Aboriginal Corporation (ATOAC)

Awabakal and Guringai is one of the 600 or more language groups or 'nations' that existed across Australia at the time of European contact and are part of the oldest and continuous living Culture in human history.

Our People were recorded within our Traditional Country and acknowledged in the first records ever made of the Aboriginal People of the wider Lake Macquarie, Newcastle, Maitland, Wollombi, Cessnock, Kurri Kurri, Central Coast, Hawkesbury, North Shore and various Sydney areas. Prominent people such as L.E.Threlkeld, Jonathon Warner and many others documented our Peoples Cultural Heritage and Language in detail going back to the very early 1800's.

Our people believe that all our sites and Traditional Culture that has existed for many thousands of years within our area are a tangible link to our Ancestors and our past. Surveys and assessments within our Traditional Country have identified Aboriginal Cultural Heritage Sites (the tangible evidence of occupation) and (the intangible evidence) of landscape features of cultural value embedded within a landscape that provided physical and spiritual sustenance to the Awabakal and Guringai Peoples.

The survival of these sites is significant to the continuation of the collective knowledge and inspiration for our young people and coming generations of Awabakal and Guringai Peoples, and those Aboriginal People that are invited into our Country. We acknowledge our Ancestors for passing on knowledge and also the legacy for us to continue what they put into place, to pass on our Cultural Heritage and Values to protect our sites for all those in the future.

The Awabakal and Guringai presence extends from the present day back many thousands of years and is reflected in both tangible and intangible aspects of Aboriginal Culture, Heritage, Value and history. As Awabakal and Guringai Peoples, we hold Cultural Knowledge that has been passed down from our Ancestors about our Traditional Country for thousands of years and a spiritual awareness, connectedness, presence, and value of place that connects us with the Land of our People. Therefore, the Awabakal and Guringai People have a continuing, contemporary history of obligation to protect and preserve the Cultural Heritage within our traditional cultural boundary areas.

We maintain concerns over Mining and Development licences being approved within our Traditional Cultural Boundary, and the adverse impacts this has on our Cultural Heritage, Values, landscape and sea country features, and the footprints of our Ancestors which are being impacted through cumulative and overlapping development, mining and unmonitored and unmanaged human recreational activities. The mental, physical and spiritual wellbeing of the Awabakal and Guringai Peoples and those Aboriginal Peoples that feel an association to this landscape is also a contemporary phenomenon and not just 'a thing of the past'.

The Awabakal and Guringai Aboriginal Cultural Heritage sites are identified as having significant Cultural and Spiritual Value and are numerous within our Traditional Cultural Boundary. These sites and landscape features link contemporary Awabakal and Guringai Peoples through generations of their Ancestors and are extremely important teaching places and places of spiritual renewal.

The custodial rights and obligations of our people Caring for Country underpin the principles of this statement of significance. It is highlighted, however, that the Awabakal and Guringai Peoples in no way support any impact to our sites, landscape features and cultural value or any aspect of the natural environment within our Awabakal and Guringai Traditional Boundary. Aboriginal people inherit the right and obligation to Care for Country and endorsing any form of harm in our view is assessed as culturally and ethically inappropriate. (**© Awabakal & Guringai 2013)**

Awabakal Descendants Traditional Owners Aboriginal Corporation (ADTOAC)

"This area, as part of what is the Traditional Awabakal Country, is considered by our People to be of great importance within our Cultural Heritage. There are a variety of reasons our People have benefited from using this location over thousands of years.

One of the earliest documented accounts of the importance of the areas around Lake Macquarie for the Awabakal is attributed to the Reverend L.E. Threlkeld. For us, this area has not just a physical presence within the Cultural Heritage of our People, but it is part of our oral history and incorporates places of spiritual significance. The landforms and resources of this locale fulfilled not just the basic needs that underpinned our Peoples subsistence but also satisfied the many other aspects that made up what can only be described here as being part of the very cultural foundations of our People.

Needless to say, our People have had a long history within this area which is unsurpassed. Our apical Ancestor, Mahrahkah, an Awabakal woman and her two daughters were recorded by the Reverend L.E. Threlkeld and Jonathan Warner as living in and around these areas which all formed part of their Traditional Country. This apart from everything else makes it a very important location for our family, knowing that Mahrahkah walked these areas before any white man was ever seen in the Newcastle and Lake Macquarie region. She was intrinsically acquainted with her Land, and she has left a legacy for us to carry on in this day and age and to pass onto our Descendants.

This area is of very high significance to the Awabakal and therefore it would be expected that after many generations of our People that have walked the pathways of their Ancestors it should be obvious there would be many areas that contain evidence of this connection resulting from thousands of years of occupation on varying levels by our People. Traditionally these areas were the supply of rich resources of which our People have depended on over millennia. There are physical reminders left by our Ancestors, some in the form of middens, scarred trees or stone tools (artefacts) and grinding grooves which provide us as Descendants of the Awabakal People an opportunity to make a connection through time with our Ancestors. This connection is manifest in a variety of ways; one is through the physical senses such as knowing we are seeing where they lived or touching what they used. By holding or touching something our Ancestors handled, something they made, possibly many thousands of years previously, gives rise to a sense of perception, appreciation, familiarity and recognition of who we are and reinforces where we belong and our birthright as Awabakal Descendants".

(Shane Frost, Managing Director – Awabakal Descent Traditional Owner Aboriginal Corporation March 2012)

Bahtabah Local Aboriginal Land Council

"We acknowledge the Elders past and present and the Aboriginal people who are the traditional custodians of the Mandalong area. Aboriginal people have utilised this area for their cultural, spiritual and ceremonial purposes. The Mandalong landscape is covered with the traditions and customs of Aboriginal people and the flora and fauna that inhabit these areas have a special significance to the Aboriginal people of the Mandalong area. The Aboriginal people of Mandalong took a holistic approach to incorporate the environment into their way of life.

Today, the Bahtabah Local Aboriginal Land Council our sites officers that participate in the recording of sites for this management plan are still working to protect our cultural heritage sites to ensure that the Aboriginal traditional and customary values of Mandalong are sustainable for the current and future generations to enjoy".

(Michael Green CEO Bahtabah Local Aboriginal Land Council 2012)

Darkinjung Local Aboriginal Land Council

“To the Darkinjung people, the significance of the Mandalong area lies within the landscape, the hills, valleys, creeks and rivers, including areas surrounding an Aboriginal cultural heritage site. These places can be seen in a spiritual sense and is very important to them. The landscape can be an extension of a site, or the landforms and features within the landscape can be the Aboriginal cultural heritage site. These sites can also be connected intangibility through sight lines or connected through walking and trading tracks, including dreaming tracks to other sites or places of significance. These features are all part of the Darkinjung cultural landscape.

Darkinjung cultural heritage sites, sight lines, walking, trading tracks and dreaming tracks are associated with stories. These stories connect sites with other sites across Darkinjung country and beyond and could have been utilised and handed down over hundreds of years. The spiritual and cultural connection that the Darkinjung people have to the land, cultural heritage sites and the cultural landscape provides a physical and intangible link to ancestors and the past. This connection attaches the Aboriginal community to land, traditions and strengthens bonds within the Darkinjung Aboriginal community.”

(Sharon Hodgetts Project Officer Culture and Heritage and Suzanne Naden Operations Manager Darkinjung Local Aboriginal Land Council 5 October 2012)

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Appendix 2	AHIMS Search Results

1.0 Introduction

Mandalong Mine is an existing underground longwall coal mining operation producing thermal coal that is supplied to domestic and export markets. It is located approximately 35 kilometres south-west of Newcastle near Morisset in New South Wales (refer to Figure 1.1). Mandalong Mine is 100 percent owned and operated by Centennial Mandalong Pty. Limited (Centennial Mandalong), a subsidiary of Centennial Coal Company Limited (Centennial). Centennial is a wholly owned subsidiary of Banpu Public Company Limited. Mandalong Mine operates under Development Consent SSD-5144 which was granted on 12 October 2015 by the NSW Planning Assessment Commission under Part 4, Division 4.1 of the *NSW Environmental Planning and Assessment Act 1979* (EP&A Act) (NSW Government 1979) and provided for extension of the mining area with a production limit of 6 million tonnes per annum of thermal coal from the West Wallarah and Wallarah-Great Northern Seams.

The currently approved Mandalong Mine comprises the underground workings and surface infrastructure of the following:

- The Mandalong Mine Access Site, encompassing underground workings and associated surface infrastructure near Morisset.
- Delivery of run-of-mine coal from the underground workings to the Cooranbong Entry Site. The Cooranbong Entry Site coal handling and processing facilities are approved under the Northern Coal Logistic Project (SSD-5145).
- Delivery of run-of-mine coal from the underground workings to the Delta Entry Site, located near Wyee at the Vales Point Rail Unloader Facility. The coal handling facility is approved under DA35-2-2004.
- Mandalong South Surface Site (MSSS), encompassing ventilation shafts, ventilation fans and underground delivery boreholes located approximately 6 kilometres south-west of the Mandalong Mine Access Site.

In accordance with the relevant conditions of SSD-5144, Mandalong currently manages Aboriginal cultural heritage within the SSD-5144 approval area under the provisions of the Northern Region Aboriginal Cultural Heritage Management Plan (ACHMP – Centennial 2016).

Centennial Mandalong is seeking to modify SSD-5144 to change the currently approved mine plan to allow for the inclusion of longwall 34 (LW34), which will be situated to the east of LW30. The proposed modification is referred to as Modification 10 or Mod 10.

Centennial Mandalong has engaged Umwelt to work with the registered Aboriginal parties to complete an Aboriginal Cultural Heritage Assessment (ACHA) for the proposed modification. Umwelt and Centennial Mandalong recognise that the registered Aboriginal parties have primary responsibility for assessing the cultural significance of the lands for which they are traditional custodians and/or to which they have contemporary connection and all comments and feedback provided by Aboriginal parties are documented in this report.

This report has been prepared in accordance with the *Guide to Investigating, Assessing and Reporting on Aboriginal Cultural Heritage in NSW* (OEH 2011), with all consultation undertaken in accordance with the *Aboriginal Cultural Heritage Consultation Requirements for Proponents* (DECCW 2010a) (the consultation requirements), as documented in **Appendix 1**. The report incorporates required archaeological technical information in accordance with the *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW 2010b) (the Code of Practice) and will inform the modification report (MR) for the proposed modification.

1.1 Proposed Modification Description

The progression of underground mining at Mandalong Mine is regularly reviewed dependent on ongoing monitoring and geological conditions. Centennial Mandalong has encountered poor geological conditions within the Mandalong Southern Extension Area, including a fault zone and igneous sill. In response to these conditions and in order to maintain coal production, improve mining conditions and improve the financial viability of Mandalong, amendments to the approved mine plan were approved as part of a modification to SSD-5144 (herein referred to as MOD 9). As part of MOD 9, Centennial Mandalong received approval to amend the approved mine plan, including the reorientation of LW30-LW33.

Since the approval of MOD 9 in April 2021, Centennial Mandalong has continued to review the progression of underground mining within the Mandalong Southern Extension Area. As a result of these investigations, the decision has been made to shorten LW30 and remove LW33 from the mine plan. The shortening of LW30 and removal of LW33 are estimated to result in the sterilisation of approximately 0.4 million tonnes (Mt) and 1.6 Mt of coal, respectively. Consequently, Centennial Mandalong has explored options to access additional coal resources.

Centennial Mandalong is now seeking to modify SSD-5144, pursuant to Section 4.55(2) of the EP&A Act, and change Mandalong's approved mine plan to include LW34 to the east of LW30 (herein referred to as MOD 10 or the proposed modification).

The addition of LW34 will maximise resource extraction within the West Wallarah Seam and Mandalong's development consent boundary and improve the continuity of coal extraction and employment at Mandalong. The location of LW34 is shown in **Figure 1.2.** The proposed modification area (as shown in **Figure 1.2**) includes LW34 and the associated 20mm contour line (based on subsidence modelling as per DgS 2021), It comprises approximately 52 hectares in total area.

1.2 Objectives of this Assessment

The key objective of this assessment is to ensure that the Aboriginal cultural values of the Modification Area are appropriately assessed with reference to the approach specified in the *Guide to Investigating, Assessing and Reporting on Aboriginal Cultural Heritage in NSW*, the consultation requirements and with the Code of Practice. In order to achieve this, it is emphasised that Aboriginal people are the primary determinants of the cultural significance of their heritage and this ACHA is prepared to ensure that the information provided by registered Aboriginal parties is documented and presented in a manner that informs decision making on the management of Aboriginal cultural heritage within the Modification Area whilst ensuring that the required archaeological information is also appropriately documented.

In order to demonstrate how this ACHA meets these objectives, **Table 1.1** documents the required components with reference to the section of this document in which they are addressed.

Table 1.1 Required Information

Required Information (Aboriginal cultural heritage assessment)	Relevant Section	Required Information (Aboriginal archaeological assessment)	Relevant Section
Introduction	1	Introduction	1
Description of the area	1 and 3	Investigator and contributors	1.4
Consultation process	2	Description of Modification	1
Summary and analysis of background information	4.3	Landscape context	3
Cultural heritage values and statement of significance	7	Previous archaeological work and regional character	4
Avoiding and/or mitigating harm	9	Predictions	4.3
Recommendations	10	Sampling strategy and field methods	5
		Results	6
		Analysis and discussion	6.4
		Scientific values and significance assessment	7
		Impact assessment	8
		Management and mitigation measures	9
		Recommendations	10

1.3 Statutory Context

In relation to this assessment, the relevant statutory controls for the protection of Aboriginal heritage are the EP&A Act and the *NSW National Parks and Wildlife Act 1974* (the NPW Act). Reference is also made to the requirements of the *Heritage Act 1977.*

1.3.1 Environmental Planning and Assessment Act 1979

The EP&A Act is the main system of land use planning and development regulation legislation in NSW. SSD5144 was granted under Part 4 of the EP&A Act and was approved as State Significant Development. It is noted that Division 4.41 (d) of the EP&A Act specifies that it is not necessary to obtain an Aboriginal Heritage Impact Permit (AHIP) under Section 90 of the NPW Act for designated State Significant Development. Projects approved as State Significant Development under the EP&A Act are subject to conditions of approval issued by the NSW Department of Planning, Industry and Environment (DPIE) and (where relevant) Aboriginal cultural heritage is addressed by appropriate conditions.

1.3.2 National Parks and Wildlife Act 1974

Heritage NSW is primarily responsible for regulating the management of Aboriginal cultural heritage in NSW under the NPW Act. The NPW Act is accompanied by the *National Parks and Wildlife Regulation 2019* (the Regulation) and a range of codes and guides including the *Guide to Investigating, Assessing and Reporting on Aboriginal Cultural Heritage in NSW* (OEH 2011), the consultation requirements and the Code of Practice (DECCW 2010b).

The NPW Act defines an Aboriginal object as:

> *..any deposit, object or material evidence (not being a handicraft made for sale) relating to the Aboriginal habitation of the area that comprises New South Wales.*

Under Section 84 of the NPW Act, an Aboriginal Place must be declared by the Minister as a place that, in the opinion of the Minister, is or was of special significance with respect to Aboriginal culture. Section 86(4) of the NPW Act states that a person must not harm or desecrate an Aboriginal Place.

In accordance with Section 86(1) of the NPW Act, it is an offence to harm or desecrate a known Aboriginal object, whilst it is also an offence to harm an Aboriginal object under Section 86(2). Harm to an object or place is defined as any act or omission that:

- destroys, defaces or damages an object or place, or
- in relation to an object – moves the object from the land on which it had been situated, or
- is specified by the regulations, or
- causes or permits the object or place to be harmed in a manner referred to in paragraph (a), (b) or (c),
- but does not include any act or omission that:
- desecrates the object or place (noting that desecration constitutes a separate offence to harm), or
- is trivial or negligible, or
- is excluded from this definition by the regulations.

Section 87 (1) of the NPW Act specifies that it is a defence to prosecution under Section 86(1) and Section 86 (2) if the harm or desecration of an Aboriginal object was authorised by an Aboriginal Heritage Impact Permit (AHIP) and the activities were carried out in accordance with that AHIP. As noted above, it is not necessary to obtain an Aboriginal Heritage Impact Permit (AHIP) under Section 90 of the NPW Act for designated State Significant Development.

Section 87 (2,4) also establishes that it is a defence to prosecution under Section 86(2) (the strict liability offence) if due diligence is exercised to reasonably determine that the activity or omission is a low impact act or omission. The NPW Regulation specifies that compliance with the due diligence code is taken to constitute due diligence in determining whether a proposed activity will harm an Aboriginal object. The Regulation identifies that compliance with the Code of Practice (DECCW 2010b) is excluded from the definition of harm.

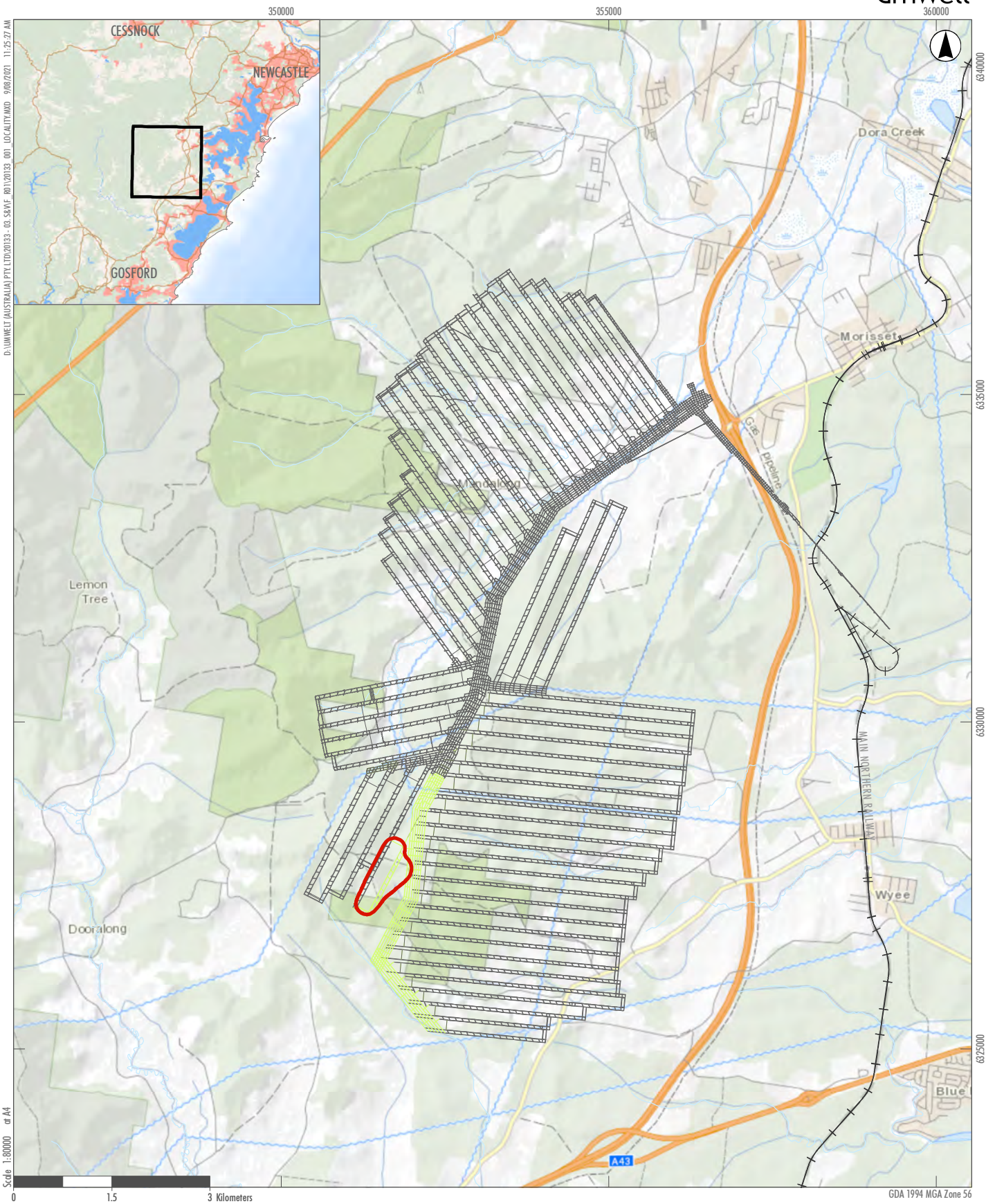
1.3.3 Heritage Act 1977

The *Heritage Act 1977* provides protection for heritage within NSW. The Act provides protection of historic places, structures, relics, moveable objects and landscapes of significance. The Act also affords protection to Aboriginal places of State heritage significance included on the State Heritage Register (SHR) or subject to an Interim Heritage Order. This assessment does not comprise an assessment in accordance with the provisions of the *Heritage Act 1977* (Umwelt 2021a).

1.4 Report Authorship

This report has been prepared by Ashley O'Sullivan (Umwelt Senior Archaeologist) and Nicola Roche (Umwelt Manager, Cultural Heritage). Drafting input was provided by Umwelt's drafting team.

During the process of the development of this report, information relevant to the assessment of Aboriginal cultural heritage values within the Modification Area was provided by representatives of registered Aboriginal parties who participated in the survey. Correspondence and comments provided by Aboriginal parties are reviewed in **Section 2.0**.



Legend

- Modification Area
- Proposed Workings
- Approved Workings
- Watercourses
- Railway Line

FIGURE 1.1

Location of the Centennial Mandalong Operations

Image Source: ESRI (2021) Data source: DSFI (2020)

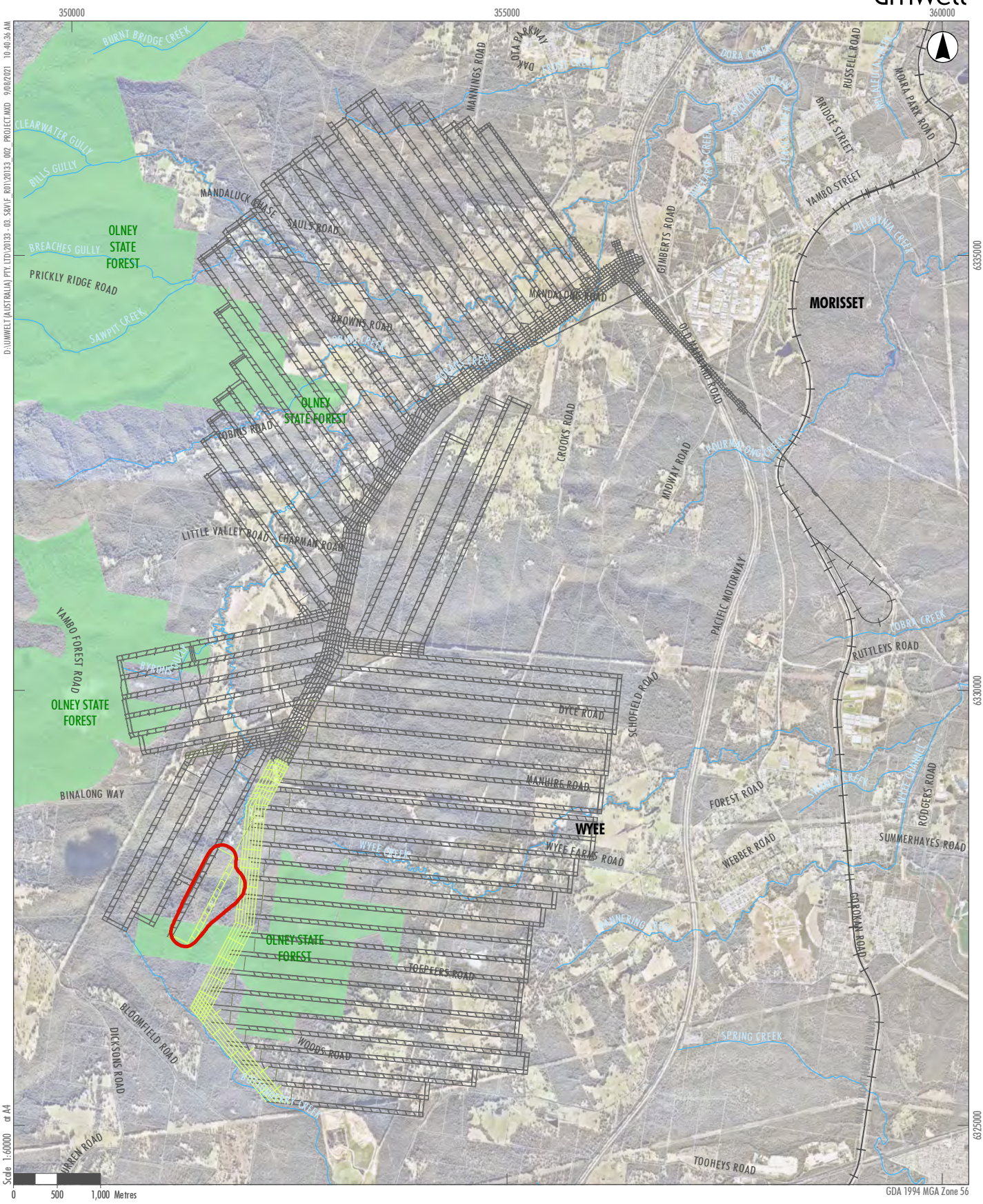


FIGURE 1.2

Location of Modification Area

Image Source: Nearmap (Jun 2021) Data source: DSFI (2020)

2.0 Aboriginal Party Consultation

Consultation with Aboriginal parties is an integral part of identifying and assessing the significance of Aboriginal objects and/or places and determining and carrying out appropriate strategies to mitigate impacts upon Aboriginal heritage. In accordance with current requirements and expectations, consultation with Aboriginal parties regarding the modification was undertaken in accordance with the relevant aspects of Division 2, Clause 60 of the NPW Regulation and the consultation requirements. The documentation of the outcomes of Aboriginal party consultation in this report reflects the requirements of the *Guide to investigating assessing and reporting on Aboriginal Cultural Heritage in NSW*.

2.1 Identification of Registered Aboriginal Parties

Consultation with Aboriginal parties in relation to approved activities at Mandalong Mine and the development of Centennial's Northern Region ACHMP has been ongoing since 2011 and has been undertaken in accordance with all relevant requirements and to the satisfaction of the regulatory authorities. Consultation with the registered Aboriginal parties identified in Centennial's Northern Region ACHMP has been consistent and ongoing. The registered Aboriginal parties for the current assessment are:

- Awabakal Descendants Traditional Owners Aboriginal Corporation
- Awabakal Traditional Owners Aboriginal Corporation
- Bahtahbah Local Aboriginal Land Council
- Biraban Local Aboriginal Land Council
- Cacatua Cultural Consultants
- Darkinjung Local Aboriginal Land Council
- Guringai Tribal Link Aboriginal Corporation
- Wonn1 Contracting
- Yula-Punaal Education and Healing Aboriginal Corporation.

2.2 Notification and Consultation Regarding Assessment Methodology

A letter providing information regarding the proposed modification and incorporating a draft methodology for the assessment was originally provided to all registered Aboriginal parties on 12 August 2020. It was requested that all Aboriginal parties provide comment on the proposed assessment methodology.

Following the provision of the initial draft methodology and completion of the initial survey, the need for additional survey was identified. A second draft methodology was provided to the registered Aboriginal parties on 22 June 2021, including the proposed methodology for additional survey. Copies of all communication regarding the draft methodology are provided in full in **Appendix 1** and summarised in **Table 2.1** below.

Table 2.1 Summary of Aboriginal Party Consultation

Date	Type of Consultation	Aboriginal Parties Contacted	Outcome
12 August 2020	Provision of assessment methodology to RAPs for review and comment.	Awabakal Descendants Traditional Owners Aboriginal Corporation	Expression of Interest (EOI) received. Comments on the methodology were supportive of the proposed approach.
		Awabakal Traditional Owners Aboriginal Corporation	EOI received. Comments on the methodology were supportive of the proposed approach.
		Bahtahbah Local Aboriginal Land Council	EOI received. No comment on the methodology was provided.
		Biraban Local Aboriginal Land Council	No response to methodology provided.
		Cacatua Cultural Consultants	EOI received. No comment on the methodology was provided.
		Darkinjung Local Aboriginal Land Council	Expression of Interest (EOI) received. No comment on the methodology was provided.
		Guringai Tribal Link Aboriginal Corporation	EOI received. Comments on the methodology were supportive of the proposed approach.
		Wonn1 Contracting	EOI received. No comment on the methodology was provided.
		Yula-Punaal Education and Healing Aboriginal Corporation	No response provided
14 – 17 September 2020	First survey with registered Aboriginal parties that submitted EOI in undertaking fieldwork	Awabakal Descendants Traditional Owners Aboriginal Corporation	Field survey undertaken by Peter Leven/ Tori Leven
		Awabakal Traditional Owners Aboriginal Corporation	Field survey undertaken by Kyle Howie
		Bahtahbah Local Aboriginal Land Council	Field survey undertaken by Norman Archibald
		Cacatua Cultural Consultants	Field survey undertaken by Ashley Sampson
		Darkinjung Local Aboriginal Land Council	Field survey undertaken by Barry Williams
		Guringai Tribal Link Aboriginal Corporation	Field survey undertaken by Tracey Howie
		Wonn1 Contracting	Field survey undertaken by Arthur Fletcher
26 February 2021	Provision of draft ACHA to registered Aboriginal parties for review and	Awabakal Descendants Traditional Owners Aboriginal Corporation	Verbal comment received from Peter Leven, described below in **Section 2.5**.
		Awabakal Traditional Owners Aboriginal Corporation	Written comment received from Kerrie Brauer, described below in **Section 2.5**.

Date	Type of Consultation	Aboriginal Parties Contacted	Outcome
	comment. This was a previous iteration of the current ACHA, which was subsequently revised based on changes in proposed longwall layout	Bahtahbah Local Aboriginal Land Council	
		Biraban Local Aboriginal Land Council	
		Cacatua Cultural Consultants	
		Darkinjung Local Aboriginal Land Council	
		Guringai Tribal Link Aboriginal Corporation	Verbal comment received from Tracey Howie, described below in **Section 2.5**.
		Wonn1 Contracting	
		Yula-Punaal Education and Healing Aboriginal Corporation	
22 June 2021	Updated methodology (including new survey area) provided to all registered Aboriginal parties for review and comment	Awabakal Descendants Traditional Owners Aboriginal Corporation	No responses received
		Awabakal Traditional Owners Aboriginal Corporation	
		Bahtahbah Local Aboriginal Land Council	
		Biraban Local Aboriginal Land Council	
		Cacatua Cultural Consultants	
		Darkinjung Local Aboriginal Land Council	
		Guringai Tribal Link Aboriginal Corporation	
		Wonn1 Contracting	
		Yula-Punaal Education and Healing Aboriginal Corporation	
21 July 2021	Second survey completed	Awabakal Descendants Traditional Owners Aboriginal Corporation	Unavailable to attend
		Awabakal Traditional Owners Aboriginal Corporation	Field survey undertaken by Kyle Howie
		Bahtahbah Local Aboriginal Land Council	Field survey undertaken by Norman Archibald
		Cacatua Cultural Consultants	Unable to attend
		Darkinjung Local Aboriginal Land Council	Unable to attend
		Guringai Tribal Link Aboriginal Corporation	Field survey undertaken by Tracey Howie
		Wonn1 Contracting	Field survey undertaken by Arthur Fletcher

Date	Type of Consultation	Aboriginal Parties Contacted	Outcome
10 August 2021	Provision of draft ACHA (updated) to registered Aboriginal parties for review and comment	Awabakal Descendants Traditional Owners Aboriginal Corporation	
		Awabakal Traditional Owners Aboriginal Corporation	
		Bahtahbah Local Aboriginal Land Council	
		Biraban Local Aboriginal Land Council	
		Cacatua Cultural Consultants	
		Darkinjung Local Aboriginal Land Council	
		Guringai Tribal Link Aboriginal Corporation	
		Wonn1 Contracting	
		Yula-Punaal Education and Healing Aboriginal Corporation	

2.3 Aboriginal Party Participation in Survey

The survey of the Modification Area was undertaken with the Aboriginal party representatives listed in **Table 2.2.**

Table 2.2 Aboriginal party survey representatives

Date	Organisation	Name
14 – 17 September 2020	Awabakal Descendants Traditional Owners Aboriginal Corporation	Peter Leven Tori Leven
	Awabakal Traditional Owners Aboriginal Corporation	Kyle Howie
	Biraban Local Aboriginal Land Council	Norman Archibald
	Cacatua Cultural Consultants	Ashley Sampson
	Darkinjung Local Aboriginal Land Council	Barry Williams
	Guringai Tribal Link Aboriginal Corporation	Tracey Howie
	Wonn1 Contracting	Arthur Fletcher
21 July 2021	Awabakal Traditional Owners Aboriginal Corporation	Kyle Howie
	Biraban Local Aboriginal Land Council	Norman Archibald
	Guringai Tribal Link Aboriginal Corporation	Tracey Howie
	Wonn1 Contracting	Arthur Fletcher

2.3.1 Outcomes of In-Field Consultation

This section documents specific feedback received from Aboriginal party representatives during the survey.

During the survey, the Aboriginal party representatives identified that they were aware of the relatively high numbers of sites in the surrounding landscape, and the cultural value of the broader landscape to Aboriginal people. Aboriginal party representatives identified that sites present within the Modification Area further demonstrated that Aboriginal people intensively utilised this landscape for the purposes of camping, resource gathering and general subsistence practices. It was noted that all sites within this landscape (that is generally subject to low disturbance due to the challenging terrain and unsuitability for residential or commercial development) should be protected to ensure that these are not damaged by any of the proposed works.

In particular, rock shelter sites were seen as significant because it is very likely that Aboriginal people historically would have utilised these and similar sites for camping, protection from the elements or opportunistically when using the landscape more generally.

2.4 Cultural Heritage Significance Workshop

Centennial Mandalong conducted a cultural heritage significance workshop with members of the Aboriginal community to understand the Aboriginal cultural significance of sites identified within the Modification Area. Based on the outcomes of this workshop, cultural significance ratings were attributed to each site based on the assessment process described in the Northern Region ACHMP. Further information on this can be found in **Section 8.1.** A copy of the cultural heritage significance workshop minutes can be found in **Appendix 1.**

2.5 Consultation Regarding the Draft Assessment

A copy of the draft ACHA was originally provided to all registered Aboriginal parties on 26 February 2021 with an invitation to review and comment on all aspects of the document. Written comment was received from Kerrie Brauer (ATOAC) who provided an updated Statement of Significance as provided in the foreword of this report. Kerrie also provided some additional comments to be included in **Section 4.1**, Table 4.1 and **Section 8.2** of this report. These comments have been addressed in the document. During a brief discussion while on other site work in March, Peter Leven (ADTOAC) and Tracie Howie (A&G) indicated that they had reviewed the report and had no additional comments.

Following changes to the draft ACHA to incorporate additional survey results, the draft ACHA was provided to all registered Aboriginal parties on **10 August 2021** to review and comment. Written comment on the revised report was received from Wonn1 Contracting (refer to **Appendix 1**), who identified that they had reviewed the report and were supportive of the outcomes in the report. Verbal comment was provided by Kerrie Brauer (on behalf of Awabakal Traditional Owners Aboriginal Corporation) who indicated that she had reviewed the report and accepted the recommendations.

3.0 Environmental Context

The decisions that people make regarding such things as where they live, the range of resources they use, and other aspects of daily life may be influenced by the environment in which they live. The preservation and visibility of sites is also affected by environmental factors such as vegetation cover, past land-use and disturbance. A review of the environmental context of the Modification Area is therefore integral to considerations of site visibility, preservation and occurrence within the Modification Area.

This section provides a summary of key environmental information for the Modification Area and discusses the implications of this information for the archaeological evaluation of the Modification Area.

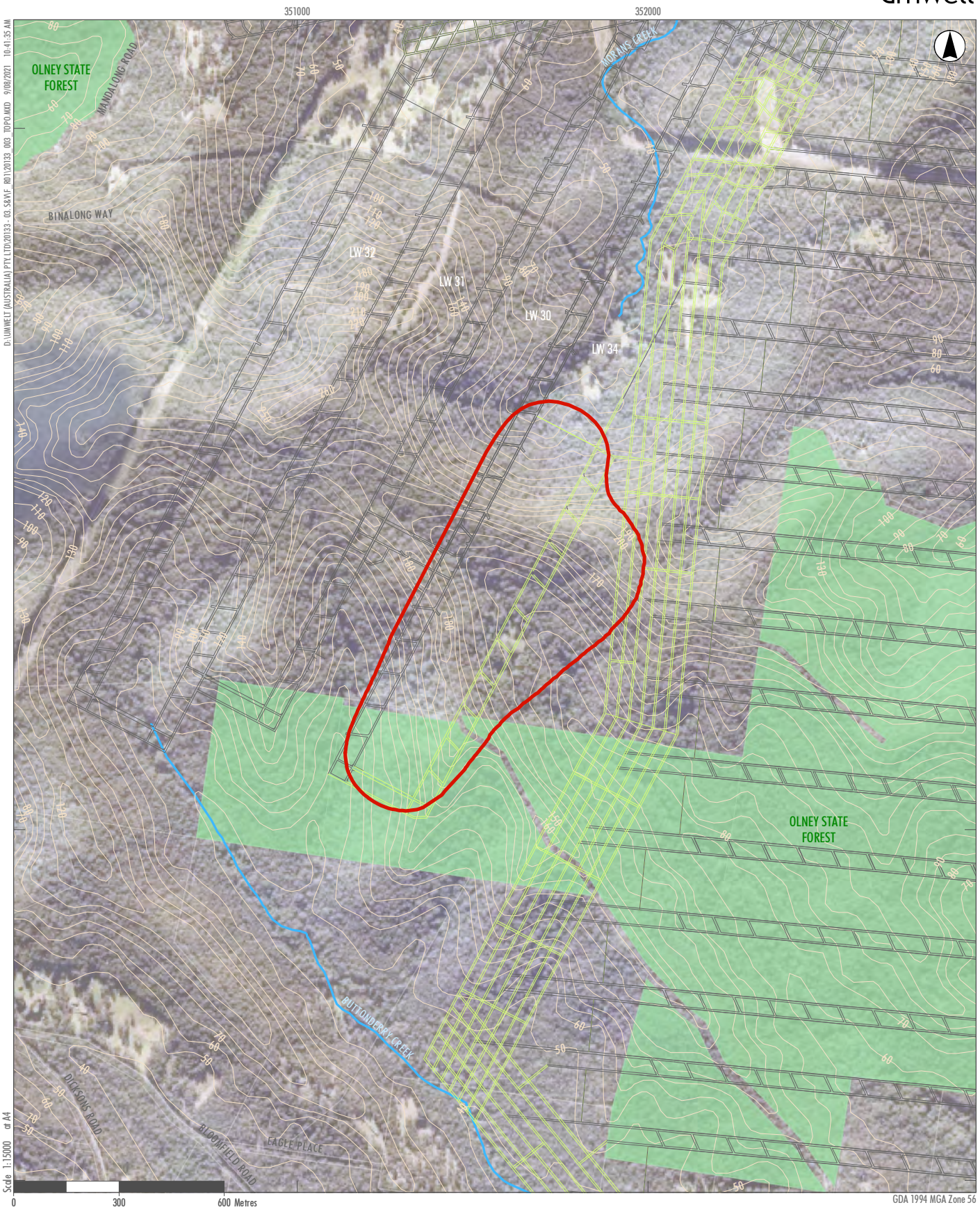
3.1 Landforms and Hydrology

For the purposes of this ACHA, the Modification Area has been divided into landform types based on slope and geomorphic classification and disturbance types. A range of landforms have been identified across the Modification Area (refer to **Table 3.1** and **Figure 3.1**), with ridgelines and slopes being the most common. Gently inclined and moderately inclined slopes are the most dominant slope types, however there are instances of steeply inclined slopes across the area that are susceptible to slope wash and erosion where the topsoil is exposed. Other key landform elements identified include disturbed terrain (heavily impacted as a result of historical land use activities) and drainage lines/watercourses.

Table 3.1 Landform Types

Landform Types
Ridges
Crests
Drainage Lines/watercourses
Disturbed Terrain
Slopes comprising: • Gently inclined • Moderately inclined • Steep slopes

The main topographic features of the Modification Area are steeply inclined ridges and wide valley floors (Department of Lands 2006, RPS 2013). The majority of ridges are an extension of the high point of the Yambo Trigonometry Station (264m elevation Australian Height Datum - AHD) at the top of Toepfers and Kiah Ridge Roads. A first order tributary bisects the Modification Area. An upper tributary of Buttonderry Creek passes immediately to the west of the Modification Area, is relatively steep and only joins the valley floor further to the west and south of the Modification Area. The steep ridges are dissected by a number of narrow watercourses within the Modification Area. Many of the smaller watercourses are not shown on topographic maps for the area. These are very limited in catchment relative to the larger watercourses.



Legend

- Modification Area
- Proposed Workings
- Approved Workings
- State Forest
- Property Boundaries
- Watercourses
- Contours (10 m)

FIGURE 3.1

Topography of the Modification Area

Image Source: Nearmap (Jun 2021) Data source: DSFI (2020)

3.2 Geology and Soils

The Modification Area is located on the Narrabeen geological group (Patonga Claystone and Terrigal Formations), as shown in **Figure 3.2**. These geological formations are characterised by sandstone, interbedded sandstone, siltstone, and claystone. The Quaternary deposits are characterised by undifferentiated alluvial deposits, sand, clay, and gravel.

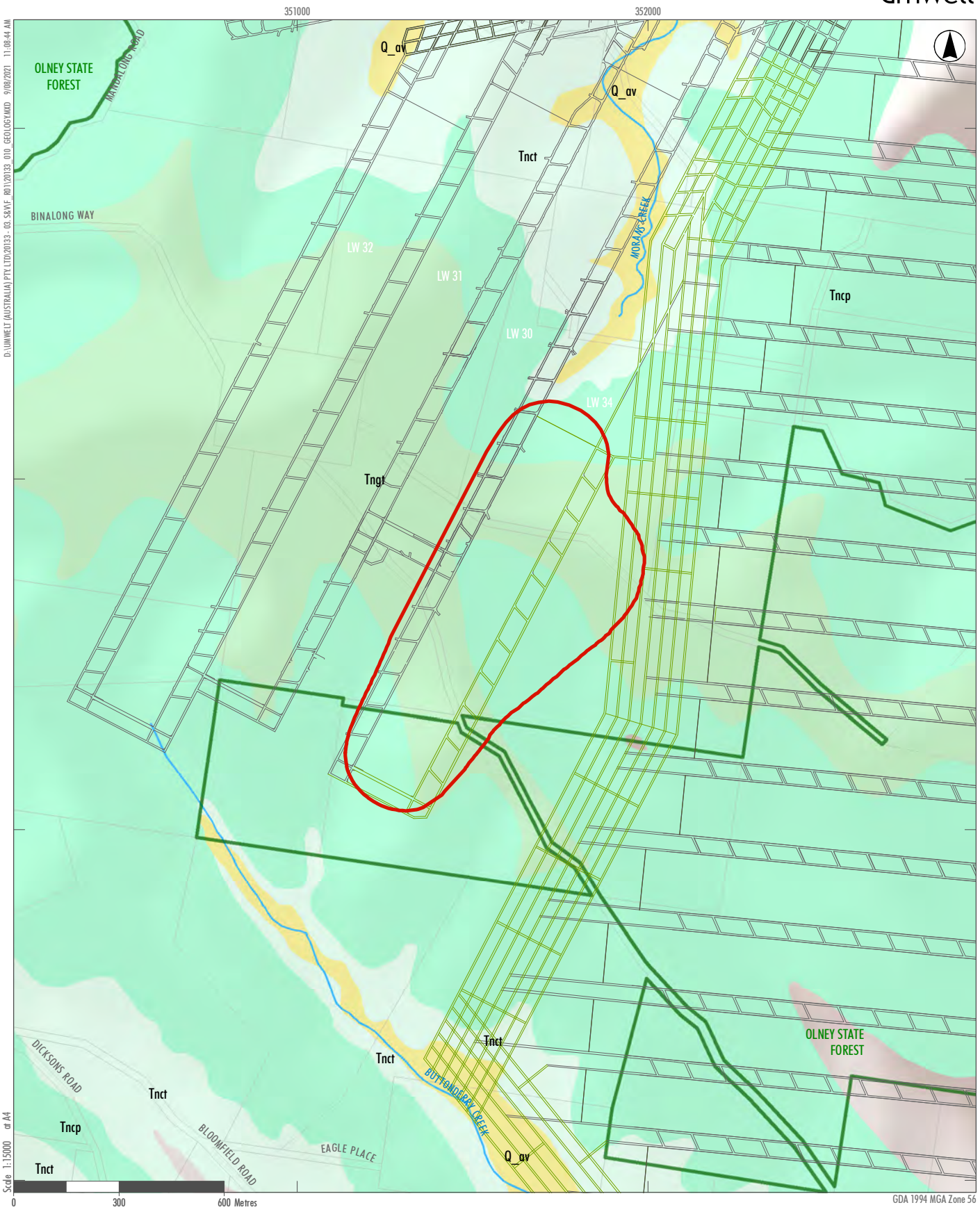
Based on the geological description of this formation, it does not appear that stone raw materials suitable for artefact manufacture would have been available within the Modification Area but would have been sourced from other locations within the region. The presence of sandstone in the Modification Area shows that there is a likelihood of identifying grinding grooves and rock shelters.

The Modification Area is underlain by the Watagan and Mandalong soil landscapes, with potential overlap in the northern section into the Gorokan soil landscape (refer to **Figure 3.3**). The depth of topsoil is a critical consideration for the likely presence of sub-surface archaeological deposits because intact deposits are typically only found within A horizon soils. Within the Modification Area, the soil landscapes provide a varying level of A horizon soil depths, as outlined in **Table 3.2** below.

The Gorokan soil landscape is highly acidic and prone to toxic concentration of aluminium (Murphy, 1993). Typical soil profiles vary according to the landform, as described in **Table 3.2**. Based on the information provided in this table, soils within this soil landscape are typically relatively shallow. These soils are typically highly erodible and subject to seasonal, localised waterlogging, with levels of erosion linked to landform.

The Mandalong soil landscape is typically moderately acidic. Typical soil profiles are consistently shallow throughout the soil landscape, as described in **Table 3.2**. Based on the information provided, these soils are highly erodible and subject to exposure of subsoil clays where erosion is present. On crests within this soil landscape, and upon slopes, soils generally develop on either siltstone and mudstone substrate, or sandstone substrate.

The Watagan soil landscape is typically moderately acidic. Typical soil profiles vary by landform and by underlying parent rock, with sandstone extrusions common on steeper slopes and on crests. As shown in **Table 3.2**, the soil profiles are generally deepest on slopes upon exposed sandstone outcrop.



Legend

- Modification Area
- Proposed Workings
- Approved Workings
- State Forest
- Property Boundaries
- Watercourses

Cenozoic Sedimentary Province

- Q_av - Alluvium - Alluvial valley deposits

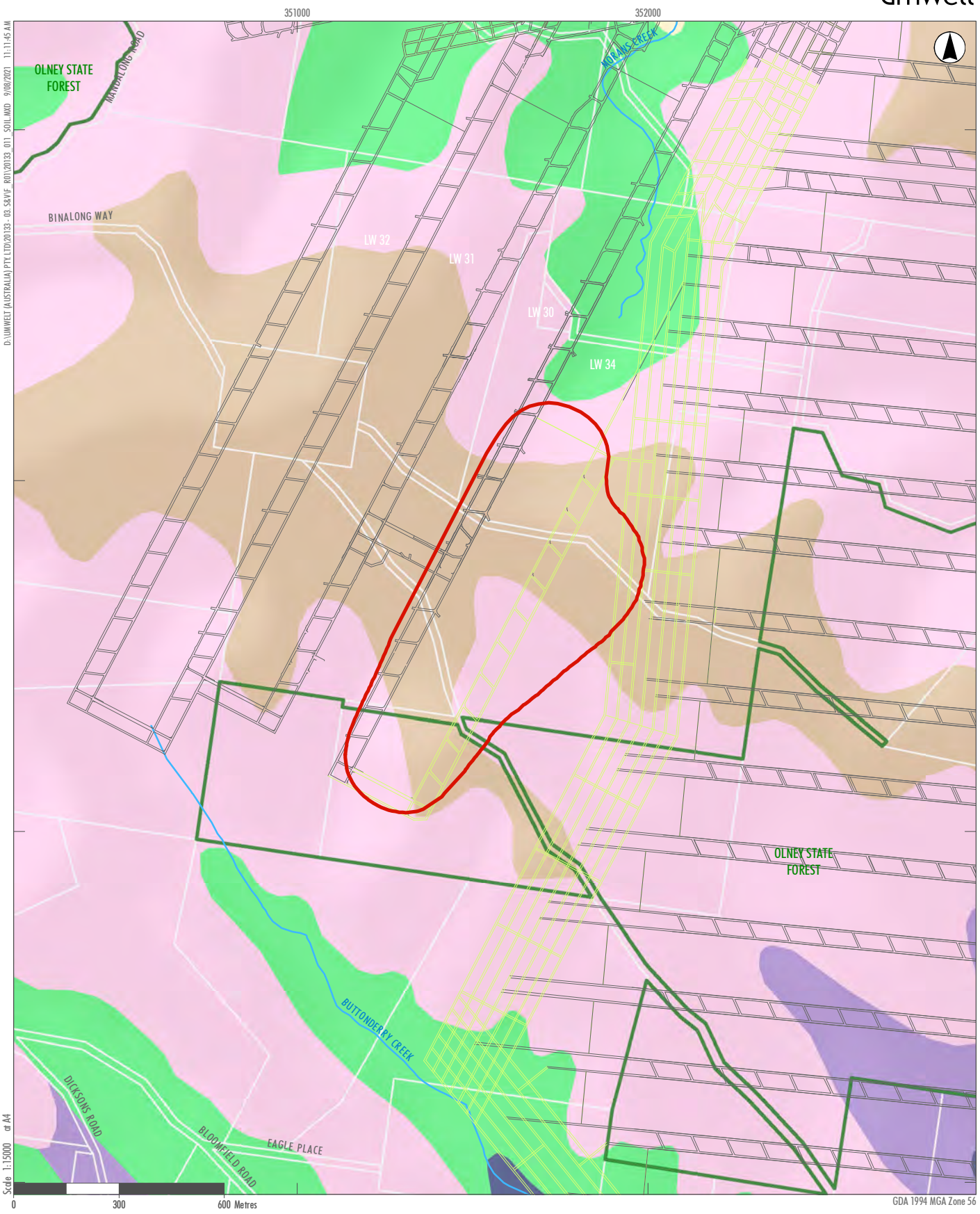
Permo-Triassic Basins

- Tncp - Narrabeen Group Clifton Subgroup Patonga Claystone
- Tnct - Narrabeen Group Clifton Subgroup Tuggerah Formation
- Tngt - Narrabeen Group Gosford Subgroup Terrigal Formation

FIGURE 3.2

Geology of the Modification Area

Image Source: Nearmap (Feb 2021) Data source: DSFI (2020); CIO (2020)



Legend

- Modification Area
- Proposed Workings
- Approved Workings
- State Forest
- Property Boundaries
- Watercourses

Soil Landscape

- Gorokan
- Mandalong
- Watagan
- Woddburys Bridge
- WYONG
- Yarramalong

FIGURE 3.3

Soil Landscapes of the Modification Area

Image Source: Nearmap (Feb 2021) Data source: DSFI (2020); SALIS (2012)

Table 3.2 Summary of the soil landscape information relevant to the Modification Area (from Murphy 1993)

Soil Landscape	A[1] soil horizon	A[2] soil horizon	B soil horizon	Typical topsoil depth
Gorokan	10 to 15 cm of loose dark brown loamy sand	10 to 50 cm of yellowish brown hard setting clayey sand	Yellowish brown strongly pedal clay	Up to 65 cm
Mandalong	Up to 10cm of hard setting stony brown sandy clay loam	-	On crests or sandstone, yellowish brown pedal clay with sand grains upon underlying sandstone parent material. On slopes overlying siltstone or mudstone substrate, slaking cracking plastic pedal clay generally overlies.	Up to 10cm
Watagan	20-100cm when overlying sandstone. Often deepest on slopes. Typically up to 40cm when overlying fine-grained bedrock	Typically up to 40cm when overlying fine-grained bedrock	Mottled, coarse-grained light sandy clay loam to medium clay on sandstone colluvium. Brown strongly pedal clay on fine-grained bedrock. Light grey mottled clay on shale bedrock.	20 – 100cm, with >100cm present in drainage flats.

3.3 Flora and Fauna

The Modification Area is generally comprised of low open forest with a grassy understorey. Parts of the Modification Area have been previously cleared of all vegetation to support historical land use practices, with the vegetated areas of the Modification Area comprising regrowth vegetation dominated by Eucalypt species. This vegetation clearance would have initially occurred in association with the historical mining activity, with subsequent clearance associated with construction of adjacent infrastructure (including roads and services) and the establishment and ongoing operation of Mandalong Mine.

Prior to this vegetation clearance, key species present within the area would have included smooth barked apple (*Angophora costata*), scribbly gum (*Eucalyptus haemastoma*), red bloodwood (*E.gummifera*), brown stringybark (*E. capitellata*), and forest oak (*Allocasuarina torulosa*). Common understorey species include mountain devil (*Lambertia formosa*), hill banksia (*Banksia spinulosa var. collina*), banksia (*Banksia oblongifolia*), flaky-barked tea-tree (*Leptospermum att enuatum*), broad-leaf drumsticks (*Isopogon anemonifolus*).

This vegetation community would have provided a range of plant resources that would have been used by Aboriginal people for food, medicine, shelter and the manufacture of artefacts. In addition, this vegetation community would have hosted a variety of fauna which would also have been utilised by past Aboriginal peoples for food and raw material.

3.4 Land Use History

As recounted by RPS (2013), the Mandalong area was primarily settled from the early 1830s however substantial land clearance and development is unlikely to have commenced until the mid-late 1800s. From this early period, the trade in timber was reportedly one of the key economic activities in the area in addition to grazing/dairying. In general terms, the importance of timber harvesting as an economic activity in the region has implications for the preservation of archaeological evidence. Harvesting of mature trees substantially reduces the likelihood that Aboriginal scarred trees will remain in the area.

In addition, vegetation clearance often results in substantial changes in erosion regimes, increasing rates of erosion, particularly on steeply inclined landforms. Changes in erosion can in turn impact drainage line morphology, potentially resulting in incision of tributary streams and extension of gullies, erosion and sedimentation during major floods, and in some places, increases in water salinity (Dean-Jones and Mitchell 1993:4).

A review of aerial imagery clearly shows that the cleared portions of the Modification Area have been impacted by erosion over time, and that the impacts of this erosion have likely been exacerbated by previous vegetation clearance and ongoing vegetation maintenance for the existing electrical easement and tracks throughout.

4.0 Cultural Context

In order to adequately undertake an assessment of Aboriginal cultural heritage within an area, it is necessary to also understand the cultural context of the area. The term cultural context encompasses both ethnohistoric information regarding how Aboriginal people lived in the region during the period of non-Aboriginal settlement, and the information that we currently have access to regarding the patterns of distribution of archaeological evidence, based largely on the outcomes of previous archaeological assessments.

4.1 Ethnohistoric Information

Historical records, such as official records and personal observations recorded in diaries or publications, can provide information on the Aboriginal history of a region since European contact. Although a valuable source of information, the limitations of these documents must be recognised as colonial observers generally tended to record unusual rather than everyday events, religious and social life rather than economic activity, and men's behaviour rather than that of women and children. As such, ethnohistoric records are neither unbiased nor complete, and they cannot provide a complete understanding of Aboriginal beliefs and practices at the time of contact.

For the reasons discussed above, there are often issues with using ethnohistoric accounts to identify specific boundaries for Aboriginal nations or clans. There are different versions of Awabakal tribal boundaries documented by various sources however, it is generally understood that Awabakal country extended south from the Hunter River to Norah Head and Wyong and extended west to include the coastal bordering ranges (refer to Umwelt 2010). Awabakal country was bounded to the north by the Worimi, to the west by the Wonnarua, to the south-west by the Darkinjung and to the south along the coast by the Kurring-gai people. Threlkeld (a key source of information about the Awabakal, as discussed below) noted that different Aboriginal tribes were linked to specific areas but recognised that '*the natives here are connected in a kind of circle extending to the Hawkesbury and Port Stephens*' (Threlkeld 1825 in Gunson 1974).

In terms of records specific to the vicinity of the Modification Area, records relating to Aboriginal people being issued with blankets at Lake Macquarie in 1833 reference three Aboriginal women and 13 men who collected blankets as 'deriving their designation' from the Kurungbong tribe and frequenting the Kurungbong and Lake districts (Gunson 1974:362-364). The modern township of Cooranbong is located within 10 km of the Modification Area and, while it is a broad assumption, the designation of the 'Kurungbong' tribe is indicative that these may have been people who lived in the vicinity of the Modification Area.

Much of the information that is currently understood about the Awabakal people comes from the writings of missionary Lancelot Threlkeld, who initially established a mission at Belmont in 1825-6. This mission proved very costly and was considered unsustainable by the London Missionary Society. Threlkeld subsequently obtained a second land grant at Toronto and established the Ebenezer mission which he operated until 1841. During this time, Threlkeld devoted substantial time and effort to recording the Awabakal language and documented key aspects of Awabakal life, including aspects of material culture, spiritual beliefs, family structures, ceremonial practices and general aspects of day-to-day life. These are summarised and discussed in Umwelt (2010, 2011).

In broad terms, these records demonstrate that the Aboriginal people that Threlkeld wrote about were a society with highly developed beliefs and customs, who placed importance on key features in the landscape that were linked to beliefs and practices and who had a highly evolved understanding of how to live within their country in a manner that was sustainable prior to non-Aboriginal invasion.

However, Threlkeld was keenly aware of the negative impacts of this invasion and the ongoing growth of non-Aboriginal settlement in Newcastle and Lake Macquarie. He noted that the number of Aboriginal people occupying the Belmont, and subsequently Toronto missions, significantly decreased as a result of both the effects of disease and the ongoing attraction of employment in Newcastle (Threlkeld in Gunson 1974). His letters frequently documented the 'lamentable' treatment of Aboriginal people in the local area.

On behalf of ATOAC, Kerrie Brauer identified that 'the Awabakal and Guringai people have cultural and family ties with the Kurungbong tribe. With the amount of recorded sites, it shows that the Mandalong region was rich in cultural material and resources, considering the amount of rock shelters, grinding grooves and cultural material recorded with the Mandalong Mine Area. No further comments were received from other registered Aboriginal parties.

4.2 Archaeological Context

A review of available archaeological information is crucial to the archaeological assessment process, as it informs our understanding of archaeological site patterning, site survival and the potential for detection of extant archaeological sites. This information is discussed with reference to the outcomes of a search of the Aboriginal Heritage Information Management System (AHIMS) database (which documents the location and nature of sites for which site cards have been lodged) and a summary of the outcomes of previous archaeological investigations in the local area.

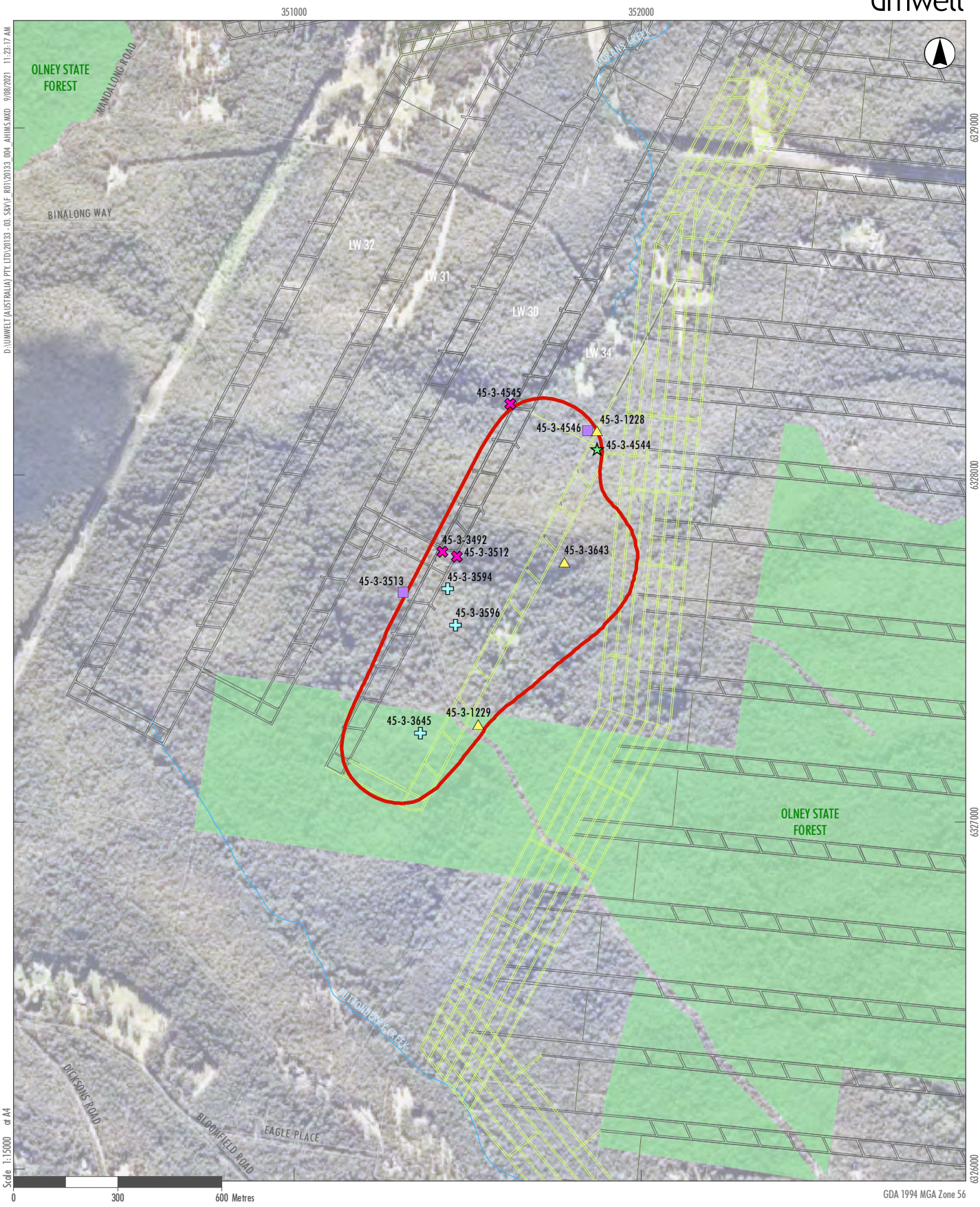
This information is then considered with reference to key environmental characteristics discussed above to establish a predictive archaeological model for the Modification Area.

4.2.1 AHIMS Results

A search of the AHIMS register was undertaken on 20 December 2020. The search encompassed an area of Easting: 349000 – 353000 and Northing: 6325800 and 6329600. The extensive search is attached at **Appendix 2**. The relative frequency of site types within the search area is outlined in **Table 4.1** with the site status summary of the AHIMS results outlined in **Table 4.2**. The recorded location of sites is shown in **Figure 4.1**.

As shown in the below table, sites associated with sandstone outcrops (either grinding grooves or habitation structures – which are typically rock shelters in this case) comprise over 53% of the total sites recorded within the search area. Further to this, most Potential Archaeological Deposit (PAD) and Art (Pigment or Engraved) sites within the search area are located within rock shelters, leaving a total of approximately 78% of sites recorded within the search area located on or within sandstone outcrop locations (such as sandstone benches or rock shelters). This is largely reflective of the nature of investigation in this area, as sites upon these sandstone formations are the most likely to be subject to impacts through longwall mining (such as cracking). The level of vegetation within the Modification Area is likely to have minimised visibility and exposure, and in turn has reduced the number of surface sites that are identifiable.

A number of modified trees (carved or scarred) have also been recorded within the search area. The presence of trees of this nature is likely associated with areas where historical logging practices have not occurred.



Legend

- Modification Area
- Proposed Workings
- Approved Workings
- State Forest
- Property Boundaries
- Watercourses

AHIMS Register Sites

- Grinding Groove
- Habitation Structure (no PAD or Objects)
- Rock Shelter with PAD
- Rock Shelter with Art
- Rock Shelter with Artefacts and PAD

FIGURE 4.1

Location of Previously Recorded Sites

Image Source: Nearmap (Jun 2021) Data source: DSFI (2020); AHIMS (2020)

Table 4.1 Relative frequency of site types in the search area

Site Type	Frequency	Percentage
Aboriginal Resource and Gathering	8	7.92%
Art (Pigment or Engraved)	8	7.92%
Artefact	11	10.89%
Artefact, Art (Pigment or Engraved)	1	0.99%
Grinding Groove	33	32.67%
Habitation Structure (comprising both rock shelters and rock overhangs)	21	20.79%
Modified Tree (Carved or Scarred)	5	4.95%
Potential Archaeological Deposit (PAD)	13	12.87%
Water Hole	1	0.99%
Total	**101**	

Table 4.2 Status of sites within the search area

Site Status	Frequency	Percentage
Valid	86	85.19%
Deleted	15	14.85%
Grand Total	**101**	

Based on the outcomes of the information compiled for the Mod 9 Heritage Management Plan (Umwelt 2021), there are some discrepancies between the AHIMS records and ground-truthed site locations in relation to sites within Mandalong area. The 12 sites listed in **Table 4.3** below are those known to be located within the Modification Area and/or within 15 metres of the Modification Area boundary. The inclusion of sites within 15 metres of the boundary was based on the potential dimensions of the site as compared to single point data. The sites comprise three grinding groove sites, three rock shelters with art (one of which may not be Aboriginal in origin), one rock shelter with artefacts and PAD, two rock shelters with PAD and three habitation structures (rock overhangs) that did not contain any areas of PAD or Aboriginal objects. Detailed information on these sites is provided in **Table 4.4**, with images provided in **Plates 4.1-4.13**.

Those sites referenced as being subject to the Mod 9 HMP have been assessed in relation to predicted subsidence impacts associated with the mining of LW30-31 and have been subject to additional baseline recording in accordance with the requirements of the HMP (Umwelt 2021).

Table 4.3 Previously recorded sites within the Modification Area

AHIMS	Site Name	Site feature	E_MGA	N_MGA
45-3-1228	Morans Creek Corrected	Rock shelter with art	351873	6328128
45-3-1229	Olney Corrected	Rock shelter with art	351530	6327281
45-3-3492	RPS CYL05	Grinding groove	351427	6327780
45-3-3512	RPS PS26	Grinding groove	351469	6327765
45-3-3513	RPS PS28	Rock shelter with PAD	351314	6327661
45-3-3594	RPS PS27	Habitation structure (no PAD or objects)	351443	6327671
45-3-3596	RPS PS30	Habitation structure (no PAD or objects)	351465	6327567
45-3-3643	RPS PS07	Rock shelter with art	351779	6327749
45-3-3645	RPS PS31	Habitation structure (no PAD or objects)	351364	6327255
45-3-4544	MS9-RS-3	Rock shelter with artefacts & PAD	351873	6328074
45-3-4545	MS9-GG-3	Grinding groove	351623	6328204
45-3-4546	MS9-RS-2	Rock shelter with PAD	351846	6328128

Table 4.4 Previously Recorded Aboriginal Sites

AHIMS ID	Site Name	Site identified	Site description
45-3-1228	Moran's Creek	Rock shelter with art	The rock shelter is as described in the original recording, with art present internally re-identified. Entrance is east facing with a moderately sized opening leading to a large, cavernous space internally. The shelter itself is part of a complex of larger boulders that have been subject to significant erosional processes, resulting in shelter spaces like this one. A number of other shelters in proximity to have formed similarly but do not contain art. Site is located east of ephemeral creek. Various artworks are present on the shelter walls, as recorded by Dyall in 1983. Max internal depth: 4.3m Max opening height: 135cm max opening width: 4.3m max height: 2.2m The recorded location of the site is incorrect, with the correct location some 200m south of the recording. Correct coordinates to be provided in an updated site card. Figures used in this report place this site at its corrected location.
45-3-1229	Olney	Rock shelter with art	The rock shelter was originally recorded as being within 5m across by 2m high with a sloping ceiling. The art within the shelter was described as yellow ochre being sub-ovoid in shape with vertical lines marked. This site was not subject to inspection in relation to Mod 9 however the location was ground-truthed by Mandalong staff and the recorded coordinates differ from those listed on AHIMS.
45-3-3492	RPS MAND STH CYL05	Grinding Groove	This site was originally recorded by RPS during the survey for the EIS. This site is comprised of 19 grinding grooves in four clusters upon three sandstone benches. Cluster 1 contains one grinding groove, Cluster 2 comprises seven grooves, Cluster 3 comprises two grooves and Cluster 4 comprises nine grooves. Cluster 1 and 2 are located upon the same bench, with Cluster 3 and 4 located upon additional benches.

AHIMS ID	Site Name	Site identified	Site description
45-3-3512	RPS MAND STH PS26	Grinding Groove	The site was originally recorded by RPS during the survey for the EIS. The site is described by RPS (2013) as containing a large number (between 6-31) of grooves incised upon one sandstone bench, with no further grinding grooves observed on other benches in the area. Based on the results of inspections completed under the Mod 9 HMP, this site comprises 12 grinding grooves located upon a sandstone bench, with the creek in this location running east to west. All the grooves are located upon one bench, which is an elongated flat bench with a small bowl area that retained water present upon the bench. A number of larger sandstone benches are present in close proximity; however, the shape and nature of these benches are largely unsuitable for grinding grooves.
45-3-3513	RPS MAND STH PS28	Rock shelter with PAD	Very large rock shelter located amongst prominent sandstone formation at the top of a ridgeline. Shelter provides full protection from weather and is divided into three distinct spaces. A large open space with standing room is found at the opening, a middle area of shoulder height and a raised rock bed and a third area of crawling space. The internal walls of the shelter are formed of actively eroding sandstone that has eroded in such a way for form a series of ledges with a gently sloping internal gradient. No artwork or cultural material was identified, however it is likely that this shelter has been used historically given the modern items found (bottles and ceramics). An area of PAD was previously identified within the shelter, however it is quite shallow deposit and only retains limited potential. Max opening width: 690cm Max depth: 690cm Max internal width: 19.5m Max opening height: 1.5m Max internal height: 2.3m Max main area length: 11m A small secondary shelter is located approx. 50 metres to the south/southeast with a crawl space opening. This space extends into a larger cavity capable of sheltering multiple individuals.
45-3-3594	RPS MAND STH PS27	Habitation structure (no PAD or objects)	Large rock shelter in poor condition, primarily comprised of conglomerate, pebbly sandstone with one clear opening. The floor of the rock shelter is a much cleaner sandstone. A number of small cracks were observed at the opening, likely further weathering from the poor-quality sandstone observed at the opening. No deposit is present in the floor of the shelter Max opening width: 490cm Max depth: 740cm Max internal width: 510cm Max opening height: 110cm Max internal height: 120cm
45-3-3596	RPS MAND STH PS30	Habitation structure (no PAD or objects	This site was originally recorded as a rock overhang approximately 3.1 metres long x 3.6 metres wide with two openings stacked above each other. There was no deposit (PAD) within either opening and no Aboriginal objects were recorded.

AHIMS ID	Site Name	Site identified	Site description
45-3-3643	RPS MAND STH PS07	Rock shelter with art	This site was originally recorded as a rock shelter measuring 3.7m x 3.2m x 0.7m with an area of sandy deposit near the shelter dripline. Charcoal motifs were recorded on the back wall of the shelter and images of these are included on the site card. Some of these appear to be modern graffiti based on the nature of the motifs.
45-3-3645	RPS MAND STH PS31	Habitation structure (no PAD or objects	This site was originally recorded as a rock overhang 3.5 metres by 4.2 metres by 1.8 metres in size. No Aboriginal objects were identified within the overhang, and it did not contain any deposit (PAD).
45-3-4544	MS9-RS-3	Rock shelter with artefacts and PAD	This site is a rock shelter located approx. 60 metres south of MS9-RS-2. The entrance is north facing with a small shallow opening with crawl space only. Two chert flakes were identified, potentially in situ. These consisted of 1 broken chert flake with 50% cortex and 1 broken chert flake with no retouch (with pot-lid scars indicating fire effect). A fragmented long bone (mammalian/marsupial) was also identified however this was relatively new in appearance. The shelter has a large angular shelf in the southern wall, with deeply incised angular grooving due to erosion. Within the shelter itself, a shallow area of potential deposit was observed. Max entrance height: 140cm Max internal depth: 350cm Max entrance length: 5m Max height: 4.2m
45-3-4545	MS9-GG-3	Grinding groove	This site consisted of a minimum of four grinding grooves located along an ephemeral creek, upon a sandstone platform. Dense vegetation is present in the surrounding area, however, visibility across the sandstone benches was good. The grooves were located across two sandstone benches.
45-3-4546	MS9-RS-2	Rock shelter with PAD	This site is a large rock shelter identified mid-way up a steep slope, south of ephemeral creek. No artefactual or cultural material recovered, however a small area of deposit with the potential to contain evidence of Aboriginal occupation was identified within the shelter. The site was recorded as a shelter given proximity to both the previously recorded site 45-3-1228 (Moran's Creek) and the newly identified MS9-RS-3 (containing PAD and two artefacts) and the present of deposits in one portions of the shelter. The shelter is well protected from the elements and has formed through erosional processes impacting a large sandstone boulder that has broken away from up slope at some stage. The internal space is gently sloped, with pitting along the roof surface and the entrance is faces west. Max opening height: 464cm Total height approx.: 7-8m Max opening length: 6.75m Max depth: 6.7m

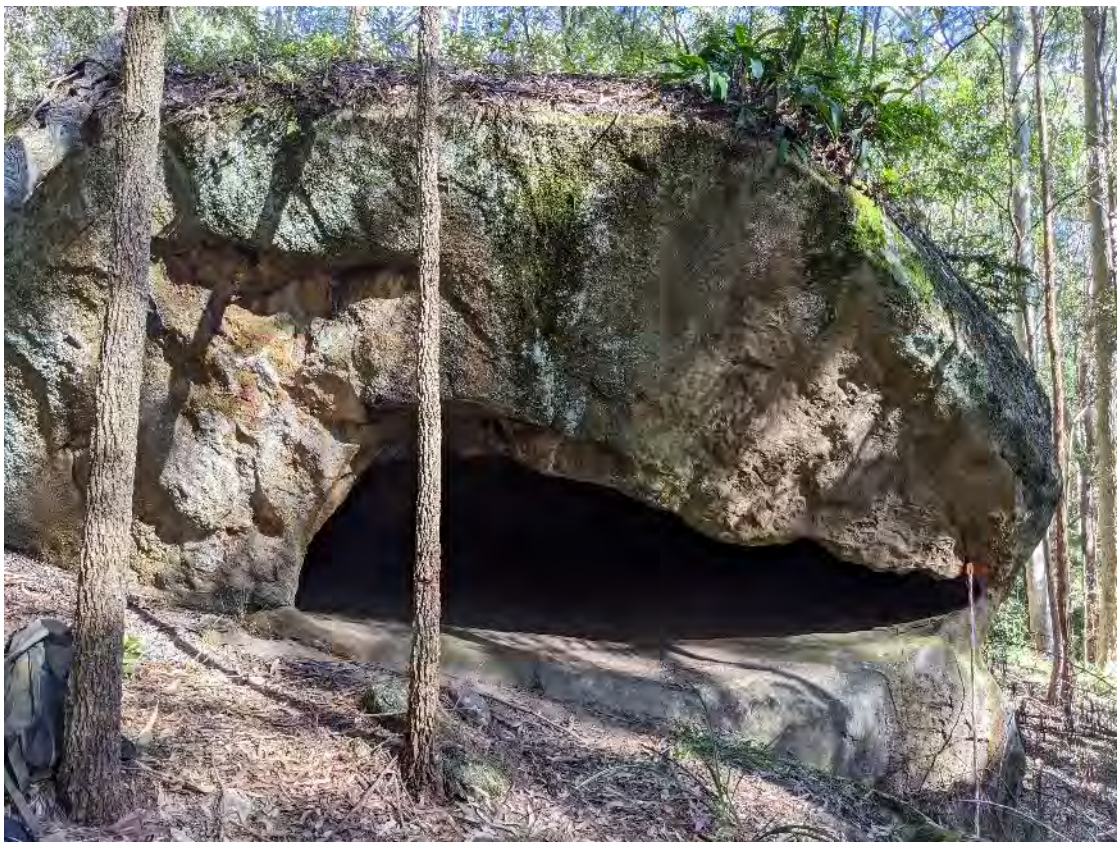


Plate 4.1 45-3-1228 external view

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Plate 4.2 45-3-1228 internal view

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Plate 4.3 45-3-1229 (photo – Jeff Dunwoodie)



Plate 4.4 RPS CYL05

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Plate 4.5 RPS PS26

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Plate 4.6 RPS PS28

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Plate 4.7 RPS PS27

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Plate 4.8 RPS PS30

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Plate 4.9 RPS PS07 external

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Plate 4.10 RPS PS31

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Plate 4.11 MS9-RS-3

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Plate 4.12 MS9-GG-3

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Plate 4.13 MS9-RS-2

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4.2.2 Archaeological Context

The regional distribution of sites within the Lake Macquarie Local Government Area is reviewed by Umwelt (2011) with reference to major landscape elements, noting key variations between the type and nature of archaeological sites located in varying contexts including the coast, lake shore and inland elevated ranges. Based on the model provided by Umwelt (2011) sites such as middens and large stone artefact scatters are most commonly found bordering Lake Macquarie and key estuarine watercourses that flow into Lake Macquarie but are also linked to the occurrence of suitable freshwater resources.

Within freshwater creek lines, site types will include stone artefact scatters and grinding grooves (where suitable sandstone exposures are present), noting that site occurrence is affected both by the reliability of the water sources and the inclination of bordering slopes. These creek lines were also used as a means of passage through the landscape from the coast and lowlands into the elevated ranges such as the Sugarloaf Range. Within these elevated mountain places, Umwelt (2011) note the potential for ceremonial sites but also reference the occurrence of sites such as rock shelters and grinding grooves (where the geology and topography is suitable).

These general predictions are considered with reference to the specific archaeological record of the Modification Area and its immediate surrounds, as discussed below.

The registered sites have primarily been recorded as a result of previous ACHAs and investigations conducted in relation to proposed developments in the local area. These are discussed below.

Umwelt (2021)

Umwelt (2021), in consultation with the registered Aboriginal parties, developed a Heritage Management Plan (MOD 9 HMP) for the Extraction Plan for the mining of LW30-31. In accordance with approval requirements, the HMP included the completion of survey in areas not surveyed as part of previous Aboriginal cultural heritage assessments. Over the course of the survey an additional nine new Aboriginal archaeological sites and one rock overhang (with no PAD or artefacts) were identified in the HMP Area in addition to six previously recorded sites. The newly recorded sites included three (AHIMS 45-3-4544, 45-3-4545 and 45-3-4546) located within the Modification Area while the previously recorded sites included all the sites within the current Modification Area with the exception of AHIMS 45-3-1229., 45-3-3643, 45-3-3596 and 45-3-3645. Subsidence impacts to these sites are approved under Mod 9, with the approved level of subsidence for Mod 9 provided in **Table 4.5** below.

Table 4.5 Mod 9 approved subsidence impacts for sites within current Modification Area

AHIMS #	Site Name	Site Feature (corrected)	Cracking Damage Potential	Erosion Damage Potential
45-3-1228	Morans Creek	Rock shelter with art	Very unlikely	Very unlikely
45-3-3492	RPS CYL05	Grinding groove	Unlikely	Unlikely
45-3-3512	RPS PS26	Grinding groove	Unlikely	Unlikely
45-3-3513	RPS PS28	Rock shelter with PAD	Very unlikely	Very unlikely
45-3-3594	RPS PS27	Habitation structure (no PAD or objects)	Very unlikely	Very unlikely
45-3-4544	MS9-RS-3	Rock shelter with artefacts & PAD	Very unlikely	Very unlikely
45-3-4545	MS9-GG-3	Grinding groove	Possible	Possible
45-3-4546	MS9-RS-2	Rock shelter with PAD	Very unlikely	Very unlikely

The Mod 9 HMP (Umwelt 2021) includes a range of management requirements for the recorded sites, including the requirement to undertake baseline recording prior to the occurrence of subsidence. This baseline recording for the above sites has been completed.

Umwelt (2018)

Umwelt (2018) completed an ACHA of a (then) proposed 7.7 km long 33kV power line, which extended from Mandalong Road to the Mandalong South Surface Site (MSSS). The assessment area comprised a variety of landforms, including modified slopes, slopes, drainage lines and crests. As a result of the survey undertaken to inform the assessment, three new archaeological sites were identified, all of which were recorded as isolated finds.

'Mandalong IF1' consisted of a single broken flake of tuff identified within a moderately inclined slope landform within the existing powerline easement. 'Mandalong IF2' consisted of a broken flake of silcrete located within the existing powerline easement on a gently inclined slope leading towards a minor drainage line. 'Mandalong IF3' consisted of a broken flake of chert located in a moderately inclined slope landform within the existing powerline easement. Based on the nature of the landform, the limited depths of

remnant topsoil and the level of disturbance at each of the sites, it was assessed that the potential for additional artefacts to be present within a sub-surface context in association with these sites was low.

In addition to the three sites described above, two specific areas within Survey Unit 7 and Survey Unit 20 were assessed to have low to moderate archaeological potential, due to their proximity to drainage lines and being located on relatively level ground with topsoil deposit present.

In consultation with the registered Aboriginal parties, the report recommended surface collection for the three newly identified sites (isolated finds), and an inspection of the areas of low to moderate archaeological potential by Aboriginal parties and an archaeologist following vegetation clearance in those areas. These works have been completed.

The remainder of the area was assessed to have low archaeological potential as it comprises landforms that do not provide direct access to reliable water sources, have a slope inclination that is not conducive to camping/occupation activities, have a limited depth of remnant topsoil and have been subject to varying levels of disturbance.

RPS (2013)

RPS (2013) completed an assessment of 2,360 ha of private and public land for the now approved Mandalong Southern Extension project, including the current Modification Area. The assessment resulted in the recording of 130 new archaeological sites in addition to 20 previously recorded sites. The most common site types were grinding grooves, rock shelters with PAD and scarred tress, although several artefact scatters were recorded in addition to stone arrangements.

The Mandalong Southern Extension Area is characterised by steeply inclined ridges with first and second order streams/drainage lines that drain into Morans Creek in the north and east. Typically, rock shelters were located on or within 200 m of the ridge crests and were formed from weathering sheets of sandstone or large boulders.

Grinding groove sites were located in the first and second order drainage lines and were typically identified on smooth, fine-grained sandstone sheets at elevations between 80 and 100 m AHD. It was observed that sandstone exposed in drainage lines above 100 m elevation tended to be rough and unsuitable for grinding grooves. Sandstone below 80 m tended to be more 'blocky' and did not have flat surfaces suitable for grinding grooves. Larger sandstone sheets were noted at the confluence of drainage lines and thus provided larger surfaces for grinding grooves. The numbers of grooves within each site ranged from single grooves to over 25 grooves at three sites. The majority of grinding grooves appeared to be for sharpening stone hatchet heads and typically were between 20 and 40 centimetres (cm) in length. Often pools of water were identified in close proximity to the grooves.

Artefact scatters were identified on the passes between catchments or on the gently sloped valley floor where Morans Creek became a third order stream. There was no distinct spatial patterning for scarred trees, however it was recognised that the area had previously been logged and thus the scarred trees identified probably represented a very small sample of their original distribution. In general, scarred trees were identified in areas that were inaccessible to logging, such as on steep slopes for which there was no vehicle access, or near steeply sided watercourses. Stone arrangements were generally comprised of vertically heaped blocks of stone or arranged in a circle; the stone blocks tended to be over 40 cm in length.

In reviewing these results, RPS (2013) suggested that the distribution of sites indicates that Aboriginal camping activities took place on the valley floors and in rock shelters and benching landforms on the ridgelines and upper slope/crest landforms and that the transition between these areas was potentially undertaken along watercourses (first and second order) as evidenced by the regular occurrence of grinding grooves. RPS (2013) noted that the Mandalong Southern Extension area may have been utilised as a transit

route between the low-lying lacustrine environments and the Watagan uplands. The presence of grinding groove sites with more than 20 grooves was considered to support the proposition that the area may have supported larger groups of Aboriginal people than previously thought.

In relation to potential impacts and mitigation requirements for the identified sites regarding the original Mandalong Southern Extension Project, it was assessed that the majority of the sites were 'unlikely' or 'very unlikely' to be impacted by proposed longwall mining.

As this assessment was undertaken to inform the EIS for the Mandalong South extension area, it included the current Modification Area however, at the time of survey, access was not available to all land parcels.

RPS (2016a)

RPS (2016) completed an ACHA for the Mandalong Transmission Line TL24 Relocation Project (SSD-5144 Mod 1), the easement for which is located approximately 6 km to the southwest of the current Modification Area. Four previously recorded sites (three sets of grinding grooves, a scarred tree and a stone arrangement) were inspected. The proposed works were assessed as unlikely to result in impact to the identified sites, which were protected with a suitable buffer.

RPS (2016b)

RPS (2016) completed an ACHA for a proposed extension to longwall panel 24 and the addition of longwall panel 24A within the Mandalong Southern Extension Area (SSD-5144 Mod 5). The assessment resulted in the identification of one scarred tree. Based on the low likelihood of impacts to the site, it was recommended that it be subject to monitoring under the provisions of Centennial's Northern Region ACHMP (2016).

Insite Heritage (2008)

This assessment was conducted to support a rezoning application. The site was located at Morisset Park Road, Morisset Park, approximately 5 km east of the current Modification Area. No surface archaeological evidence was identified. However, it was assessed that there was a low to moderate potential for small artefact scatter/s to be concealed under topsoil, with a recommendation that the area be designated a PAD (Insite Heritage 2008).

Besant (2001)

As a result of the assessment for a proposed school site on the lake foreshore approximately 5 km southeast of the current Modification Area, a series of test excavations were conducted. A total of 88 artefacts were recovered from a former beach ridge landform. The artefacts included geometric microliths and a knapping floor. It was considered that some of these artefacts were located undisturbed and in situ, while other artefacts appeared to have been re-deposited by wave action, displaying water worn features.

4.3 Predictive Model

Given that there are 12 previously sites recorded within the Modification Area, it is important to consider how these sites relate to the known environmental context and the regional archaeological context. The presence of these sites within the Modification Area helps inform the discussion regarding the potential for additional sites to be present and not previously recorded, particularly in areas that may not yet have been subject to archaeological survey. When the archaeological pattern for the region and local area is considered with reference to the environmental context of the Modification Area, the following predictions may be made in terms of the potential for additional (previously unidentified) sites to be present within the Modification Area:

- Scarred trees may be present within an area if suitable mature trees remain extant. Based on the occurrence of logging activity throughout the area, this likelihood is greatest in areas that may formerly have been difficult to access and/or remove logged timber. The potential for this site type to be present within the Modification Area is therefore assessed as low.

- Artefact scatters/isolated artefacts may be present within the Modification Area. While there is evidence of Aboriginal use of the area (based on the results of RPS (2013)), sites containing artefact scatters are generally poorly represented. This is likely due to the nature of archaeological survey focusing on areas of sandstone outcrop, where sites are more likely to be significantly impacted by undermining. Given the level of vegetation identified throughout the Modification Area, visibility may be a significant factor in identification of any surface artefact sites. There is also the possibility, given the disturbance history of the Modification Area, that any artefacts present may have been relocated or disturbed. However, should sites of this nature be present, it would be expected that they would be located upon flat or gently sloping landforms in proximity to watercourses, with perennial watercourses usually preferred. The potential for this site type to be identified within the Modification Area is therefore assessed as low due to the absence of perennial watercourses and the elevated or inclined nature of the majority of the area.

- Grinding groove sites occur most often in association with watercourses, where sandstone outcrops of a quality/inclination to provide a suitable grinding matrix occur. Should suitable sandstone exposure within drainage lines be present within the Modification Area, there is moderate to high potential for these site types to be present.

- The potential for rock shelter sites to be present depends on the presence of suitable sandstone outcrops or boulders in areas of suitable topography for weathering of the outcrops/boulders to form shelters. Based on the landforms within which the Modification Area is located and the presence of a recorded rock shelter and a rock overhang, should suitable outcrop be identified, the potential to identify additional rock shelters to those already recorded is considered to be moderate. Rock shelters are typically an easier site type to identify however the potential for additional sites of this type recognises that the Modification Area was not previously exhaustively surveyed.

- Stone arrangements are more likely to occur on high points such as crests. Stone arrangements are very susceptible to disturbance. As already noted, based on the landforms within which the Modification Area is located, as well as the proximity of the Modification Area to contemporary disturbance (including infrastructure, roadways and private residences) it is highly unlikely for any stone arrangements to be present in areas subject to disturbance. Where disturbance within the Modification Area is limited, stone arrangements may be present.

5.0 Survey Methodology

As discussed in **Section 4.0** above, the Modification Area was included within the larger area assessed as part of the original ACHA (RPS 2013) undertaken to inform the application for SSD-5144. At the time of the original assessment, a number of land parcels could not be surveyed due to lack of landholder consent. The intent of the current survey was to revisit previously recorded sites not recently subject to inspection in association with Mod 9 and to identify any additional sites that may be present. The eight previously recorded sites located within the Modification Area subject to assessment and baseline recording under the Mod 9 HMP were not reinspected during the survey as they had been subject to recent detailed recording.

5.1 Survey Strategy

The survey was undertaken to ensure that a representative sample of all landforms within the Modification Area was surveyed, as required to ensure compliance with the Code of Practice.

Based on the nature of the proposed impacts, the portions of the Modification Area that were predicted to be subject to the greatest amount of potential subsidence impacts were subject to intensive survey. This included the minor drainage line (in association with which grinding grooves may be identified), slope areas likely to contain rock outcrop suitable for use as shelter (in association with which rock shelter sites may be identified) and crests and ridges (in association with which stone arrangements may be identified) where these landforms are mapped as intersecting with areas of subsidence.

All efforts were made to achieve maximum survey coverage via pedestrian survey. Based on the size of the Modification Area, the Modification Area was surveyed in units that reflected a combination of the property boundaries and the most appropriate access to each landform.

Consideration of the potential for Aboriginal archaeological deposits to be present but not visible was a key component of the survey, as will be discussed further in **Section 5.5**.

5.2 Information Recorded During Survey

The survey units were defined and named with reference to Requirement 5c of the Code of Practice, including recording start and finish points and/or boundaries for all survey units using a hand-held GPS receiver (set to allow recording of data with datum MGA94) and topographic mapping (where relevant), with track logs to be recorded for all pedestrian transects. Start and finish points/boundaries for survey units were defined based on landforms, Modification Area boundaries, access or other arbitrary terminations (as specified in the Code of Practice). The spacing between individuals was also be recorded for each survey unit.

The distribution of survey participants across the survey units was discussed in the field with survey participants. Survey participants were generally spaced between 5 to 20 m apart where possible, dependent on ground surface visibility and density of vegetation.

Photographs were taken within the survey unit. Information recorded for the survey unit included:

- the landform
- gradient (where relevant)
- vegetation

- geology and soils (where suitable areas of exposure/visibility were present)
- identified Aboriginal resources
- levels of average ground surface visibility within the survey unit (in accordance with Requirement 9 of the Code of Practice)
- extent and type of exposures within the survey unit (with reference to the factors leading to the exposure such as erosion, earth-moving activities, proximal construction works, etc.)
- any site or area of identified Aboriginal archaeological potential present within the survey unit
- any site or area of identified historical archaeological potential present within the survey unit.

5.3 Survey Coverage

In accordance with the Code of Practice, the survey coverage description includes landform unit, the total area surveyed within the landform unit and the quantification of the level of ground surface visibility and exposure. Ground surface visibility is defined as "the amount of bare ground (or visibility) on the exposures which might reveal artefacts or other archaeological materials" (DECCW 2010:13). Exposure is defined as "the percentage of land for which erosion and exposure was sufficient to reveal archaeological material on the surface of the ground" (DECCW 2010:13). As such, exposure refers to the potential for an area to reveal subsurface artefacts or deposits rather than the mere observation of the amount of bare ground.

The calculation of effective survey coverage is undertaken to designate the proportion of the Modification Area in which it is possible to accurately assess the presence or absence of archaeological material. Survey coverage is calculated by multiplying the survey unit area by the percentage of ground surface visibility and exposure within the survey unit. The survey coverage is then expressed as a percentage for the whole survey unit.

5.4 Unsurveyed Areas

As discussed in the above sections, previous investigations in part of the Modification Area have been undertaken as part of the preparation of the Mod 9 HMP (Umwelt 2021). It was not intended to resurvey these areas as part of the current assessment but to incorporate the results of the previous assessment in terms of outcomes and recommendations. Any Aboriginal archaeological sites within this area previously surveyed are still considered within the impact assessment of this ACHA.

5.5 Assessment of Sub-Surface Archaeological Potential

The assessment was undertaken with reference to factors including the archaeological context of the local area, the evaluation of the soil profile (based on soil landscape mapping, exposed soil profiles identified during the survey and geomorphic understandings of the area) and the identification of landforms that may have greater archaeological sensitivity. The following terms will be employed to classify the sub-surface archaeological potential of specific locations

- **no archaeological potential**: areas where the natural soil profile has been removed through geomorphic processes or human action, thereby removing any archaeological resource of the location. Examples of this category would include a landslide or industrial quarry sites.

- **low archaeological potential**: landscape areas that may have been utilised by Aboriginal people in the past, but at a lower intensity than all surrounding landforms. The density of artefacts deposited within these areas would therefore be low. This category also includes landscape areas of low terrain integrity, where geomorphic processes or human action may have redistributed artefacts from their deposited locations, resulting in site disturbance or destruction.

- **moderate archaeological potential**: landscape areas that are predicted to have been utilised by Aboriginal people in the past, but not intensively or repeatedly. There is therefore potential for artefact deposition, but at a lower frequency and density than in areas of high archaeological potential. Terrain integrity in these areas may be variable, but the majority of open camp sites are expected to be of low to moderate integrity only, with geomorphic processes not acting to bury deposits *in situ.*

- **high archaeological potential**: landscape areas predicted to have been intensively or repeatedly utilised by Aboriginal people in the past, such as creek confluences or elevated terraces above major watercourses. Terrain integrity in these areas may be variable, but the majority of open camp sites are expected to be of low to moderate integrity only, with geomorphic processes not acting to bury deposits *in situ.*

- **very high archaeological potential**: landscape areas predicted to have been more intensively or repeatedly utilised than all surrounding landforms by Aboriginal people in the past, such as major creek confluences or lagoons. Terrain integrity in these areas may be variable, but these landforms may include areas of high terrain integrity, where geomorphic processes may have acted to bury deposits *in situ*. Sites may therefore be of very high archaeological potential.

5.6 Habitation Structures (Rock Shelters and Rock Overhangs)

Given previous complexities in recording rock shelters for the assessment completed by RPS (2013), recognition of the use of the landscape from an archaeological perspective versus a cultural perspective was determined as an important aspect for this assessment. Heritage NSW includes habitation structures (typically rock shelters) as a site feature. This category can include the potential archaeological deposits within the shelter, the shell or artefact deposits clearly spilling from the shelter, and the art on the rock shelter itself. As a result, it was determined throughout the recording of sites within the Modification Area, that any sites defined as rock shelters would only be ones that contained either areas of potential archaeological deposit, stone artefacts, culturally deposited shell or art.

However, it is recognised that shelters that do not contain this evidence of Aboriginal occupation were still likely utilised by Aboriginal people in the past. Recognition of this was deemed as important to the registered Aboriginal parties, who identified that these other shelters that do not contain evidence of occupation may have either been utilised opportunistically or their evidence of occupation may have been removed by historical or environmental impacts. As a result, these shelters that do not contain evidence of occupation are recognised as rock overhangs. These overhangs will not be recommended for listing on the AHIMS database, however their significance to registered Aboriginal parties is recognised through their ongoing management.

6.0 Results

The survey of the Modification Area was conducted by archaeologists and registered Aboriginal party representatives between 14 and 17 September 2020 and 21 July 2021. Participants in the survey are listed in **Table 6.1**.

Table 6.1 Survey Participants

Date	Organisation	Name
Date 14 – 17 September 2020	Awabakal Descendants Traditional Owners Aboriginal Corporation	Peter Leven Tori Leven
	Awabakal Traditional Owners Aboriginal Corporation	Kyle Howie
	Biraban Local Aboriginal Land Council	Norman Archibald
	Cacatua Cultural Consultants	Ashley Sampson
	Darkinjung Local Aboriginal Land Council	Barry Williams
	Guringai Tribal Link Aboriginal Corporation	Tracey Howie
	Wonn1 Contracting	Arthur Fletcher
21 July 2021	Awabakal Traditional Owners Aboriginal Corporation	Kyle Howie
	Bahtahbah Local Aboriginal Land Council	Norman Archibald
	Guringai Tribal Link Aboriginal Corporation	Tracey Howie
	Wonn1 Contracting	Arthur Fletcher

6.1 Information Provided by Aboriginal Party Representatives

In accordance with the approved methodology, Aboriginal party representatives who participated in the survey were requested to provide information on any Aboriginal cultural values that they identified within the Modification Area. Key information provided by Aboriginal party representatives is documented in **Section 2.5** and is not repeated here.

6.2 Results of the Archaeological Survey

The archaeological survey of the Modification Area was conducted between 14 and 17 September 2020 and 21 July 2021 by Ashley O'Sullivan (Senior Archaeologist, Umwelt), Alison Fenwick (Archaeologist, Umwelt) and members of the Aboriginal parties outlined in **Table 6.1** above, accompanied by Jeff Dunwoodie and Kieran Fiatarone (Centennial Mandalong). Based on the nature of access to properties within the Modification Area, survey units were established largely based on discrete Lot and DP boundaries. This was determined as the most appropriate course of recording given the varying nature of clearance and disturbance identified within each property. Four survey units were identified within the Modification Area (SU1 – SU4, refer to **Figure 6.1**) with one unit within the Modification Area having been subject to previous archaeological survey as part of the Modification 9 HMP. The ground surface visibility (GSV) and exposure were recorded and analysed for each survey unit, as shown in **Table 6.2**.



Legend

- Modification Area
- Proposed Workings
- Approved Workings
- Property Boundaries
- Watercourses
- Survey Tracks

Survey Units

- Area Previously Surveyed
- SU1
- SU2
- SU3
- SU4

FIGURE 6.1

Location of Survey Units

Image Source: Nearmap (Jun 2021) Data source: DSFI (2020)

Table 6.2 Description of Survey Units with the Modification Area

Survey Unit	Description	Photo Reference
Area Previously Surveyed	This area can be described as mid and lower slopes that trend north-south off a ridge line within SU1 towards Morans Creek. The area is very well vegetated, with limited areas of exposure. Some exposures were observed during the original survey, however these were predominantly associated with areas of modern disturbance such as tracks, dams and where vegetation has been cleared. Morans Creek retained limited sandstone outcrop within this area, however a large grouping of sandstone boulders was observed at the confluence of Morans Creek and an unnamed tributary. Three rockshelter sites were observed within this grouping of shetlers, including one previously recorded shelter (Morans Creek – corrected location) and two newly identified shelters with areas of PAD and/or surface artefacts (being MS9-RS-2 and MS9-RS-3). Three Aboriginal sites have been previously recorded within this area as part of prior surveys, being Morans Creek, MS9-RS-2 and MS9-RS3.	
SU1	SU1 is a small section of ridge and upper slopes that extend east to west along Toepfers Road. Both sides of the ridge were surveyed for the potential for additional rock shelter sites to be present within the rock outcrop. Visibility within this survey unit was largely constrained to existing tracks (such as Toepfers Road) or upon sandstone bench. This survey unit was well vegetated, with areas of exposure predominantly limited to Toepfers Road or upon sandstone outcrop. RPS PS07 is located on a south facing portion of the ridge, located upon the same sandstone outcrop as an extensive number of rock shelters located further to the west. While suitable outcrop for rockshelters was present on the south side of Toepfers Road, no additional Aboriginal sites were observed outside of the previously recorded site within the survey unit. One small potential rock overhang was observed during the course of the survey, however in discussion with the Aboriginal parties present, it was not identified as a site as there was no area of deposit or evidence of use. Also, the size of the overhang was largely deemed unsuitable for ongoing use. It was discussed that the overhang may have been used opportunistically for use to escape inclement weather. One Aboriginal site was observed within SU1, being RPS PS07.	**Plate 6.1 – 6.3**

Survey Unit	Description	Photo Reference
SU2	SU2 comprised the lower slopes of the ridgelines contained within SU1 and SU3, leading to the tributary creek line at the base of the slopes. Slopes in proximity to the creek line were generally lower gradient when compared to the mid and upper slopes on either side of the creek line. When compared to the other survey units, SU2 has been subject to the most significant modern disturbance through the creation of a driveway extending from Kiar Ridge Road down to the property present on the south side of the creek line. Significant vegetation removal and landform modification has occurred in proximity to the property, with this area almost entirely disturbed. An old forestry track was observed on the south side of the creek line as well, extending from the property and moving east along the creek. While modern disturbance was most visible in this survey unit, visibility across the survey unit was the poorest of the four survey units as only the driveway down to the property displayed any exposures. All other areas within the survey unit were either densely vegetated or covered with imported grasses. While two Aboriginal sites have previously been recorded within this survey unit (being two grinding grooves), no suitable outcrop was observed within the areas surveyed along the creek line away from the recorded sites. Two Aboriginal sites have been previously recorded within this survey unit as part of previous surveys for Modification 9 HMP and baseline surveys, being RPS CYL05 and RPS PS26.	**Plate 6.4 – 6.6**
SU3 / SU4	SU3 / SU4 contained largely similar landform characteristics, and therefore are discussed together. These survey units are defined by a ridgeline that runs north to south primarily within SU3, with a small spur of the ridgeline extending out along the surveyed area within SU4. The ridgeline in this area is primarily defined by the alignment of Kiar Ridge Road. Slopes on the north side of this spur extend towards the tributary located within SU2, while the slopes on the southern side of SU4 extend towards Buttonderry Creek. Visibility in these two survey units was generally quite reasonable, given how extensive Kiar Ridge Road is and the level of sandstone outcrop observed through both survey units. Survey efforts within these survey units primarily consisted of identifying the two Aboriginal sites previously recorded within these survey units that had not recently been visited, being RPS PS31 and Olney. Additional survey efforts were undertaken away from the previously recorded sites in order to understand whether sandstone outcrop observed in this area had the potential for additional rockshelter sites. While suitable outcrop for rockshelters was present either side of Kiar Ridge Road, no additional Aboriginal sites were observed to the five previously recorded across these two survey units. Five Aboriginal sites have been previously recorded across SU3/SU4, being RPS PS27, RPS PS28, RPS PS30, RPS PS31 and Olney (corrected location).	**Plate 6.7 – 6.12**



Plate 6.1 Outcrop observed within SU1

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Plate 6.2 Rock overhang observed within SU1

© Umwelt, 2021



Plate 6.3 RPS PS07

© Umwelt, 2021



Plate 6.4 Charcoal markings as described in the PS07 site card

© Umwelt, 2021



Plate 6.5 Creek line within SU2

© Umwelt, 2021



Plate 6.6 Visibility and lower slopes evident within SU2

© Umwelt, 2021



Plate 6.7 Olney rock shelter (photo – Jeff Dunwoodie)



Plate 6.8 Rock outcrop observed within SU3

© Umwelt, 2021



Plate 6.9 Rock outcrop observed within SU4, looking towards Buttonderry Creek

© Umwelt, 2021



Plate 6.10 PS31 rock shelter

© Umwelt, 2021



Plate 6.11 PS31 rock shelter, looking towards SU3

© Umwelt, 2021

6.3 Effective Coverage

Generally, the level of effective coverage within the Modification Area was low. The main factor contributing to the low coverage was the limited ground surface visibility resulting from grass cover and leaf litter, or other general vegetation such as moss coverage on stone outcrop. Where tracks were present, the level of exposure was very high (between 90 and 100%), however these areas were generally eroded to hard-setting A_2 horizon soils or B horizon soils. In some cases, the tracks had been in-filled with introduced material effectively reducing their visibility of a natural ground surface to 0%. In some cases where either 4WD use of the Modification Area was evident or significant weathering of tracks was observed (particularly in association with powerline easement tracks), this erosion exposed parent material. As such, the survey units with the highest levels of effective coverage also represented the areas with the largest amount of tracks present.

Table 6.3 Effective survey coverage of the Modification Area

Survey Unit	Survey Unit Area	Visibility %	Exposure %	Effective Coverage Area	Effective Coverage Percentage
Area Previously Surveyed	86,444 m^2	N/A	N/A	N/A	N/A
SU1	118,395 m^2	10	5	592 m^2	0.5%
SU2	124,343 m^2	5	5	310 m^2	0.25%
SU3	104,877 m^2	10	10	1,049 m^2	1%
SU4	88,273 m^2	5	10	441 m^2	0.5%

6.4 Summary of Archaeological Results

The survey of the Modification Area comprised a pedestrian survey in accordance with the sampling strategy outlined in **Section 5.0.** No new Aboriginal objects or sites were observed during the course of the survey. However, the Modification Area contains twelve previously recorded Aboriginal sites.

Smaller overhang sites were identified within the Modification Area. It is likely that these overhangs were utilised opportunistically by Aboriginal people given their proximity to areas that have demonstrated use, however no evidence of this use remains. As a result, these overhang sites have not been recommended for recording on the AHIMS database given they do not meet the necessary criteria of a rock shelter.

Low levels of visibility do not preclude the potential for additional Aboriginal stone artefacts to be present within a subsurface context throughout the Modification Area. The landforms mentioned in **Section 3.1** are, based on a review of the associated soil landscapes, typically associated with relatively shallow soil profiles that are subject to erosion, which was observed during the survey in areas of exposure and reduced vegetation.

The Modification Area has also been subject to a range of impacts as a result of modern land uses, largely relating to the establishment of infrastructure such as access tracks and powerline easements, as well as vegetation clearance in some portions. These activities are likely to have exacerbated the rate and severity of erosion in these areas, which in turn may have resulted in disturbance to topsoil profiles. During the survey of the Modification Area, the majority of soil profiles observed comprised exposed, hardened B horizon soils or shallow A horizon soils over B horizon soils or bedrock. The majority of exposed soil profiles were observed in conjunction with modern disturbances such as access track establishment or powerline easement access. It is likely, however, that these areas are not completely representative of the soil profiles within the Modification Area, as remnant vegetation will have acted to retain soils where present. What is clear from the environmental context of the Modification Area is that the soil profiles within are highly susceptible to erosion and are generally poorly formed. Given the generally sloping nature of landforms within the Modification Area, in-field observations reflected the prediction that areas where soil can be retained are very limited.

When considered with reference to the archaeological pattern identified within the local area, the criteria for differing levels of archaeological potential as described in **Section 5.5**, and the discussions held around the existing registered sites across the Modification Area, the Modification Area is assessed as having an overall low subsurface archaeological potential with subsurface deposits primarily associated with rock shelter sites. With reference to this level of potential, it is recognised that additional isolated artefacts or low-density artefact scatters may be present, but these are not likely to be common and will typically have been subject to disturbance.

It is noted that the predictive model and archaeological results within the Modification Area are largely reflective of the nature of sites focused on within the survey methodology. As previously discussed, sites formed upon sandstone are the most susceptible to disturbance through longwall mining due to subsidence, which may result in cracking. While the survey of the Modification Area undertaken as part of this assessment was comprehensive, areas of visibility were largely tied to tracks, sandstone outcrop on ridges and sandstone benches within creek lines and as such, survey focused on these areas. There may be potential for further sites or site types to be present within the Modification Area because of this focused survey. However, this potential is deemed to be low, as the regional archaeological model demonstrates that artefact sites or dense artefact deposits have been identified upon elevated, level platforms in association with perennial creek lines. Landforms of this nature were not observed consistently within the Modification Area, and where they were observed, demonstrated no evidence of containing surface or subsurface archaeological deposit.

With regard to identification of further sites that were the focus of this investigation (being grinding grooves and rock shelters), while some potential remains for sites of this nature to be further identified, this potential is considered to be low. Further grinding grooves may be observed along creek lines within the Modification Area not subject to survey (primarily where vegetation was too dense to traverse the creek lines), or where vegetation coverage (predominantly moss growth) has covered the presence of grooves upon the sandstone benches. Further rock shelter sites may be observed upon rock outcrop not identified or accessible during the survey of the Modification Area. However, as mentioned above, given the comprehensive nature of the in-field survey targeting the landforms where these sites would be located, this potential for further sites to be identified is low.

Based on the criteria for the assessment of archaeological potential, the Modification Area is deemed to have low archaeological potential for further Aboriginal archaeological sites to be identified across its entirety. Should further sites be present, it is considered that these are most likely to be grinding grooves located upon sandstone benches where visibility was very poor.

7.0 Significance Assessment

The Burra Charter: the Australia ICOMOS Charter for Places of Cultural Significance (Australia ICOMOS 2013) (the Burra Charter) defines cultural significance as the sum of the qualities or values that a place embodies. The Burra Charter identifies the values – aesthetic, historic, archaeological, social or cultural and spiritual – that contribute to cultural significance.

- **Social** or **cultural** value refers to the spiritual, traditional, historical and contemporary associations and attachments of a place (OEH 2011:8). It is noted that a consensus as to the cultural value of an object or place is not always possible as people experience places and events differently.

- **Spiritual** value refers to the intangible values embodied in a place, which give it importance in the spiritual identity.

- **Archaeological** value refers to the potential physical remains and the ability of those remains to provide an understanding about an aspect of the past.

- **Aesthetic** value refers to the sensory and perceptual experience of a place. It may consider form, scale, texture and material of the fabric or landscape and may also include smell and sounds associated with the place (OEH 2011:9).

- **Historic** value encompasses all aspects of history and as such is often underlying other values. A place may have historic value because it has influenced, or been influenced by, an historic event, phase, movement or activity, person or group of people.

7.1 Social or Cultural Value

Cultural value refers to the spiritual, traditional, historical or contemporary associations and attachments a place has for Aboriginal people (OEH 2011:8). There is not always consensus about the cultural value of a place as people experience places and events differently, and in some instances cultural values may be in direct conflict. Cultural significance can only be determined by Aboriginal people and is identified through Aboriginal community consultation.

It is noted that the registered Aboriginal parties have previously identified the local area as being of very high significance, as documented in the preface to this report.

It was recognised that registered Aboriginal parties may wish to provide information regarding the cultural significance of the Modification Area. In accordance with the approach included within Centennial's Northern Region ACHMP and developed in consultation with the registered Aboriginal parties, it is requested that the registered Aboriginal parties specifically consider the cultural significance of the Modification Area against the agreed criteria provided in **Table 7.1**. The significance ranking point system used to attribute significance against these criteria is provided in **Table 7.2.**

Table 7.1 Criteria from ACHMP for assessment of Aboriginal cultural significance

Criteria	Description
Ceremonial/Spiritual/Dreaming Connection	This criterion refers to any ceremonial, spiritual or dreaming connection that the site may have to the Traditional Owner Group/s. This criterion also considers its past teaching potential.
Rarity	This criterion refers to how rare the site is in reference to location, site type, site integrity on a local and regional scale. Rarity is also assessed on its archaeological potential.
Inter-relatedness	This criterion refers to whether the site is believed to be related or associated to another site in the landscape.
Teaching potential	This criterion refers to any potential future and/or present use for educational purposes in the teaching of culture and history.
Aesthetics	This criterion refers to the site's aesthetic qualities. Please note that the notion of visual appeal is a subjective concept.
Outlook	Outlook refers to whether the site has an extensive outlook over country and/or if the area of the site has an attractive perspective to the Traditional Owners.

Table 7.2 Cultural significance ranking system from ACHMP

Ranking System	Points
High Cultural Significance	1 Point
High to Very High Cultural Significance	2 Points
Very High Cultural Significance	3 Points
Very High to Extremely High Cultural Significance	4 Points
Extremely High Cultural Significance	5 Points

7.1.1 Cultural Significance of the Recorded Sites

Centennial Mandalong conducted a cultural heritage significance workshop with members of the Aboriginal community to understand the Aboriginal cultural significance of sites identified within the Modification Area during the Mod 9 HMP process. Based on the outcomes of this assessment, the assessments of cultural significance in **Table 7.3** were agreed upon by those in attendance. A copy of the cultural heritage significance workshop minutes can be found in **Appendix 1.** The significance of other previously recorded sites was also previously assessed in accordance with the agreed methodology, with the outcomes of the prior assessments also included in **Table 7.3**.

Table 7.3 Cultural significance attributed to the sites within the Modification Area

AHIMS #	Site Name	Overall Cultural Significance
45-3-1228	Moran's Creek;	Extremely high
45-3-1229	Olney	Extremely high
45-3-3492	RPS MAND STH CYL05	Extremely high
45-3-3512	RPS MAND STH PS26	Extremely high
45-3-3513	RPS MAND STH PS28	Extremely high
45-3-3594	RPS MAND STH PS27	Not assessed
45-3-3596	RPS MAND STH PS30	Not assessed
45-3-3643	RPS MAND STH PS07	Not assessed
45-3-3645	RPS MAND STH PS31	Not assessed
45-3-4544	**MS9-RS-3**	**Extremely high**
45-3-4545	**MS9-GG-3**	**Very high to extremely high**
45-3-4546	**MS9-RS-2**	**Extremely high**

*Sites in bold are those identified during the Mod 9 HMP survey and for which cultural significance was recently evaluated. Cultural significance for the other previously recorded sites is taken from the Northern Region ACHMP.

No further information on the cultural significance of identified sites was provided by the registered Aboriginal parties following their review of the draft ACHA.

In addition to the site-specific information, please refer to the Statements of Significance at the foreword to this report.

7.2 Scientific Values and Significance Assessment

Archaeological significance is determined by assessing Aboriginal sites/places/objects against a number of archaeological criteria as set out in the Code of Practice. The assessment of Aboriginal archaeological significance is used to develop a series of cultural heritage management and impact mitigation strategies. The archaeological significance of the Modification Area has been assessed in accordance with the criteria provided in **Table 7.4**

Table 7.4 Archaeological significance assessment criteria

Criterion	Low	Moderate	High
Rarity	The site within the surrounding landscape, its integrity, contents and/or potential for subsurface artefacts, are common within the local and regional context.	The site within the surrounding landscape, its integrity, contents and/or potential for subsurface artefacts, are common within the local context but not the regional context.	The site within the surrounding landscape, its integrity, contents and/or potential for subsurface artefacts, are rare within the local and regional context.
Representativeness	This site, when viewed in relation to its integrity, contents and/or potential for subsurface artefacts is common within a local and regional context and sites of similar nature (or in better condition) are already set aside for conservation within the region.	This site, when viewed in relation to its integrity, contents and/or potential for subsurface artefacts, is uncommon within a local context but common in a regional context and sites of similar nature (or in better condition) are already set aside for conservation within the region.	This site, when viewed in relation to its integrity, contents and/or potential for subsurface artefacts is uncommon within a local and regional context and sites of similar nature (or in better condition) are not already set aside for conservation within the locality or region.
Research potential	The site, when viewed in relation to its integrity, contents and/or potential for subsurface artefacts has limited potential to contribute to a greater understanding of how Aboriginal people lived within this area or region.	The site, when viewed in relation to its integrity, contents and/or potential for subsurface artefacts has moderate potential to contribute to a greater understanding of how Aboriginal people lived within this area or region.	The site, when viewed in relation to its integrity, contents and/or potential for subsurface artefacts has high potential to contribute to a greater understanding of how Aboriginal people lived within this area or region.
Education potential	The site is not readily accessible and/or when viewed in relation to its contents, integrity and location in the landscape has limited suitability to be used for educational purposes. Other sites with higher education potential are known to be present in the local area and region.	The site is not readily accessible and/or when viewed in relation to its contents, integrity and location in the landscape provides a tangible example that is suitable to assist in educating people regarding how Aboriginal people lived in this area or region. However, other sites with higher education potential are known or expected to be present in the local area or region.	The site is readily accessible and/or when viewed in relation to its contents, integrity and location in the landscape, provides a very good tangible example that is suitable to assist in educating people regarding how Aboriginal people lived in this area or region. Other sites of higher education potential are generally not known to exist in the local area or region.
Integrity	Stratigraphic integrity of the site has clearly been destroyed due to major disturbance/loss of topsoil. The level of disturbance is likely to have removed all spatial and chronological information.	The site appears to have been subject to moderate levels of disturbance, however, there is a moderate possibility that useful spatial information can still be obtained from subsurface investigation of the site, even if it is unlikely that any useful chronological evidence survives.	The site appears relatively undisturbed and there is a high possibility that useful spatial information can still be obtained from subsurface investigation of the site, even if it is still unlikely that any useful chronological evidence survives.

A summary of the scientific significance of sites using information from the Mod 9 HMP and Northern Region ACHMP is presented in **Table 7.5**.

The archaeological significance of site 45-3-1229 is not addressed in the ACHMP. In considering the significance of this site, it is recognised that rock shelters are locally common but are regionally rare. The rarity of the site is further increased by the presence of applied art on the shelter walls, albeit rarely limited. The significance of this site is therefore assessed consistently with the Morans Creek rock shelter with art and is considered of high significance based on its rarity, research potential, educational potential and integrity.

Table 7.5 Summary of Archaeological Significance for Previously Recorded Sites with the Modification Area

AHIMS #	Site Name	Archaeological significance (local)
45-3-1228	Moran's Creek;	High
45-3-1229	Olney	Not assessed
45-3-3492	RPS MAND STH CYL05	High
45-3-3512	RPS MAND STH PS26	High
45-3-3513	RPS MAND STH PS28	High
45-3-3594	RPS MAND STH PS27	High (from RPS 2013)
45-3-3596	RPS MAND STH PS30	High*
45-3-3643	RPS MAND STH PS07	High
45-3-3645	RPS MAND STH PS31	High
45-3-4544	MS9-RS-3	High
45-3-4545	MS9-GG-3	Moderate to high
45-3-4546	MS9-RS-2	Moderate to high

*Significance assessment for this site references it as 'shelter with art' which differs from all other records for this site. Possible error in ACHMP

7.3 Historic Value

Historic value encompasses all aspects of history and often underlies other values. A place may have historic value because it has influenced or been influenced by a historic event, phase, movement, activity, person or group of people.

No specific areas or items of historical value (including those with a direct association with Aboriginal people) were identified in the Modification Area during the assessment.

7.4 Aesthetic Value

Aesthetic value refers to the sensory and perceptual experience of a place. It may consider form, scale, texture and material of the fabric of the landscape and may also include smell and sounds associated with the place (OEH 2011:9). No notable aesthetic values were identified in relation to the identified sites or the Modification Area as a whole.

7.5 Intergenerational Equity

Intergenerational equity is the principle whereby the present generation should ensure the health, diversity and productivity of the environment for the benefit of future generations (Commonwealth of Australia, 2002:5).

When assessing likely harm on Aboriginal objects and places, it is important to consider the principles of ecologically sustainable development (ESD), in particular the precautionary principle and the principle of intergenerational equity. Intergenerational equity is:

"…the principle whereby the present generation should ensure the health, diversity and productivity of the environment for the benefit of future generations.

In terms of Aboriginal heritage, intergenerational equity can be considered in terms of the cumulative impacts to Aboriginal objects and places in a region. If few Aboriginal objects and places remain in a region (for example, because of impacts under previous AHIPs), fewer opportunities remain for future generations of Aboriginal people to enjoy the cultural benefits of those Aboriginal objects and places.

Information about the integrity, rarity or representativeness of the Aboriginal objects and places proposed to be impacted, and how they illustrate the occupation and use of land by Aboriginal people across the region, will be relevant to the consideration of intergenerational equity and the understanding of the cumulative impacts of a proposal. Where there is uncertainty, the precautionary principle should also be followed (DECC 2009: 26)*".*

The Modification Area contains 12 sites that have been identified to be of very high to extremely high significance to Aboriginal people (as identified by the registered Aboriginal parties during in-field consultation and in previous significance assessments). It is noted that no sites within the Modification Area have any higher potential for subsidence impacts than 'Possible' (discussed further in **Section 8.0**, with potential impacts to be avoided or minimised by the implementation of a management and monitoring program, with mitigation proposed only where absolutely necessary (see **Section 9.0**). This should ensure that impacts to Aboriginal sites (of both scientific and cultural significance) are minimised, and the cultural significance of sites retained throughout.

8.0 Impact Assessment

Subsidence predictions for Modification 10 have been provided by Centennial Mandalong (DgS July 2021). The below section considers the impacts of the predicted subsidence levels on Aboriginal heritage sites identified within the Modification Area.

Impacts are expressed in terms of the likelihood of impact from cracking or erosion. The subsidence assessment for the proposed modification (DgS 2021) specifies the following ranges for potential subsidence impacts:

- Very unlikely (<5% probability)
- Unlikely (5-10% probability)
- Possible (10-25% probability)
- Likely (>25% probability).

8.1 Impact to Aboriginal Heritage Sites

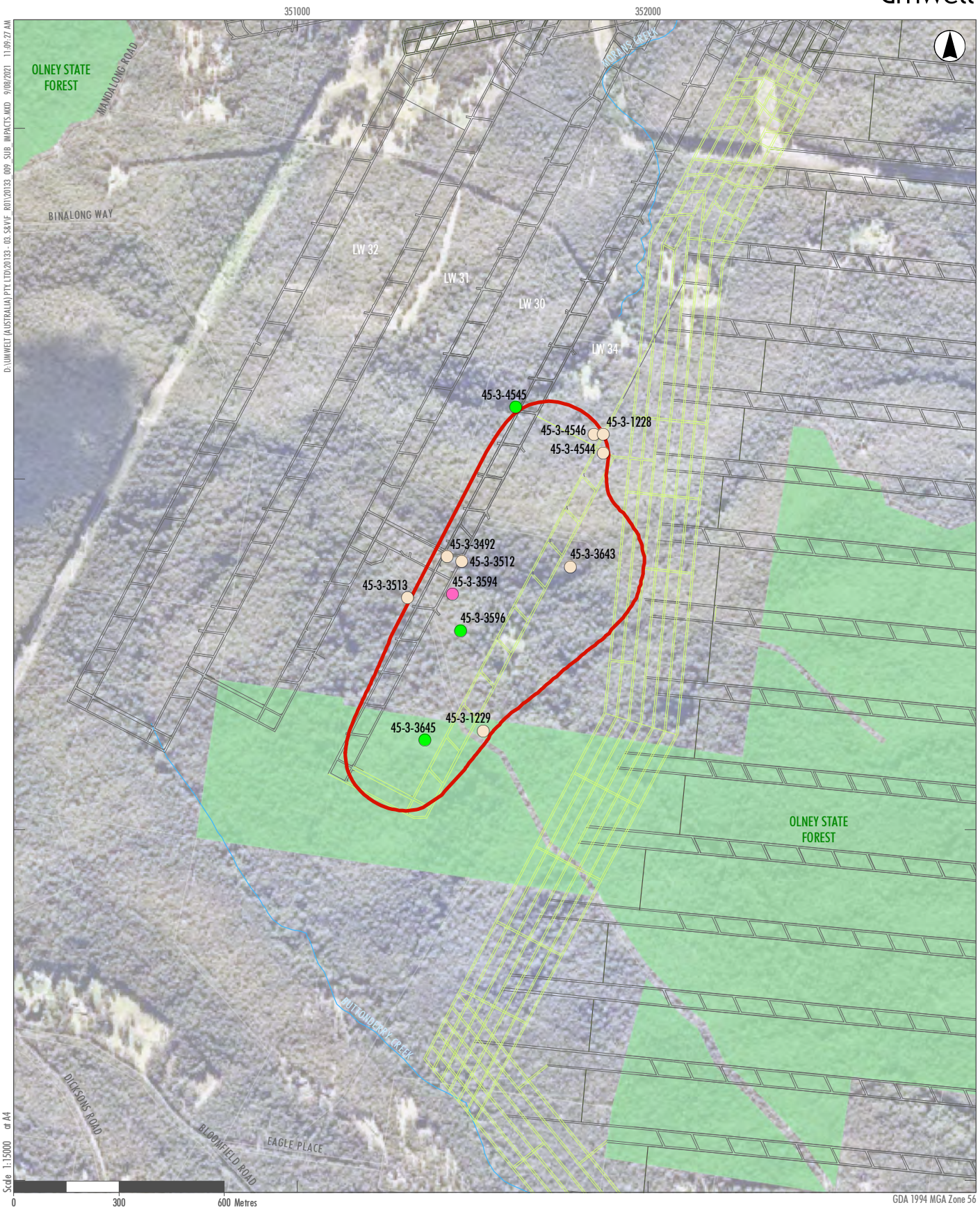
Twelve Aboriginal sites have been identified within the Modification Area, all of which were recorded prior to the current surveys. The predicted levels of impact to these sites in terms of the probability of cracking and erosion at each of the recorded sites is provided in **Table 8.1** and are compared to the levels of impact currently approved under SSD-5144 (Modification 9).

Of these sites, subsidence impacts (in the form of cracking) are assessed as possible at AHIMS 45-3-3596 and 45-3-3645 (both habitation structures with no PAD or objects) and at 45-3-4545 (grinding groove). This predicted level of impacts is consistent with the current approval under SSD-5144 (Modification 9) for 45-3-3596 and 45-3-4545, with the level of predicted subsidence at 45-3-3645 increasing from unlikely to possible as a result of the proposed modification.

Subsidence impacts are unlikely or very unlikely at the remaining 9 sites. Of these sites, predicted subsidence levels are slightly higher than those approved under SSD-5144 (Modification 9) at five sites, being AHIMS 45-2-1228, 45-3-1229, 45-3-3513, 45-3-4544 and 45-3-4546 where the predicted likelihood of cracking has increased from very unlikely to unlikely.

A summary of subsidence impacts by site type is provided in **Table 8.2**.

The predicted subsidence impacts are shown for each site in **Figure 8.1**.



Legend

- Modification Area
- Proposed Workings
- Approved Workings
- State Forest
- Property Boundaries
- Watercourses

Subsidence Prediction

- Possible
- Unlikely
- Very Unlikely

FIGURE 8.1

Recorded Aboriginal Archaeological Sites with Associated Subsidence Predictions

Image Source: Nearmap (Jun 2021) Data source: DSFI (2020)

Table 8.1 Predicted Subsidence Impacts for Aboriginal Sites for Mod 10 (Source: Table 6B DgS July 2021) as compared to previously approved subsidence impacts

AHIMS #	Site Name	Site Type	Previously approved level of subsidence under SSD-5144 (Cracking/erosion)	Mod 10 Cracking Damage Potential*	Mod 10 Erosion Damage Potential*
45-3-1228	Morans Creek	Rock shelter with art	Very unlikely/very unlikely*	**Unlikely**	**Unlikely**
45-3-1229	Olney	Rock shelter with art	Very unlikely/very unlikely^	**Unlikely**	Very unlikely
45-3-3492	RPS CYL05	Grinding groove	Unlikely/Unlikely*	Unlikely	Unlikely
45-3-3512	RPS PS26	Grinding groove	Unlikely/Unlikely*	Unlikely	**Possible**
45-3-3513	RPS PS28	Rock shelter with PAD	Very unlikely/very unlikely*	**Unlikely**	Very unlikely
45-3-3594	RPS PS27	Habitation structure (no PAD or objects)	Very unlikely/very unlikely*	Very unlikely	**Unlikely**
45-3-3596	RPS PS30	Habitation structure (no PAD or objects)	Not provided	Possible	Very unlikely
45-3-3643	RPS PS07	Habitation structure (no PAD or objects). Possible art but not confirmed as Aboriginal	Unlikely/very unlikely^	Unlikely	Very unlikely
45-3-3645	RPS PS31	Habitation structure (no PAD or objects)	Unlikely/unlikely^	**Possible**	Unlikely
45-3-4544	MS9-RS-3	Rock shelter with artefacts & PAD	Very unlikely/very unlikely*	**Unlikely**	**Unlikely**
45-3-4545	MS9-GG-3	Grinding groove	Possible/possible*	Possible	Possible
45-3-4546	MS9-RS-2	Rock shelter with PAD	Very unlikely/very unlikely*	**Unlikely**	**Unlikely**

^ From Mandalong South EIS (2013) and associated Response to Submissions

* Mod 9 approval

Table 8.2 Summary of predicted subsidence impacts with reference to site types

Level of Predicted Subsidence	Site Types
Very unlikely (applicable to 1 site)	1 habitation structure with no PAD or objects
Unlikely (applicable to 8 sites)	2 sets of grinding grooves 3 rock shelters with art 1 rock shelter with artefacts & PAD 2 rock shelters with PAD
Possible (applicable to 3 sites)	2 habitation structures with no PAD or objects (of which one is approved for this level of impact under existing provisions of SSD-5144) 1 set of grinding grooves (approved for this level of impact under existing provisions of SSD-5144)

8.2 Impact to Aboriginal Cultural Value

On behalf of ATOAC, Kerrie Brauer provided the following statement.

> With regards to the Impact to Aboriginal Cultural Value, we would like to mention that although there are always the potential to damage and/or destroy a recorded cultural site, this aspect is a concern and distressing for the Awabakal and Guringai traditional descendants, the cultural value however still remains, as each site has a connectedness to other sites that will never be damaged and/or destroyed, so the Cultural Value still remains, which is a holistic perspective that is integrated within our culture.

Any further comments received from the registered Aboriginal parties in response to this draft report will be included here.

9.0 Management and Mitigation Strategies

There are a range of management strategies that are available in relation to the Modification Area that include varying levels of mitigation of identified or potential harm. The selection of management strategies is guided by the information included in the preceding sections of this ACHA.

The management strategies are discussed below.

9.1 Strategy 1 Conservation

This management strategy would involve the conservation of the Modification Area, which in turn would require that the proposed modification not proceed in its current form. The assessment of impacts associated with the proposed modification demonstrates that the proposed modification will possibly result in subsidence impacts (cracking) to two habitation structures with no PAD or objects and one set of grinding grooves. Of these sites, one of the habitation structures and the grinding groove site are approved for this level of impact under existing provisions of SSD-5144. If the proposed modification was not to proceed, it would therefore result in the avoidance of impacts to one habitation structure that contains no archaeological evidence and no potential for such evidence to be present in a subsurface context.

From an archaeological perspective, impacts associated with the proposed modification can be mitigated appropriately by the application of Strategy 2.

9.2 Strategy 2 Mitigation of Predicted Impacts

Strategy 2 involves implementing a program of ground-truthing subsidence predictions in areas adjoining the recorded sites considered possible to be subject to subsidence impacts, being one grinding groove site and two habitation structures that do not contain any Aboriginal objects or PAD. Where predictions are demonstrated to be accurate in the adjoining area, it may be necessary to further consult with a suitably qualified expert to provide advice on ways in which subsidence impacts can be mitigated at the sites. In addition, a program of monitoring of all recorded sites to assess potential subsidence impacts should be applied consistent with that approved under the Northern Region ACHMP. Further detail on the proposed strategies is provided in **Section 11.0**.

9.3 Strategy 4 Impacts without Salvage

Strategy 4 would involve proceeding with the proposed modification and the subsequent disturbance to any cultural material that may be present in the Modification Area without any further salvage. As discussed above, the Modification Area contains recorded sites of a level of cultural significance and archaeological significance such that this management strategy is not suitable. However, the remainder of the Modification Area does not contain recorded Aboriginal objects and is assessed as having low archaeological potential. From an archaeological perspective it is therefore justifiable to undertake the proposed works in the areas of low archaeological potential without undertaking salvage activities (noting that if objects are identified over the course of the proposed works, additional management requirements will apply).

10.0 Recommendations

The section includes recommendations provided from an archaeological perspective and makes provision for recommendations that the Aboriginal parties may wish to include in addition to the archaeological recommendations.

10.1 Aboriginal Party Recommendation

Any additional recommendations were provided by the registered Aboriginal parties in response to the draft ACHA will be included here.

10.2 Archaeological Recommendations

The following recommendations have been developed in light of the archaeological context of the region, the findings of previous archaeological assessments of the Modification Area, the potential impacts of the proposed modification, current cultural heritage legislation and the nature and extent of archaeological sites and areas of archaeological potential identified within the Modification Area.

1. Centennial Mandalong should ensure that all employees, contractors and industrial tenants are aware that it is an offence under Section 86 of the NPW Act to harm or desecrate an Aboriginal object unless that harm has been subject to approval as part of the necessary approvals process.

2. The identified archaeological sites within the Modification Area should be subject to the mitigation and management strategies provided in **Section 11.0**.

3. Should predicted subsidence impacts at the recorded archaeological sites increase from the levels identified in **Section 8.0** Centennial Mandalong should consult with the registered Aboriginal parties and a suitably qualified archaeologist to reassess the suitability of the proposed management and mitigation strategies and methodologies. Where necessary, the management and mitigation strategies and methodologies should be revised but should remain consistent with the approach specified in the Northern Region ACHMP.

4. In the event that further Aboriginal archaeological sites are identified within the Modification Area, the strategies outlined in **Section 11.3** must be followed.

5. In the event that suspected human skeletal material be identified within the Modification Area, all works should cease immediately and the NSW Police Force, NSW Heritage and the registered Aboriginal parties should be contacted, and the appropriate management strategies outlined in the Northern Region ACHMP be followed.

11.0 Management and Mitigation Methodologies

This section provides recommended management and mitigation methodologies to be applied to the Modification Area. No revision of the proposed management and mitigation methodologies were requested by the registered Aboriginal parties in response to their review of the draft ACHA.

11.1 Mitigation of Predicted Impacts

As documented in **Section 8.0**, subsidence impacts are considered 'possible' at two habitation structures with no PAD or Aboriginal objects and one grinding groove site. Of these, impacts are approved at one habitation structure and one grinding groove site and the methodologies discussed below are consistent with those in the Mod 9HMP, which already applies to these two sites.

Mitigation of impacts to habitation structures that do not contain PAD or objects is considered unnecessary given the nature of the sites and the lack of evidence or archaeological deposit. Detailed baseline recording (as identified in **Section 11.2**) is considered adequate at sites AHIMS 45-3-3596 and 45-3-3645.

In relation to the grinding groove site (AHIMS 45-3-4545), a review of the nature of subsidence impacts in the adjoining areas should be conducted based on available data as mining progresses. Where the predicted level of subsidence for the site is 'possible' or higher, Centennial will continue to consult with the registered Aboriginal parties regarding detailed recording (as specified in **Section 11.2**) and documentation of the site as there is limited potential for any other technique to mitigate impacts at this site. This is consistent with the predicted outcomes and associated management strategy currently approved and subject to the Mod 9 HMP (Umwelt 2021).

Where updated subsidence predictions are 'unlikely' or lower, the sites should be subject to ongoing monitoring, as detailed in **Section 11.2**.

11.2 Monitoring Program

The aim of the monitoring program is to identify whether there is a risk of harm to Aboriginal sites as a result of mining activities and to identify appropriate mitigation strategies, if required. The monitoring program is a key component of the approved Northern Region ACHMP, and the approach taken in this ACHA ensures consistency with the approved ACHMP.

The monitoring program needs to record the condition of the site before mining (baseline survey and baseline check) and the condition of the site after mining (post mining initial condition and post mining secondary condition check) and thus has been separated into three phases.

- Phase 1: Baseline recording (prior to the occurrence of undermining in the vicinity of the site). This involves the recording of the condition of the site before mining.

- Phase 2: Post mining primary recording (immediately after undermining in the vicinity of the site). The purpose of this monitoring is to evaluate whether there has been any change to the site and if any change that has occurred is the result of subsidence.

- Phase 3: Post mining secondary recording (approximately 8 months after undermining). The purpose of this monitoring is to identify whether there has been any change to the site in the period since mining and to make an assessment on whether conditions have stabilised. If conditions have stabilised, no further monitoring is required. If subsidence has not stabilised further monitoring will be required.

The methodology for site monitoring involves documentation of site condition with the minimum information to be recorded comprising the location of the site (including GPS coordinates), provision of a site plan (where relevant), completion of detailed digital photography and field notes documenting general condition.

11.2.1 Monitoring Protocols for Habitation Structures and Grinding Grooves

The monitoring requirements for grinding groove and habitation structure sites are provided below with reference to each relevant phase.

Phase 1: In order to manage and assess any impacts to grinding groove/habitation structure sites, a baseline recording must be undertaken before the commencement of mining. The baseline recording must include the following:

- Detailed archaeological recording
- Archival-quality photos
- The designation of survey control points for monitoring, to be completed by suitably qualified surveyors.

The suitably qualified archaeologist responsible for undertaking the detailed recording should complete detailed photography and observations of the rock morphology (surface) should be recorded, including the presence of any existing cracking and weathering. The archival-quality photographs should be taken in accordance with Heritage NSW guidelines. A 3D terrestrial scan of the grinding groove/habitation structures sites should be considered if appropriate.

A minimum of six (6) control points should be nominated on the grinding groove/habitation structure sites. The recording of control points must be undertaken by a suitably qualified surveyor (appointed by Centennial or suitably qualified archaeologist) in consultation with the archaeologist using a total station or better equipment if available. The purpose of the control points is to provide points of reference on the grinding groove/habitation structure sites in order to later monitor the effects of subsidence. The location of these control points should preferably be tied to known surveyed points outside the zone of influence and/or other permanent points such as electricity transmission towers.

Phase 2: Within a reasonable timeframe after the completion of undermining, the condition of the site must be reinspected, and the condition of the site compared to the last documented results. Again, observations of the rock morphology (surface) should also be recorded, particularly if there is widening of existing cracks and/or development of new cracks. Signs of sheet erosion or exfoliation must also be recorded and archived. This data must be compared to recorded information in Phase 1.

If the site is assessed to be at greater risk of harm as a result of mining activities, Centennial's Environmental team must notify Heritage NSW and the registered Aboriginal parties that there is potential for harm to the site and consult on appropriate management/mitigation strategies.

Phase 3: The post mining secondary check must be undertaken approximately 8 months after the mining activity was finished. A final check of the six (6) control point measurements must be undertaken and compared to previous results. If there are no changes to the rock surface morphology, widening of existing cracks or signs of sheet erosion/surface exfoliation, then no further monitoring is required.

If there is a discrepancy from the baseline recording and it is determined to be as a result of subsidence, Centennial must consult with the registered Aboriginal parties and a suitably qualified archaeologist to assess the potential risk of harm to the site. The appropriate mitigation measures developed by the registered Aboriginal parties and archaeologist must be followed. Where these mitigation measures are provided to repair impacts to a site or may result in changes to the integrity of the site, consultation will be required with Heritage NSW.

Phase 3a: In instances where final subsidence is not achieved until after a number of longwall extractions have taken place, then additional inspections by the registered Aboriginal parties and a suitably qualified archaeologist will be required to assess any further risks to Aboriginal sites. The same provisions for mitigation works as provided in Phase 2 will apply.

11.2.2 Monitoring Reporting

Following completion of Phase 1 and Phase 3 (which will include both Phase 2 and Phase 3 results) monitoring works, a report will be prepared detailing the outcomes of the monitoring. For the combined Phase 2 and 3 monitoring report this will include an evaluation of site condition with reference to the baseline record and will include any recommendations regarding identified impacts/potential impacts (as discussed above). A copy of each monitoring report will be supplied to the registered Aboriginal parties for review and comment.

11.3 Identification of Previously Unknown Aboriginal Cultural Heritage Sites

Should previously unidentified Aboriginal cultural heritage sites be identified over the course of activities within the Modification Area the following procedure should be applied:

- The Mandalong Environmental Co-ordinator should be contacted and advised of the location and condition of the site.
- The Environmental Co-ordinator will then contact the registered Aboriginal parties and Heritage NSW to provide information about the newly identified site and determine an appropriate management strategy.

11.4 Consultation with Registered Aboriginal Parties

Consultation should remain ongoing with the registered Aboriginal parties as detailed throughout this document and in accordance with the provisions of the Northern Region ACHMP.

12.0 References

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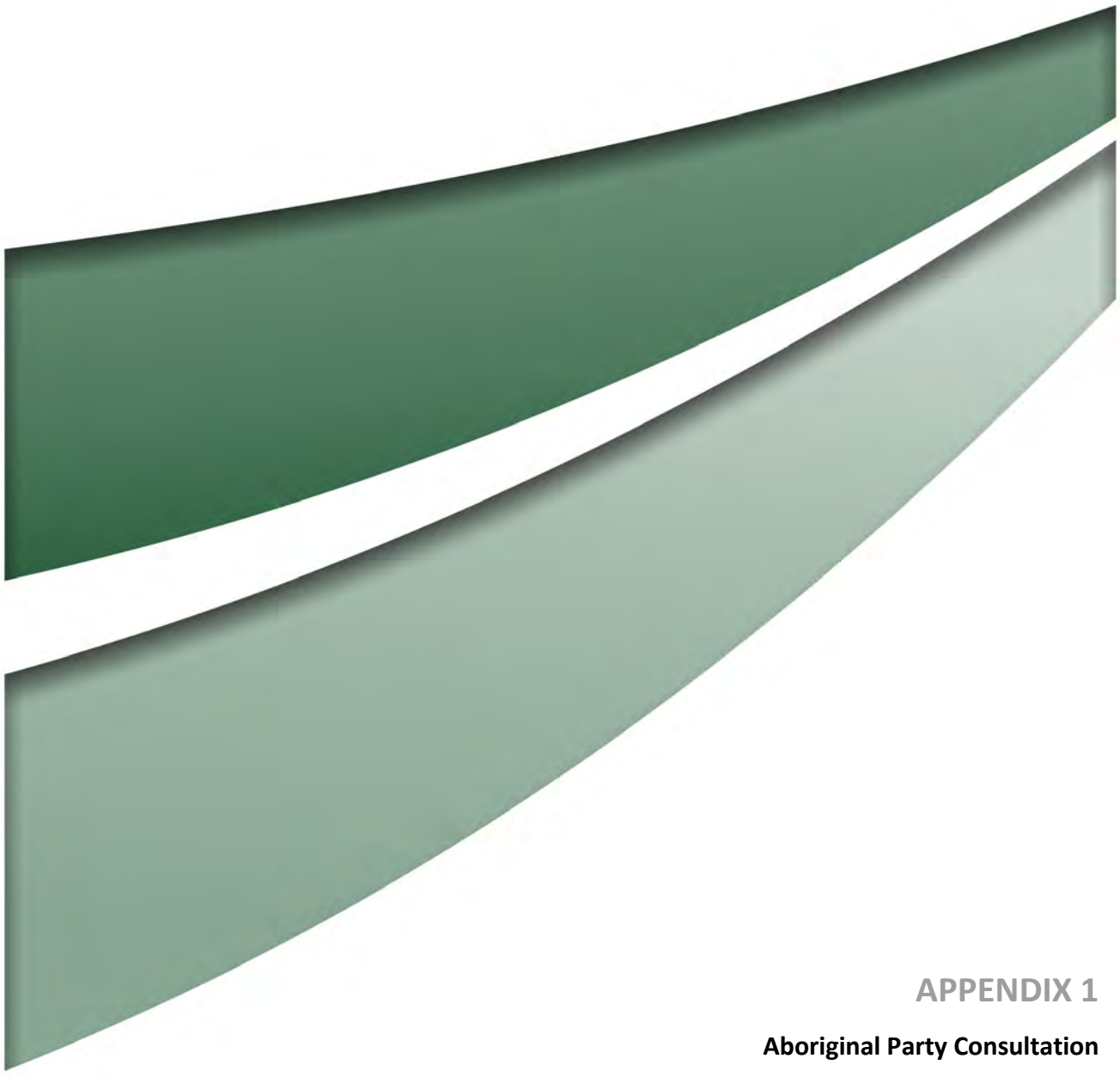
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APPENDIX 1

Aboriginal Party Consultation

Nicola Roche

From: Nicola Roche
Sent: Tuesday, 22 June 2021 11:40 AM
To: Iain Hornshaw
Subject: Mod 10 ACHA - Methodology
Attachments: 20133_Methodology_20210622a_ltr.pdf

Hi all,

Please find attached a draft methodology for the Mod 10 ACHA for Mandalong. As you no doubt remember, we have done some survey and assessment work for Mod 10 late last year and earlier this year however due to a number of factors, the Modification 10 project area now comprises the addition of LW34 only. The draft methodology attached reflects this.

Should you wish to discuss, please don't hesitate to give me a call. Other than that, I look forward to receiving your comments on the attached document.

Thanks
Nic

Nicola Roche
Manager, Cultural Heritage

Umwelt (Australia) Pty Limited
75 York Street
Teralba, NSW 2284

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Mobile: 0427 125 685

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Nicola Roche

From: Arthur Fletcher <arthur.c.fletcher@gmail.com>
Sent: Friday, 27 August 2021 2:22 PM
To: Nicola Roche
Subject: Re: 20133 Mandalong Mod 10 - Draft ACHA for review

Hi Nicola.
We hope all is well with you guys. After reviewing this Draft ACHA. We are supportive of moving forward with it . Ps All stay safe and best regards Arthur - Kauwul and Lynne.
On Fri, 27 Aug 2021 at 1:51 pm, Nicola Roche <nroche@umwelt.com.au> wrote:

> Good afternoon,
>
> Just a reminder that, as identified in the original email (included below) the comment period for the attached ACHA closes on COB Wednesday 8 September.
>
> Please don't hesitate to give me a call if you would like to discuss.
>
> Thanks
>
> Nic
>
> **Nicola Roche**
> Manager Cultural Heritage
>
> **Umwelt (Australia) Pty Limited**
> Phone: 1300 793 267
>
> Mobile: 0427 125 685
>
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>
> Please consider the environment before printing this email
>
> **From:** Nicola Roche
> **Sent:** Tuesday, 10 August 2021 8:49 AM
> **To:** Iain Hornshaw <Iain.Hornshaw@centennialcoal.com.au>

Cc: Ashley O'Sullivan <aosullivan@umwelt.com.au>
Subject: 20133 Mandalong Mod 10 - Draft ACHA for review

Good morning all,

Please find attached the draft Aboriginal Cultural Heritage Assessment for Modification 10 – Proposed Longwall 34, Mandalong Mine.

The report has been prepared in accordance with the Guide to Investigating, Assessing and Reporting on Aboriginal Cultural Heritage in NSW (OEH 2011). It also includes all relevant archaeological information, in accordance with the Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales (DECCW 2010).

Please note that the report is provided in draft format only and has been developed to incorporate feedback and comments provided by registered Aboriginal parties to date. We ask that you please review and respond carefully. All comments received will be addressed in the finalised report.

In particular, we note that there are 4 previously recorded sites (RPS MAND STH PS27, RPS MAND STH PS30, RPS MAND STH PS07 and RPS MAND STH PS31) for which the Northern Region ACHMP doesn't include an assessment of Aboriginal cultural significance. Photos and information on all of these sites is provided in the attached report to assist you in providing input on the significance of these sites using the standard ranking system for Mandalong (which is provided in Tables 7.1 and 7.2 in the attached report). If we need to meet online to discuss this, I'm happy to facilitate.

Please provide comment to me by email or post by no later than COB Wednesday 8 September 2021.

If you require any further information or if you have any queries regarding the project, please do not hesitate to contact me.

As always, if you have any questions, please just give me a call. I'm more than happy to meet with you to discuss the report as required.

Regards

Nic

Nicola Roche
Manager Cultural Heritage

Umwelt (Australia) Pty Limited
Phone: 1300 793 267

Mobile: 0427 125 685

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Nicola Roche

From: Kerrie Brauer <kerrie@awabakal.com.au>
Sent: Wednesday, 3 March 2021 2:09 PM
To: Nicola Roche
Cc: Tracey Howie; peterleven@y7mail.com
Subject: RE: 20133 Mandalong Mod 10 - Draft ACHA for review
Attachments: Statement of Significance for the Awabakak and Guringai Peoples 2013.doc

Hi Nicola,

Thank you for your email.

I have gone through the draft document and believe that it is very informative, and have made some additional comments below.

We would like to update our Statement of Significance to include the Guringai people as well (see attached), this will be from ATOAC and GTLAC.

Section 4.1, p 18, It could be mentioned here that; The Awabakal and Guringai people have cultural and family ties with the Kurungbong tribe. With the amount of recorded sites it shows that the Mandalong region was rich in cultural material and resources, considering the amount of rock shelters, grinding grooves and cultural material recorded within the Mandalong Mine area.

Table 4.1, p 20, I think that the amount of rock shelters/overhangs should be within this table considering how many were recorded , as they also were a relative frequency of site types in the area and should be included here.

Section 8.2, p66, With regards to the Impact of to Aboriginal Cultural Value, we would like to mention that although there are always the potential to damage and/or destroy a recorded cultural site, this aspect is a concern and distressing for the Awabakal and Guringai traditional descendants, the cultural value however still remains, as each site has a connectedness to other sites that will never be damaged and/or destroyed, so the Cultural Value still remains, which is a holistic perspective that is integrated within our culture.

Thanks Nic for the thoughtful aspects within the document, and happy to chat about the comments if needed.

Cheers Kerrie

ATOAC
Kerrie Brauer | Director | Administration | Awabakal Traditional Owners Aboriginal Corporation
M: 04 12 86 63 57 | E: kerrie@awabakal.com.au | www.awabakal.com.au
PO Box 122 Rutherford NSW 2320 Australia

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From: Nicola Roche [mailto:nroche@umwelt.com.au]
Sent: Friday, 26 February 2021 7:52 PM
To: Iain Hornshaw
Subject: 20133 Mandalong Mod 10 - Draft ACHA for review

Good evening all,

Please find attached the draft Aboriginal Cultural Heritage Assessment for Modification 10 – Proposed Extension of Longwalls 30-33, Mandalong Mine.

The report has been prepared in accordance with the Guide to Investigating, Assessing and Reporting on Aboriginal Cultural Heritage in NSW (OEH 2011). It also includes all relevant archaeological information, in accordance with the Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales (DECCW 2010).

Please note that the report is provided in draft format only and has been developed to incorporate feedback and comments provided by registered Aboriginal parties to date. We ask that you please review and respond carefully. All comments received will be addressed in the finalised report.

Please provide comment to me by email or post by no later than COB 29 March 2021.

If you require any further information or if you have any queries regarding the project, please do not hesitate to contact me.

As always, if you have any questions, please just give me a call. I'm more than happy to meet with you to discuss the report as required.

Regards
Nic

Nicola Roche
Manager, Cultural Heritage

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Assessment of Cultural Heritage Significance

Mandalong Modification 9 and Modification 10

Mandalong Mine

Tuesday 3 November 2020

Community attendance:

Tracey Howie:	Guringai Tribal Link Aboriginal Corporation
Kerrie Brauer	Awabakal Traditional Owners Aboriginal Corporation
Peter Leven	Awabakal Descendants Traditional Owners Aboriginal Corporation
Arthur Fletcher	Kauwul Pty Ltd
Norman Archibald	Biraban LALC

Centennial attendance

Jeff Dunwoodie	Environment and Community Coordinator: Mandalong Mine
Phil Enright	Mining Approvals Coordinator: Mandalong Mine
James Marshall	Group Manager Stakeholder Engagement: Fassifern Office

Meeting commenced 10:05 am

Apologies

Barry Williams:	Darkinjung LALC
Ashley Williams:	Biraban LALC
George Sampson:	Cacatua

Welcome and Introductions

Centennial welcomes all members to the meeting and discussed the purpose of the assessment of cultural heritage significance for previously unidentified sites in the Mod 9 and Mod 10 areas. The sites were subject to a baseline assessment between 14 September and 17 September 2020. In attendance at the baseline assessments were:

Tracey Howie:	Guringai Tribal Link Aboriginal Corporation
Arthur Fletcher:	Kauwul Pty Ltd
Kyle Howie:	Awabakal Traditional Owners Aboriginal Corporation
Peter Leven:	Awabakal Descendants Traditional Owners Aboriginal Corporation

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Tori Leven: Awabakal Descendants Traditional Owners Aboriginal Corporation

Barry Williams: Darkinjung LALC

Norman Archibald: Biraban LALC

Ashley Sampson: Cacatua

Overview of the significance assessment and the criteria for ranking and scoring was discussed (refer Tables 1 and 2). The meeting agreed that the cultural significance score be reached, and agreed to, on a consensus basis.

Table 1: Cultural Significance Criteria

Criteria	**Description**
Ceremonial/Spiritual/Dreaming Connection	This criterion refers to any ceremonial, spiritual or dreaming connection that the site may have to the Traditional Owner Group/s. This criterion also considers its past teaching potential.
Rarity	This criterion refers to how rare the site is in reference to location, site type, site integrity on a local and regional scale. Rarity is also assessed on its archaeological potential.
Inter-relatedness	This criterion refers to whether the site is believed to be related or associated to another site in the landscape.
Teaching Potential	This criterion refers to any potential future and/or present use for educational purposes in the teaching of culture and history.
Aesthetics	This criterion refers to the sites aesthetic qualities. Please note that the notion of visual appeal is a subjective concept.
Outlook	Outlook refers to whether the site has an extensive outlook over ADTOAC and ATOAC country and/or if the area of the site has an attractive perspective to the Traditional Owners.

Table 2: Cultural Significance Ranking

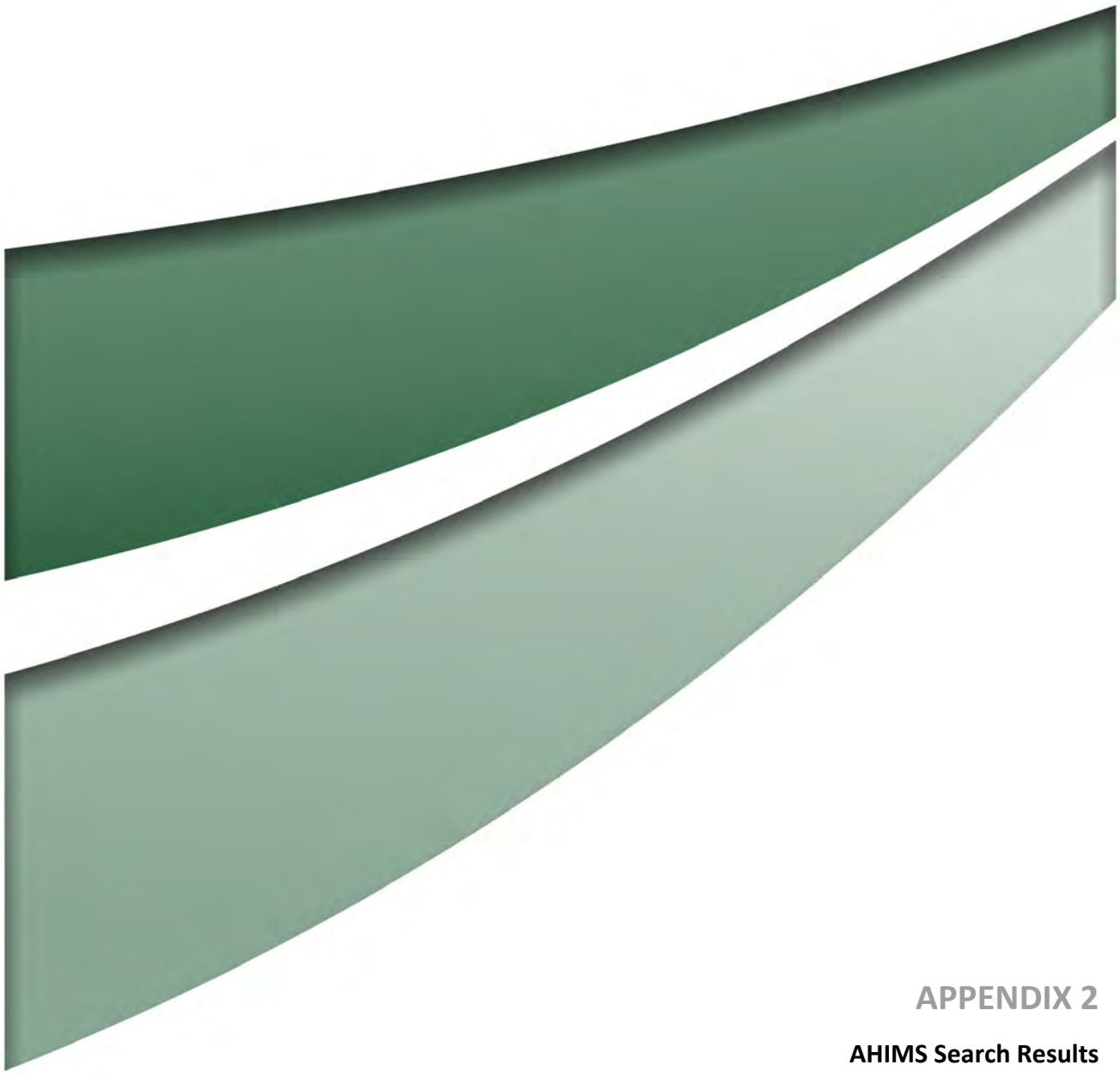
Ranking System	**Points**
High Cultural Significance	1 Point
High to Very High Cultural Significance	2 Points
Very High Cultural Significance	3 Points
Very High to Extremely High Cultural Significance	4 Points
Extremely High Cultural Significance	5 Points

Cultural Significance Score and Overall Ranking based on the 6 Criteria Assessed

Site Types	Ceremonial /Spiritual Dreaming Connection	Rarity	Inter-related-ness	Teaching Potential/ research Potential	Aesthetics of site	Outlook	Total = Overall Rank Summary of Significance	Overall Cultural Significance
MS10-GG-1	The grinding grooves are a series of 5 inter-related sites along the same creek line, within close proximity. The grinding grooves are an example of how and where people lived as they are within proximity to shelters and overhangs that have cultural significance. Grinding grooves are not naturally occurring but are human made and show land use There is no indication as to the population numbers Deeply incised grooves that are narrow indicate that the area was used to sharpen spears and other fine cutting tools. Grinding grooves are some of the last cultural heritage sites that remain and therefore need to be protected. Together the grinding grooves, in sequence and along the same creek line are considered as being Extremely High Cultural significance.							4
MS10-GG-2								4
MS10-GG-3								4
MS10-GG-4								4
MS10-GG-5								4
MS10-Tree - 1	Males were requested to leave the meeting so the cultural heritage site could be assessed in a culturally appropriate manner. Images of the site have been removed from the presentation and consultation materials.							5
MS10-OH-1	Represents a good vantage point within a ‘complex’ of smaller shelters							5
MS10-ST-1	Some scars are not taken opportunistically and hold particular significance, for example as a birth-place of a child and the scar signifies something of purpose around the birth such as a carrying basket that may have held the child, seeds etc. The variety of this scar tree is turpentine. Many such species have been lost as they were used for uses such as wharves as the oils protect the wood and as such as heightened value.							5
MS9-GG-1	Consistent with the above discussion regarding MS10-GG-1; MS10-GG-2; MS10-GG-3; MS10-GG-4 and MS10-GG-5.							4
MS9-GG-2								4
MS9-GG-3								4
MS9-OH-1	Overhang located near grinding grooves							5

Site Types	Ceremonial /Spiritual Dreaming Connection	Rarity	Inter-related-ness	Teaching Potential/ research Potential	Aesthetics of site	Outlook	Total = Overall Rank Summary of Significance	Overall Cultural Significance
MS9-OH-2	Located on a steep slope and steep inside. Opportunistic use as shelter from the weather is possible.							4
MS9-OH-3	Micro bats inhabit the overhang and is therefore important to protect the habitat.							5
MS9-RS-1	Flat, accessible and PAD potential within the shelter. Bone in the shelter looked as if it had been worked or modified in some manner. Potential for artefacts being present (hidden / covered) due to sandy floor. Elevation gives a view over Tuggerah Lakes.							5
MS9-RS-2	Appearance of a whale. Discussed art present in the cave (reference 45-3-1228) with inscriptions (names, numbers) that could reflect presence of ancestors accessing the site but years later.							5
MS9-RS-3	Small entry leading to larger cavity. Artefacts present							5
MS9-RS-4	Steep access with habitat							5

The meeting concluded at 11:45am.



APPENDIX 2

AHIMS Search Results

AHIMS Web Services (AWS)

Extensive search - Site list report

Your Ref/PO Number : Mandalong

Client Service ID : 558414

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status	SiteFeatures	SiteTypes	Reports
45-3-3438	RPS Mandalong South 03	GDA	56	352856	6329404	Closed site	Valid	Artefact : -		
Contact		Recorders	RPS Australia East Pty Ltd - Blacktown,Mrs.Tessa Boer-Mah					Permits		
45-3-2970	Olney 105	AGD	56	352190	6326920	Open site	Valid	Grinding Groove : -	Axe Grinding Groove	101093
Contact		Recorders	Brad Welsh					Permits		
45-3-2880	Toepfers road;	AGD	56	351940	6327730	Closed site	Valid	Art (Pigment or Engraved) : -	Shelter with Art	1333,101093
Contact		Recorders	Warren Bluff					Permits		
45-3-2881	Toepfers Road;	AGD	56	351950	6327740	Closed site	Valid	Art (Pigment or Engraved) : -	Shelter with Art	1333,101093
Contact		Recorders	Warren Bluff					Permits		
45-3-2889	Toepfers Road	AGD	56	351930	6327720	Closed site	Valid	Art (Pigment or Engraved) : -	Shelter with Art	1333,101093
Contact		Recorders	Warren Bluff					Permits		
45-3-3489	RPS CYL04	GDA	56	352959	6328590	Open site	Valid	Grinding Groove : 1		
Contact		Recorders	RPS East Australia Pty Ltd - Echuca Victoria					Permits		
45-3-3577	RPS MAND STH TBM 41	GDA	56	350661	6328450	Open site	Valid	Habitation Structure : 1		
Contact		Recorders	RPS East Australia Pty Ltd - Echuca Victoria					Permits		
45-3-3575	RPS MAND STH TBM49	GDA	56	352837	6327793	Open site	Valid	Grinding Groove : 1		
Contact		Recorders	RPS East Australia Pty Ltd - Echuca Victoria					Permits		
45-3-3586	RPS MAND STH PS01	GDA	56	351415	6328638	Open site	Valid	Habitation Structure : 1		
Contact		Recorders	RPS Australia East Pty Ltd - Hamilton					Permits		
45-3-3587	RPS MAND STH PS10	GDA	56	352207	6327686	Open site	Valid	Habitation Structure : 1		
Contact		Recorders	RPS Australia East Pty Ltd - Hamilton					Permits		
45-3-3588	RPS MAND STH PS14	GDA	56	351981	6327567	Open site	Valid	Habitation Structure : 1		
Contact		Recorders	RPS Australia East Pty Ltd - Hamilton					Permits		
45-3-3589	RPS MAND STH PS15	GDA	56	351999	6327494	Open site	Valid	Habitation Structure : 1		
Contact		Recorders	RPS Australia East Pty Ltd - Hamilton					Permits		
45-3-3460	RPS MAND STH TBM2	GDA	56	352511	6328368	Open site	Valid	Grinding Groove : 3		
Contact		Recorders	RPS Australia East Pty Ltd - Hamilton,Mrs.Tessa Boer-Mah					Permits		
45-3-3461	RPS MAND STH TBM03	GDA	56	352474	6328420	Open site	Valid	Artefact : 9		
Contact		Recorders	RPS Australia East Pty Ltd - Hamilton,Mrs.Tessa Boer-Mah					Permits		
45-3-3462	RPS MAND STH TBM06	GDA	56	352540	6328283	Open site	Valid	Grinding Groove : 1		

Report generated by AHIMS Web Service on 20/12/2020 for Ashley O'Sullivan for the following area at Datum :GDA, Zone : 56, Eastings : 349000 - 353000, Northings : 6325800 - 6329600 with a Buffer of 0 meters. Additional Info : hmp and acha. Number of Aboriginal sites and Aboriginal objects found is 101

This information is not guaranteed to be free from error omission. Office of Environment and Heritage (NSW) and its employees disclaim liability for any act done or omission made on the information and consequences of such acts or omission.

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status	SiteFeatures	SiteTypes	Reports
	Contact	**Recorders**	RPS Australia East Pty Ltd - Hamilton,Mrs.Tessa Boer-Mah					**Permits**		
45-3-3463	RPS MAND STH TBM08	GDA	56	352915	6327374	Open site	Valid	Water Hole : 1		
	Contact	**Recorders**	RPS Australia East Pty Ltd - Hamilton,Mrs.Tessa Boer-Mah					**Permits**		
45-3-3590	Duplicate of RPS MAND STH PS17	GDA	56	352003	6327431	Open site	Deleted	Habitation Structure : 1		
	Contact	**Recorders**	RPS Australia East Pty Ltd - Hamilton,RPS East Australia Pty Ltd - Echuca Victoria					**Permits**		
45-3-3591	RPS PS19	GDA	56	352323	6327515	Open site	Valid	Art (Pigment or Engraved) : 1		
	Contact	**Recorders**	RPS Australia East Pty Ltd - Hamilton					**Permits**		
45-3-3592	RPS MAND STH PS21	GDA	56	352284	6327480	Open site	Valid	Habitation Structure : 1		
	Contact	**Recorders**	RPS Australia East Pty Ltd - Hamilton					**Permits**		
45-3-3593	RPS MAND STH PS23	GDA	56	352224	6327486	Open site	Valid	Habitation Structure : 1		
	Contact	**Recorders**	RPS Australia East Pty Ltd - Hamilton					**Permits**		
45-3-3472	RPS MAND STH AH06	GDA	56	349160	6328610	Open site	Valid	Artefact : 1		
	Contact	**Recorders**	RPS East Australia Pty Ltd - Echuca Victoria					**Permits**		
45-3-3473	Duplicate of RPS MAND STH AH06	GDA	56	349160	6328610	Open site	Deleted	Artefact : 1		
	Contact	**Recorders**	RPS East Australia Pty Ltd - Echuca Victoria,RPS East Australia Pty Ltd - Echuca Vic					**Permits**		
45-3-3474	RPS MAND STH AH07	GDA	56	350483	6329160	Open site	Valid	Grinding Groove : 1		
	Contact	**Recorders**	RPS East Australia Pty Ltd - Echuca Victoria					**Permits**		
45-3-3475	RPS MAND STH AH08	GDA	56	350491	6329156	Open site	Valid	Grinding Groove : 1		
	Contact	**Recorders**	RPS East Australia Pty Ltd - Echuca Victoria					**Permits**		
45-3-3522	RPS MAND STH TBM07	GDA	56	352506	6328230	Open site	Valid	Grinding Groove : 1		
	Contact	**Recorders**	RPS East Australia Pty Ltd - Echuca Victoria					**Permits**		
45-3-3523	RPS MAND STH TBM08a	GDA	56	352381	6328119	Open site	Valid	Grinding Groove : 1		
	Contact	**Recorders**	RPS East Australia Pty Ltd - Echuca Victoria					**Permits**		
45-3-3529	RPS MAND STH TBM17	GDA	56	352843	6329468	Open site	Valid	Modified Tree (Carved or Scarred) : 1		
	Contact	**Recorders**	RPS East Australia Pty Ltd - Echuca Victoria					**Permits**		
45-3-3530	RPS MAND STH TBM19	GDA	56	352847	6329295	Open site	Valid	Potential Archaeological Deposit (PAD) : 1		
	Contact	**Recorders**	RPS East Australia Pty Ltd - Echuca Victoria					**Permits**		
45-3-3531	RPS MAND STH TBM20	GDA	56	352853	6329261	Open site	Valid	Modified Tree (Carved or Scarred) : 1		

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AHIMS Web Services (AWS)

Extensive search - Site list report

Your Ref/PO Number : Mandalong

Client Service ID : 558414

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status	SiteFeatures	SiteTypes	Reports
	Contact	Recorders	RPS East Australia Pty Ltd - Echuca Victoria					Permits		
45-3-3532	RPS MAND STH TBM22	GDA	56	352975	6329179	Open site	Valid	Modified Tree (Carved or Scarred) : 1		
	Contact	Recorders	RPS East Australia Pty Ltd - Echuca Victoria					Permits		
45-3-3533	RPS MAND STH TBM26	GDA	56	352258	6329078	Open site	Valid	Grinding Groove : 1		
	Contact	Recorders	RPS East Australia Pty Ltd - Echuca Victoria					Permits		
45-3-3534	RPS MAND STH TBM27	GDA	56	352360	6329213	Open site	Valid	Grinding Groove : 1		
	Contact	Recorders	RPS East Australia Pty Ltd - Echuca Victoria					Permits		
45-3-3535	RPS MAND STH TBM28	GDA	56	352450	6329394	Open site	Valid	Grinding Groove : 1		
	Contact	Recorders	RPS East Australia Pty Ltd - Echuca Victoria					Permits		
45-3-3536	RPS MAND STH TBM29	GDA	56	351914	6329290	Open site	Valid	Artefact : 1		
	Contact	Recorders	RPS East Australia Pty Ltd - Echuca Victoria					Permits		
45-3-3543	RPS MAND STH TBM35	GDA	56	352268	6327639	Open site	Valid	Potential Archaeological Deposit (PAD) : 1		
	Contact	Recorders	RPS East Australia Pty Ltd - Echuca Victoria					Permits		
45-3-3546	RPS MAND SOUTH TBM40	GDA	56	350352	6328553	Open site	Valid	Grinding Groove : 1		
	Contact	Recorders	RPS East Australia Pty Ltd - Echuca Victoria					Permits		
45-3-3547	RPS MAND STH TBM53	GDA	56	352721	6327776	Open site	Valid	Potential Archaeological Deposit (PAD) : 1		
	Contact	Recorders	RPS East Australia Pty Ltd - Echuca Victoria					Permits		
45-3-3548	RPS MAND STH TBM42	GDA	56	350290	6328294	Open site	Valid	Potential Archaeological Deposit (PAD) : 1		
	Contact	Recorders	RPS East Australia Pty Ltd - Echuca Victoria					Permits		
45-3-3554	RPS MAND STH TBM50	GDA	56	352809	6327783	Open site	Valid	Grinding Groove : 1		
	Contact	Recorders	RPS East Australia Pty Ltd - Echuca Victoria					Permits		
45-3-3555	RPS MAND STH TBM51	GDA	56	352785	6327759	Open site	Valid	Grinding Groove : 1		
	Contact	Recorders	RPS East Australia Pty Ltd - Echuca Victoria					Permits		
45-3-3556	RPS MAND STH TBM52	GDA	56	352767	6327771	Open site	Valid	Modified Tree (Carved or Scarred) : 1		
	Contact	Recorders	RPS East Australia Pty Ltd - Echuca Victoria					Permits		
45-3-3557	Duplicate of RPS MAND STH TBM53	GDA	56	352721	6327776	Open site	Deleted	Potential Archaeological Deposit (PAD) : 1		

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SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status	SiteFeatures	SiteTypes	Reports
	Contact	Recorders	RPS East Australia Pty Ltd - Echuca Victoria,RPS East Australia Pty Ltd - Echuca Vic					Permits		
45-3-3594	RPS MAND STH PS27	GDA	56	351546	6327861	Open site	Valid	Habitation Structure : 1		
	Contact	Recorders	RPS Australia East Pty Ltd - Hamilton					Permits		
45-3-3595	RPS MAND STH PS29	GDA	56	351252	6328056	Open site	Valid	Habitation Structure : 1		
	Contact	Recorders	RPS Australia East Pty Ltd - Hamilton					Permits		
45-3-3596	RPS MAND STH PS30	GDA	56	351568	6327757	Open site	Valid	Habitation Structure : 1		
	Contact	Recorders	RPS Australia East Pty Ltd - Hamilton					Permits		
45-3-3598	RPS MAND STH TBM 15	GDA	56	352887	6329356	Open site	Valid	Habitation Structure : 1		
	Contact	Recorders	RPS Australia East Pty Ltd - Hamilton					Permits		
45-3-3599	RPS MAND STH TBM 16	GDA	56	352918	6329416	Open site	Valid	Habitation Structure : 1		
	Contact	Recorders	RPS Australia East Pty Ltd - Hamilton					Permits		
45-3-3579	RPS MAND STH CYL06	GDA	56	352564	6328256	Open site	Valid	Grinding Groove : 1		
	Contact	Recorders	RPS East Australia Pty Ltd - Echuca Victoria					Permits		
45-3-3566	Duplicate of RPS MAND STH TBM50	GDA	56	352809	6327783	Open site	Deleted	Grinding Groove : 1		
	Contact	Recorders	RPS East Australia Pty Ltd - Echuca Victoria,RPS East Australia Pty Ltd - Echuca Vic					Permits		
45-3-3567	Duplicate of RPS MAND STH TBM51	GDA	56	352785	6327759	Open site	Deleted	Grinding Groove : 1		
	Contact	Recorders	RPS East Australia Pty Ltd - Echuca Victoria,RPS East Australia Pty Ltd - Echuca Vic					Permits		
45-3-3568	Duplicate of RPS MAND STG TBM52	GDA	56	352767	6327771	Open site	Deleted	Modified Tree (Carved or Scarred) : 1		
	Contact	Recorders	RPS East Australia Pty Ltd - Echuca Victoria,RPS East Australia Pty Ltd - Echuca Vic					Permits		
45-3-3569	Duplicate of RPS MAND STH TBM53 (second)	GDA	56	352721	6327776	Open site	Deleted	Potential Archaeological Deposit (PAD) : 1		
	Contact	Recorders	RPS East Australia Pty Ltd - Echuca Victoria,RPS East Australia Pty Ltd - Echuca Vic					Permits		
45-3-3570	Duplicate of RPS MAND STH TBM54	GDA	56	352695	6327785	Open site	Deleted	Grinding Groove : 1		
	Contact	Recorders	RPS East Australia Pty Ltd - Echuca Victoria,RPS East Australia Pty Ltd - Echuca Vic					Permits		
45-3-3491	Duplicate of RPS MAND STH	GDA	56	352564	6328256	Open site	Deleted	Grinding Groove : 1		
	Contact	Recorders	R.R.P. Property Consultants Pty Ltd,RPS East Australia Pty Ltd - Echuca Victoria					Permits		
45-3-3492	RPS MAND STH CYL05	GDA	56	351427	6327780	Open site	Valid	Grinding Groove : 1		
	Contact	Recorders	R.R.P. Property Consultants Pty Ltd					Permits		
45-3-3493	RPS CYL04c	GDA	56	352972	6328558	Open site	Valid	Grinding Groove : 1		
	Contact	Recorders	R.R.P. Property Consultants Pty Ltd					Permits		

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SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status	SiteFeatures	SiteTypes	Reports
45-3-3494	RPS CYL04b	GDA	56	352958	6328577	Open site	Valid	Grinding Groove : 1		
	Contact	Recorders	RPS East Australia Pty Ltd - Echuca Victoria					Permits		
45-3-3495	Duplicate of RPS CYL04	GDA	56	352959	6328590	Open site	Deleted	Grinding Groove : 1		
	Contact	Recorders	RPS East Australia Pty Ltd - Echuca Victoria,RPS East Australia Pty Ltd - Echuca Vic					Permits		
45-3-3503	RPS MAND STH PS06	GDA	56	352128	6327503	Open site	Valid	Potential Archaeological Deposit (PAD) : 1		
	Contact	Recorders	RPS East Australia Pty Ltd - Echuca Victoria					Permits		
45-3-3504	RPS MAND STH PS08	GDA	56	352242	6327697	Open site	Valid	Potential Archaeological Deposit (PAD) : 1		
	Contact	Recorders	RPS East Australia Pty Ltd - Echuca Victoria					Permits		
45-3-3505	RPS MAND STH PS09	GDA	56	352226	6327716	Open site	Valid	Potential Archaeological Deposit (PAD) : 1		
	Contact	Recorders	RPS East Australia Pty Ltd - Echuca Victoria					Permits		
45-3-3558	RPS MAND STH TBM54	GDA	56	352695	6327785	Open site	Valid	Grinding Groove : 1		
	Contact	Recorders	RPS East Australia Pty Ltd - Echuca Victoria					Permits		
45-3-3509	RPS PS20	GDA	56	352313	6327498	Open site	Valid	Potential Archaeological Deposit (PAD) : 1		
	Contact	Recorders	RPS East Australia Pty Ltd - Echuca Victoria					Permits		
45-3-3510	RPS MAND STH PS22	GDA	56	352265	6327465	Open site	Valid	Potential Archaeological Deposit (PAD) : 1		
	Contact	Recorders	RPS East Australia Pty Ltd - Echuca Victoria					Permits		
45-3-3511	RPS MAND STH PS25	GDA	56	351152	6327958	Open site	Valid	Artefact : 1		
	Contact	Recorders	RPS East Australia Pty Ltd - Echuca Victoria					Permits		
45-3-3512	RPS MAND STH PS26	GDA	56	351572	6327955	Open site	Valid	Grinding Groove : 1		
	Contact	Recorders	RPS East Australia Pty Ltd - Echuca Victoria					Permits		
45-3-3513	RPS MAND STH PS28	GDA	56	351314	6327661	Open site	Valid	Potential Archaeological Deposit (PAD) : 1		
	Contact	Recorders	RPS East Australia Pty Ltd - Echuca Victoria					Permits		
45-3-3514	RPS MAND STH PS32	GDA	56	351019	6328545	Open site	Valid	Potential Archaeological Deposit (PAD) : 1		
	Contact	Recorders	RPS East Australia Pty Ltd - Echuca Victoria					Permits		

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SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status	SiteFeatures	SiteTypes	Reports
45-3-3516	RPS MAND STH TBM01	GDA	56	352327	6328688	Open site	Valid	Grinding Groove : 1		
	Contact	**Recorders**	RPS East Australia Pty Ltd - Echuca Victoria						**Permits**	
45-3-3517	Duplicate of RPS MAND STH TBM02	GDA	56	352511	6328368	Open site	Deleted	Grinding Groove : 1		
	Contact	**Recorders**	RPS East Australia Pty Ltd - Echuca Victoria,RPS East Australia Pty Ltd - Echuca Vic						**Permits**	
45-3-3518	Duplicate of RPS MAND STH TBM03	GDA	56	352474	6328420	Open site	Deleted	Artefact : 1		
	Contact	**Recorders**	RPS East Australia Pty Ltd - Echuca Victoria,RPS East Australia Pty Ltd - Echuca Vic						**Permits**	
45-3-3519	RPS MAND STH TBM04	GDA	56	352479	6328518	Open site	Valid	Artefact : 1		
	Contact	**Recorders**	RPS East Australia Pty Ltd - Echuca Victoria						**Permits**	
45-3-3520	RPS MAND STH TBM05	GDA	56	352510	6328336	Open site	Valid	Grinding Groove : 1		
	Contact	**Recorders**	RPS East Australia Pty Ltd - Echuca Victoria						**Permits**	
45-3-3521	Duplicate of RPS MAND STH TBM06	GDA	56	352540	6328283	Open site	Deleted	Grinding Groove : 1		
	Contact	**Recorders**	RPS East Australia Pty Ltd - Echuca Victoria,RPS East Australia Pty Ltd - Echuca Vic						**Permits**	
45-3-3600	RPS MAND STH TBM 18	GDA	56	352863	6329360	Open site	Valid	Habitation Structure : 1		
	Contact	**Recorders**	RPS Australia East Pty Ltd - Hamilton						**Permits**	
45-3-3601	RPS MAND STH TBM 21	GDA	56	352843	6329264	Open site	Valid	Habitation Structure : 1		
	Contact	**Recorders**	RPS Australia East Pty Ltd - Hamilton						**Permits**	
45-3-3602	RPS MAND STH TBM 23	GDA	56	352843	6329249	Open site	Valid	Habitation Structure : 1		
	Contact	**Recorders**	RPS Australia East Pty Ltd - Hamilton						**Permits**	
45-3-3603	RPS MAND STH TBM 24	GDA	56	352870	6329067	Open site	Valid	Habitation Structure : 1		
	Contact	**Recorders**	RPS Australia East Pty Ltd - Hamilton						**Permits**	
45-3-3604	RPS MAND STH TBM 25	GDA	56	352973	6329010	Open site	Valid	Habitation Structure : 1		
	Contact	**Recorders**	RPS Australia East Pty Ltd - Hamilton						**Permits**	
45-3-3605	RPS MAND STH TBM 36	GDA	56	352309	6327654	Open site	Valid	Habitation Structure : 1		
	Contact	**Recorders**	RPS Australia East Pty Ltd - Hamilton						**Permits**	
45-3-3606	RPS MAND STH TBM 39	GDA	56	350226	6328052	Open site	Valid	Habitation Structure : 1		
	Contact	**Recorders**	RPS Australia East Pty Ltd - Hamilton						**Permits**	
45-3-3607	RPS MAND STH TBM 48	GDA	56	352445	6327519	Open site	Valid	Habitation Structure : 1		
	Contact	**Recorders**	RPS Australia East Pty Ltd - Hamilton						**Permits**	
45-3-3608	Duplicate of RPS MAND STH TBM 49	GDA	56	352837	6327793	Open site	Deleted	Grinding Groove : 1		
	Contact	**Recorders**	RPS Australia East Pty Ltd - Hamilton,RPS East Australia Pty Ltd - Echuca Victoria						**Permits**	

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SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status	SiteFeatures	SiteTypes	Reports
45-3-3447	Duplicate of RPS MAND STH PS 25	GDA	56	351152	6327958	Open site	Deleted	Artefact : 12		
	Contact	**Recorders**	Miss.Philippa Sokol,RPS East Australia Pty Ltd - Echuca Victoria,RPS East Australia					**Permits**	4563	
45-3-1223	Moran's Creek;	AGD	56	351900	6329000	Open site	Valid	Artefact : -	Open Camp Site	294,101093
	Contact	**Recorders**	ASRSYS					**Permits**		
45-3-1226	Buttonderry Creek	AGD	56	350900	6327700	Open site	Valid	Grinding Groove : -	Axe Grinding Groove	294,101093
	Contact	**Recorders**	ASRSYS					**Permits**		
45-3-1227	Moran's Creek	AGD	56	352200	6328800	Open site	Valid	Grinding Groove : -	Axe Grinding Groove	294,101093
	Contact	**Recorders**	ASRSYS					**Permits**		
45-3-1228	Moran's Creek;	AGD	56	351800	6328100	Closed site	Valid	Art (Pigment or Engraved) : -	Shelter with Art	294
	Contact	**Recorders**	ASRSYS					**Permits**		
45-3-1229	Olney;	AGD	56	351600	6326900	Closed site	Valid	Art (Pigment or Engraved) : -	Shelter with Art	294,101093
	Contact	**Recorders**	ASRSYS					**Permits**		
45-3-1230	Moran's Creek	AGD	56	351900	6327700	Closed site	Valid	Art (Pigment or Engraved) : -	Shelter with Art	294,101093
	Contact	**Recorders**	ASRSYS					**Permits**		
45-3-1231	Digary Creek	AGD	56	352200	6327300	Closed site	Valid	Artefact : -	Shelter with Deposit	294,101093
	Contact	**Recorders**	ASRSYS					**Permits**		
45-3-1232	Wyee Creek	AGD	56	352800	6329300	Closed site	Valid	Artefact : -, Art (Pigment or Engraved) : -	Shelter with Art,Shelter with Deposit	294,101093
	Contact	**Recorders**	ASRSYS					**Permits**		
45-3-1233	Olney	AGD	56	350200	6328100	Closed site	Valid	Art (Pigment or Engraved) : -	Shelter with Art	294,101093
	Contact	**Recorders**	ASRSYS					**Permits**		
45-3-3639	RPS MAND STH PS02	GDA	56	351342	6328621	Closed site	Valid	Aboriginal Resource and Gathering : -		
	Contact	**Recorders**	Miss.Philippa Sokol					**Permits**		
45-3-3640	RPS MAND STH PS03	GDA	56	351248	6328601	Closed site	Valid	Aboriginal Resource and Gathering : -		
	Contact	**Recorders**	Miss.Philippa Sokol					**Permits**		
45-3-3641	RPS MAND STH PS04	GDA	56	351239	6328605	Open site	Valid	Aboriginal Resource and Gathering : -		
	Contact	**Recorders**	Miss.Philippa Sokol					**Permits**		

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Extensive search - Site list report

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SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status	SiteFeatures	SiteTypes	Reports
45-3-3642	RPS MAND STH PS05	GDA	56	351320	6328602	Closed site	Valid	Aboriginal Resource and Gathering : -		
	Contact	**Recorders**	Miss.Philippa Sokol					**Permits**		
45-3-3643	RPS MAND STH PS07	GDA	56	352001	6327447	Closed site	Valid	Aboriginal Resource and Gathering : -		
	Contact	**Recorders**	Miss.Philippa Sokol					**Permits**		
45-3-3644	RPS MAND STH PS24	GDA	56	351443	6327671	Closed site	Valid	Aboriginal Resource and Gathering : -		
	Contact	**Recorders**	Miss.Philippa Sokol					**Permits**		
45-3-3645	RPS MAND STH PS31	GDA	56	351468	6327445	Open site	Valid	Aboriginal Resource and Gathering : -		
	Contact	**Recorders**	Miss.Philippa Sokol					**Permits**		
45-3-3646	RPS MAND STH PS16	GDA	56	352002	6327447	Closed site	Valid	Aboriginal Resource and Gathering : -		
	Contact	**Recorders**	Miss.Philippa Sokol					**Permits**		

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Appendix E

Biodiversity development assessment report









MANDALONG MOD 10: ADDITION OF LW34

Biodiversity Development Assessment Report



149823
2
1 October 2021

rpsgroup.com

Document status

Version	Purpose of document	Authored by	Reviewed by	Approved by	Review date
0	Internal Review	Dr Hayden Beck	Mark Aitkens	Mark Aitkens	6 August 2021
1	Final	Dr Hayden Beck	Mark Aitkens	Mark Aitkens	19 August 2021
2	Final (minor amendments)	Dr Hayden Beck	Mark Aitkens	Mark Aitkens	1 October 2021

This Biodiversity Development Assessment Report has been certified by the following accredited assessor:

Dr Hayden Beck (Accredited BAM Assessor – BAAS19000)  5 October 2021

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STAGE 1
BIODIVERSITY ASSESSMENT

1 INTRODUCTION TO STAGE 1 – BIODIVERSITY ASSESSMENT

RPS Australia East Pty Ltd (RPS) has been engaged by Centennial Mandalong (the proponent) to undertake a Biodiversity Development Assessment Report (BDAR) to assess the addition of Longwall (LW) 34 as part of Modification 10 (MOD 10) to the approved State significant development 5144 (SSD-5144) (herein referred to as the 'Project').

Mandalong Mine (Mandalong) is an existing underground coal mine near Morisset, approximately 35 kilometres (km) south-west of Newcastle, predominantly in the Lake Macquarie local government area (LGA) (**Figure 1-1**). Mandalong is operated by Centennial Mandalong Pty Limited (Centennial Mandalong).

Centennial Mandalong has approval to extract run-of-mine (ROM) coal from the West Wallarah and Wallarah-Great Northern seams using a combination of longwall and continuous mining methods. Mandalong operates under the approved SSD-5144, which was granted on 12 October 2015 by the NSW Planning Assessment Commission under Part 4, Division 4.1 of the NSW *Environmental Planning and Assessment Act* 1979 (EP&A Act).

As identified in Mandalong's Mining Operations Plan (MOP) (Centennial Coal 2018), the progression of underground mining is regularly reviewed dependent on ongoing monitoring and geological conditions. Centennial Mandalong recently encountered poor geological conditions within the Mandalong Southern Extension Area, including a fault zone and igneous sill.

In response to these conditions and in order to maintain coal production, improve mining conditions and improve the financial viability of Mandalong, amendments to the approved mine plan were sought as part of a modification to SSD-5144 (herein referred to as MOD 9). As part of MOD 9, Centennial Mandalong sought approval to amend the approved mine plan, including the reorientation of LW30-LW33.

Since the approval of MOD 9 in April 2021, Centennial Mandalong has continued to review the progression of underground mining within the Mandalong Southern Extension Area. As a result of these investigations, the decision has been made to shorten LW30 and remove LW33 from the mine plan. The shortening of LW30 and removal of LW33 are estimated to result in the sterilisation of approximately 0.4 million tonnes (Mt) and 1.6 Mt of coal, respectively. Consequently, Centennial Mandalong has explored options to optimise the mine plan to access additional coal resources.

Centennial Mandalong is seeking to modify SSD-5144, pursuant to Section 4.55(2) of the EP&A Act, to change Mandalong's approved mine plan to include LW34 (herein referred to as MOD 10 or the proposed modification). The addition of LW34 will maximise resource extraction within the West Wallarah Seam and Mandalong's development consent boundary and improve the continuity of coal extraction and employment at Mandalong. Two updates to Appendix 8 of SSD-5144 are also proposed.

Application of the Biodiversity Assessment Methodology (BAM) is mandatory (State of NSW 2020) for SSD projects and associated modifications. This BDAR is based on the application of the BAM, as required under the *Biodiversity Conservation Act* 2016 (BC Act). This BDAR addresses Stage 1 (Biodiversity Assessment) and Stage 2 (Impact Assessment) of the BAM.

The following terms are used in this document:

- **Project** – Modification to Mandalong Mine SSD-5144 for the addition of LW34;
- **Predicted Impact Area** – Areas where ponding associated with subsidence is modelled to occur;
- **Project Area** – Land within the angle-of-draw (i.e. angle between the goaf and the point on the ground surface to which subsidence is expected to occur; AOD);
- **Potential Impact Area** – Land predicted to be impacted by ponding associated with the Project;
- **Assessment Area** – Land within a 1500 m buffer from the outer extent of the Project Area; and
- **Local Area or locality** – Land within 10 km of the Project Area.

In addition to this BDAR, the attached Biodiversity Inventory Report (BIR; **Appendix A**) describes the biodiversity values of the Project Area as a basis for assessing the Project impacts on threatened biodiversity listed under the BC Act. The BIR supports the BDAR through providing comprehensive details of the survey method, efforts and results, and so is referred to throughout this BDAR. The BIR also addresses

the assessment requirements of the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) and relevant State Environmental Planning Policies (SEPPs).

1.1 Project Area particulars

Locality:	Mandalong, NSW
LGA:	Lake Macquarie City Council (LMCC) and Central Coast Council (CCC)
Lot/DP:	Lot 114 DP755238; Lot 2 DP805044; Lot 145 DP755238; Lot 115 DP755238
Project Area:	Footprint of the Project Area is approximately 52.17 ha. The location of the Project Area is shown in **Figure 1-2**.
Boundaries:	The Project Area is predominantly surrounded by vegetated lands in all directions on private land and State Forest.
Zoning:	Under the provisions of the LMCC and CCC Local Environment Plans (LEPs), the Project Area is zoned as E2 Environmental Conservation and E3 Environmental Management and RU3 Forestry. Other land uses within the broader Assessment Area are RU1 Primary Production, RE1 Public Recreation and RU2 Rural Landscape.
Current Land Use:	Bushland makes up most of the Project Area. Other land uses are tributaries of Morans, Mannering and Buttonderry creeks; local roads (including Toepfers Road and Kiar Ridge Road); private dwellings, ancillary buildings, fences and driveways; and Aboriginal cultural and historic heritage sites.
Topography:	Project Area is dominated by undulating coastal hills ranging from up to 210 m Above Sea Level (ASL) down to Morans Creek at approximately 64 m ASL. The land contains numerous watercourses, many of which are ephemeral, low order tributaries. The topography within the Project Area has been altered by local roads, earthworks associated with private properties and past state forestry activities.

1.2 The Project

Centennial Mandalong is seeking approval to add an additional longwall (LW34). The previously approved and proposed mine plans for the western longwalls in the Mandalong Southern Extension Area are shown in **Figure 1-2**.

LW34 will align with adjacent panels by maintaining the existing panel width of 200 m and all other mining geometry aspects will remain unchanged. Secondary extraction of coal as part of the proposed modification will extend beyond the previously assessed and approved footprint for secondary extraction. No changes to the development consent boundary are required.

1.3 Sources of Information

- Proposal layers and concept designs provided by Centennial Mandalong Pty Ltd;
- Department of Agriculture, Water and Environment (DAWE) Australian Government's Species Profiles and Threats (SPRAT) database (http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl) (DAWE 2021a);
- DAWEs EPBC Act Protected Matters Search Tool (http://www.environment.gov.au/epbc/protected-matters-search-tool; Accessed June 2021; DAWE 2021b);
- Department of Planning, Industry and Environment (DPIE) Threatened Species Profiles (http://www.environment.nsw.gov.au/threatenedspeciesapp/; Accessed June 2021);
- Interim Biogeographical Regionalisation for Australia (IBRA) and IBRA sub-regions (http://www.environment.gov.au/land/nrs/science/ibra);
- DPIEs profiles of threatened species, populations and ecological communities;

- DPIEs BioNet database;
- DPIEs VIS Mapping (http://www.environment.nsw.gov.au/research/VISmap.htm);
- NSW Biodiversity Values Map (https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=BVMap; Accessed June 2021); and
- State of NSW and OEH (2018). Biodiversity Assessment Method Operational Manual – Stage 1;
- State of NSW and DPIE (2019). Biodiversity Assessment Method Operational Manual – Stage 2; and
- State of NSW (2020). Biodiversity Assessment Method.

1.4 Staff Qualifications and authorship

The BDAR report was written by Dr Hayden Beck and reviewed by Mark Aitkens. Fieldwork was undertaken by Dan Creevey, Hayden Beck, Tara Boreham, John Hembra and Rhys Corrigan. Academic qualifications and professional experience of RPS staff involved in the documentation are provided in **Appendix A**.

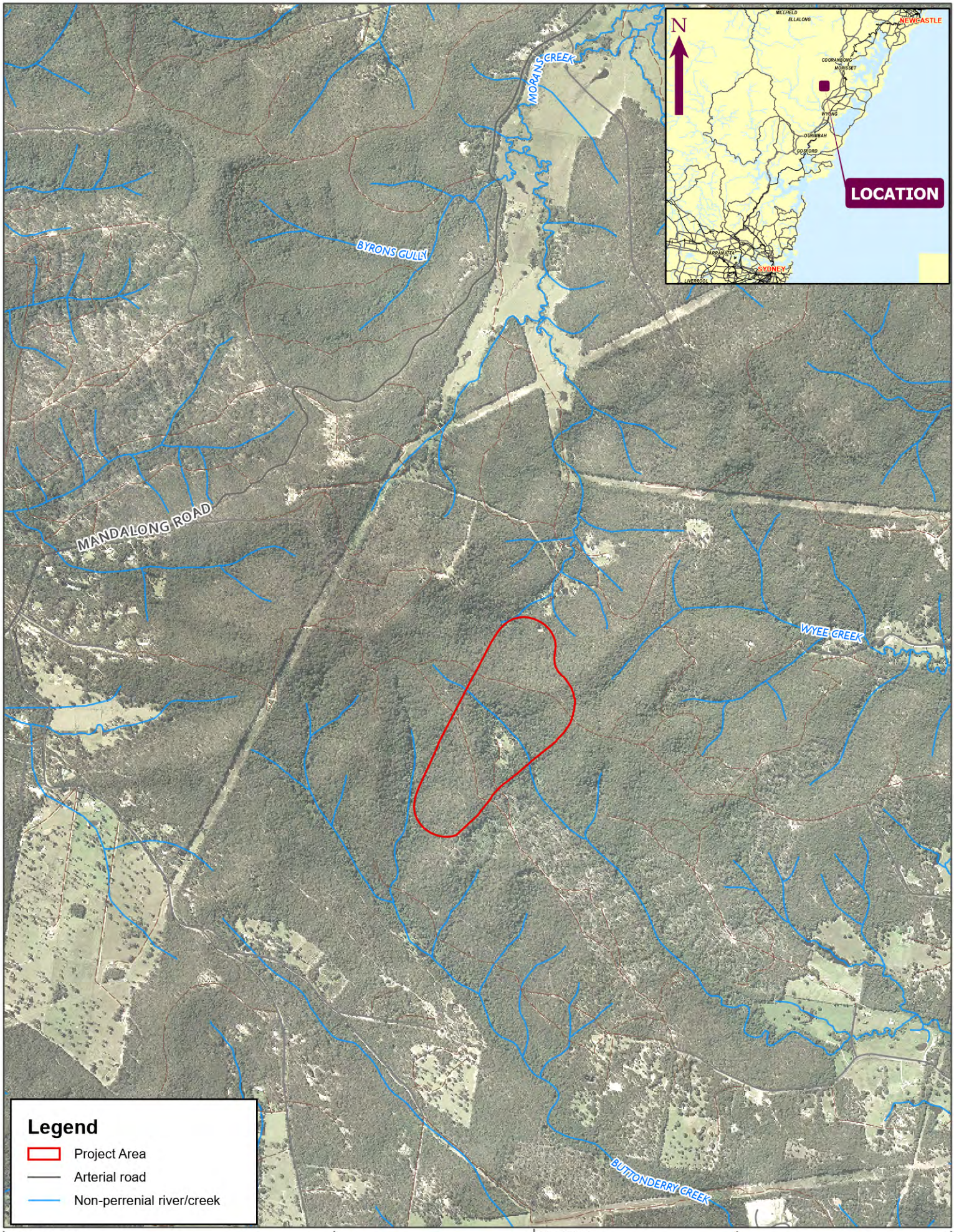


FIGURE 1-1
LOCATION MAP

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DATE EXPORTED: **19/08/2021 10:58 AM**

TECHNICIAN: **Natalie.Wood**

LOCATION:
Mandalong

DATA SOURCES
Centennial, RPS,

0 100 200 300 400 500 600 700 800 m

SCALE 1:25,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**

PROJECT: **149823**

PURPOSE: **BDAR**

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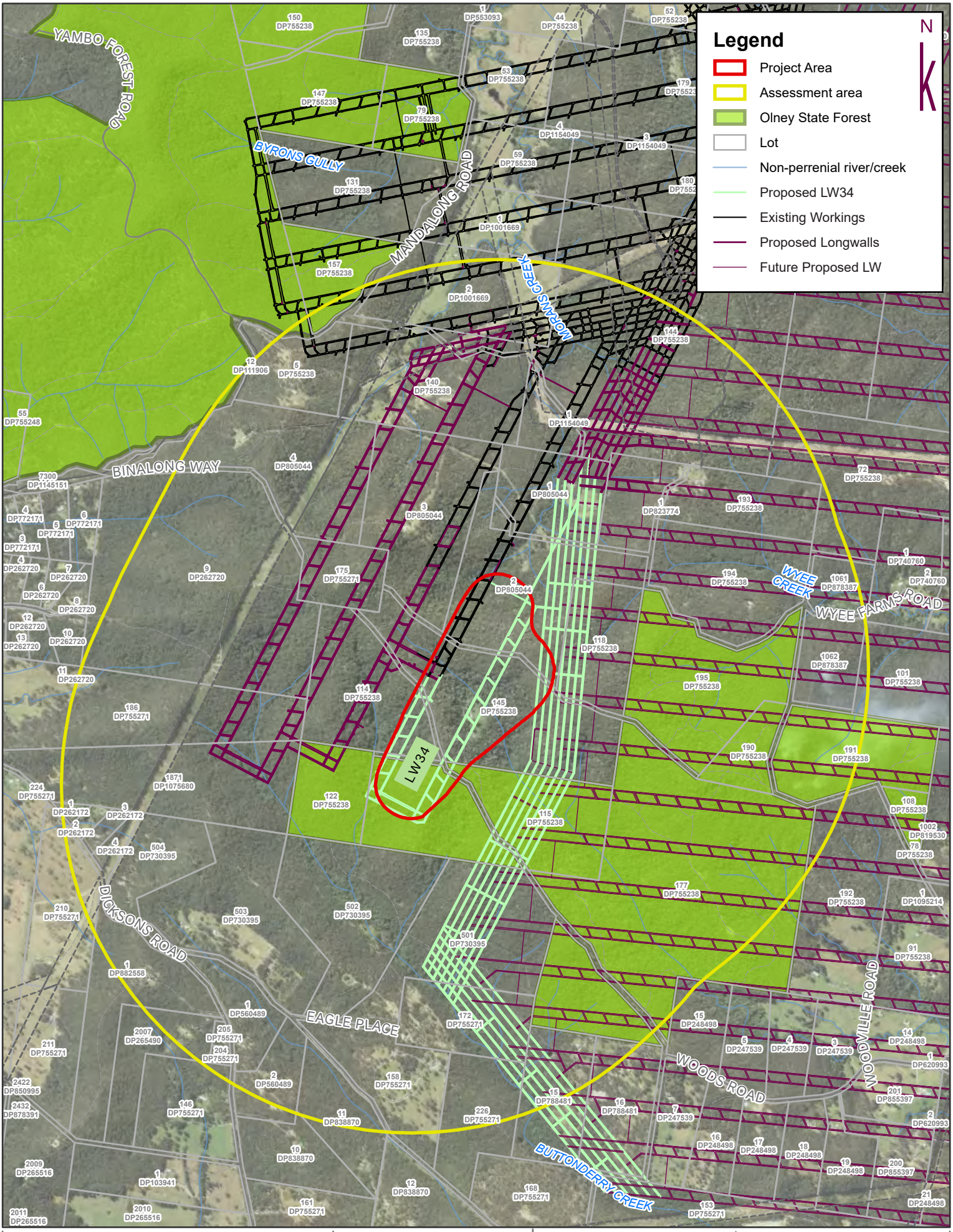


FIGURE 1-2
PROJECT AREA

VERSION:
B
DATE EXPORTED:
25/08/2021 11:00 AM
TECHNICIAN:
Robert.Suansri

LOCATION:
Mandalong

DATA SOURCES
Centennial, RPS, © Department of Finance, Services & Innovation 2018

0 100 200 300 400 500 600 700 800 m

SCALE 1:22,500 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**
PROJ: **149823**
PURPOSE: **BDAR**

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2 LANDSCAPE FEATURES

2.1 IBRA Bioregions and subregions

The Project Area is located within the NSW Sydney Interim Biogeographic Regionalisation for Australia (IBRA) region and Wyong IBRA Subregion (**Figure 2-1**).

2.2 NSW Landscape regions

The dominant Mitchell Landscape present is Gosford-Cooranbong Coastal Slopes Mitchell Landscape, with an incursion of Watagan Rise Mitchell Landscape occurring toward the middle of the Project Area (**Figure 2-1**). Further descriptions of these landscapes are provided in **Appendix A**.

2.3 Area

The Project Area footprint (i.e. AOD) is approximately 52.17 ha. Subsidence predictions indicate that there is potential for direct impact (via ponding) to approximately 0.00047 ha of native vegetation.

2.4 Native vegetation

Approximately 1136.63 ha of vegetation occurs within the 1500 m Buffer (~93.46%), according to Lake Macquarie Vegetation Mapping (Bell and Driscoll 2015). Native vegetation within this Assessment Area is shown in **Figure 2-2**.

Vegetation mapping and inspection of recent aerial photography indicates a limited amount of vegetation clearing within the locality, resulting in a continuous native vegetation patch size of over 1.5M ha, which extends into large tracts of bushland to the south and west. This vegetation is largely intact and incorporates the Watagans National Park; as well as Olney and Watagan State Forests.

2.5 Cleared Areas

Native vegetation clearing within the Assessment Area has occurred for transport, agriculture (e.g. poultry farms, horse stables and livestock), past forestry activity, industrial development, low-density residential housing, a landscaping supply depot and powerline easements. Approximately 6.54% (79.52 of 1216.15 ha) of the Assessment Area is cleared. Clearing within the Project Area has been due to:

- Public roads;
- Unsealed access tracks;
- Rubbish depot;
- Clearing by past forestry;
- Livestock farming;
- Rural housing; and
- Transmission line easements.

2.6 Rivers and Streams

First order tributaries of Morans Creek, Buttonderry Creek and Mannering Creek are located within the Project Area. Morans Creek discharges into Lake Macquarie, Mannering Creek discharges into Lake Mannering, whilst Buttonderry Creek discharges into Tuggerah Lake. Lake Macquarie and Tuggerah Lake are approximately 10 km to the northeast and southeast of the Project Area, respectively. Lake Mannering is approximately 8 km to the east of the Project Area. The ephemeral nature of Morans, Mannering and Buttonderry Creeks within the Project Area is reflected in small flows during dry periods and cease to flow during drought periods (Umwelt 2020). There is no Key Fish Habitat mapped within the Project Area (DPI 2021).

2.7 Wetlands

There are no wetlands within the Project Area. The nearest wetlands fringe Lake Mannering, which is located approximately 8 km east of the Project Area.

2.8 Connectivity Features

The Project Area provides a variety of internal habitat linkages along creeks, gullies and ridgelines, and as such is mapped primarily as a corridor of remnant native vegetation or within the Lake Macquarie Native Vegetation and Corridors Map (LMCC 2015). Apart from small patches of bushland cleared for private properties and easements within the Project Area, much of the vegetation present is recognised as corridors that contribute significantly to movement and viability of flora and fauna in the locality.

Inspection of state vegetation mapping and recent aerial photography indicates a limited amount of vegetation clearing within the locality, resulting in a very large and continuous native vegetation that extends to the Watagan Mountains and further into the Great Dividing Range (estimated to be > 1.5M ha).

The M1 Motorway and Central Coast/ Newcastle Line rail corridor present a potential barrier for fauna moving east toward Lake Macquarie.

2.9 Areas of Geological Significance and Soil Hazard Features

There are several sandstone crevices and cliffs within the Project Area, primarily associated with the Watagan Rise Mitchell Landscape (as depicted by the Watagan Soil Landscape; detailed below). Locations of these geological units and topographic data are shown in **Figure 2-1**. Formational geology for the Project Area is also provided in **Figure 2-3**.

Watagan and Mandalong Soil landscapes are in the Project Area. These soil units are prone to erosion. Soil types within the Project Area are described in **Table 2-1** and indicated in **Figure 2-4**.

Table 2-1 Soil Landscape Units

Soil Landscape	Formative Process	Composition	Hazards
Mandalong (ml)	Colluvial	Magnesic – Natric, Brown, Kurosol	Mass movement hazards, steep slopes, erosion hazards and foundation hazards. Soils have low wet-bearing strength, can be acidic, sodic and have low fertility.
Watagan (wn)	Colluvial	Dark Brown Loam, Yellowish brown sandy clay loam, sandstone colluvium	Mass movement hazard, steep slopes, soil erosion hazard, foundation hazard, occasional rock outcrop, seasonal waterlogging (localised).

2.10 Areas of Outstanding Biodiversity Value

No areas of outstanding Biodiversity Value are known to occur within the Project Area.

2.11 Project Area Context Components

2.11.1 Method of BAM assessment

A Development Assessment Case for a Major Development was applied within the BAM calculator (BAM-C).

2.11.2 Percentage of Native Vegetation Cover

The overall vegetation cover within the Assessment Area was determined using aerial photographs and Lake Macquarie Vegetation Community Mapping by Bell and Driscoll (2015).

Native vegetation cover within the Assessment Area was calculated to be approximately 93.46% (**Figure 2-2**).

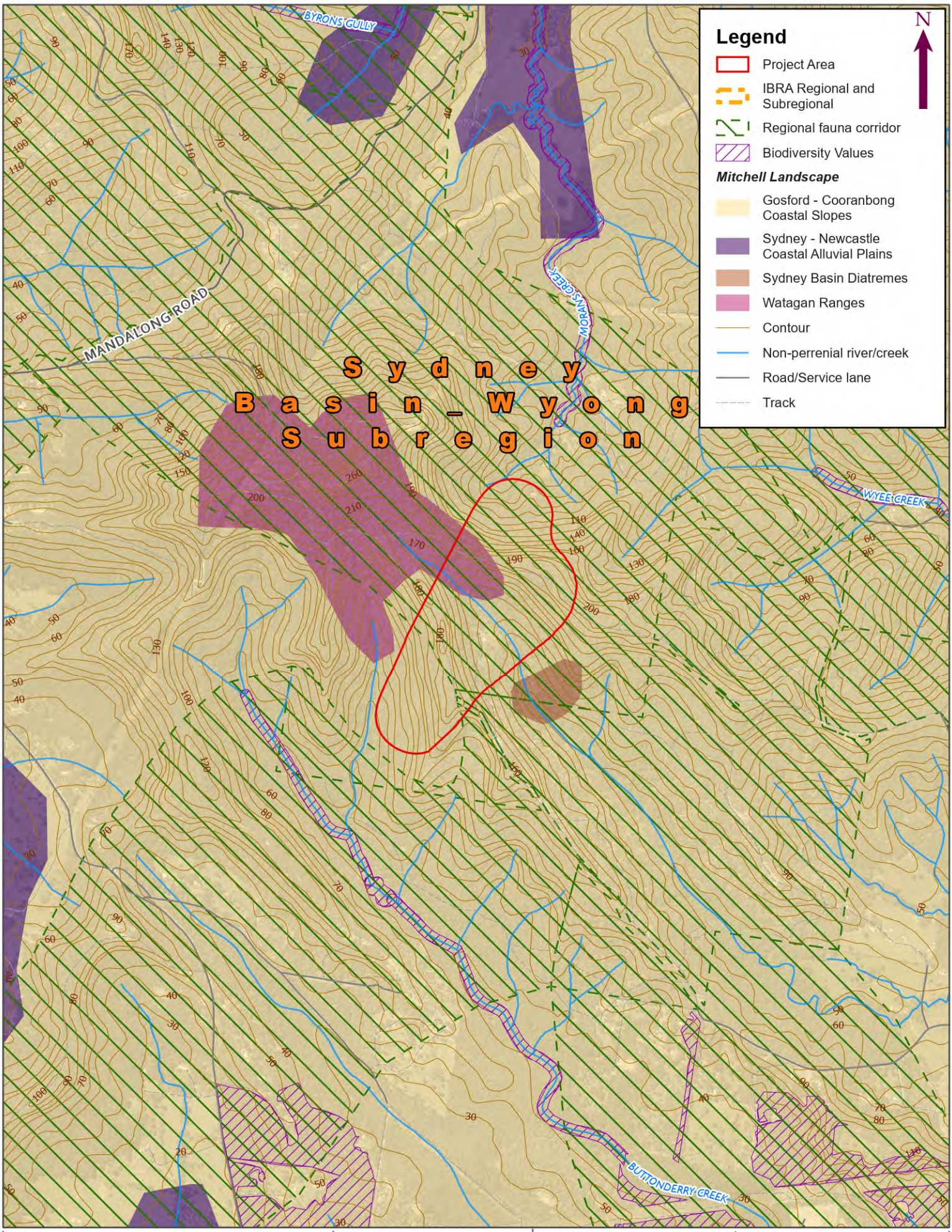


FIGURE 2-1
LANDSCAPE CONTEXT

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TECHNICIAN: **Natalie.Wood**

LOCATION:
Mandalong

DATA SOURCES
Centennial, RPS,

0 100 200 300 400 500 600 700 m

SCALE 1:20,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**

PROJECT: **149823**

PURPOSE: **BDAR**

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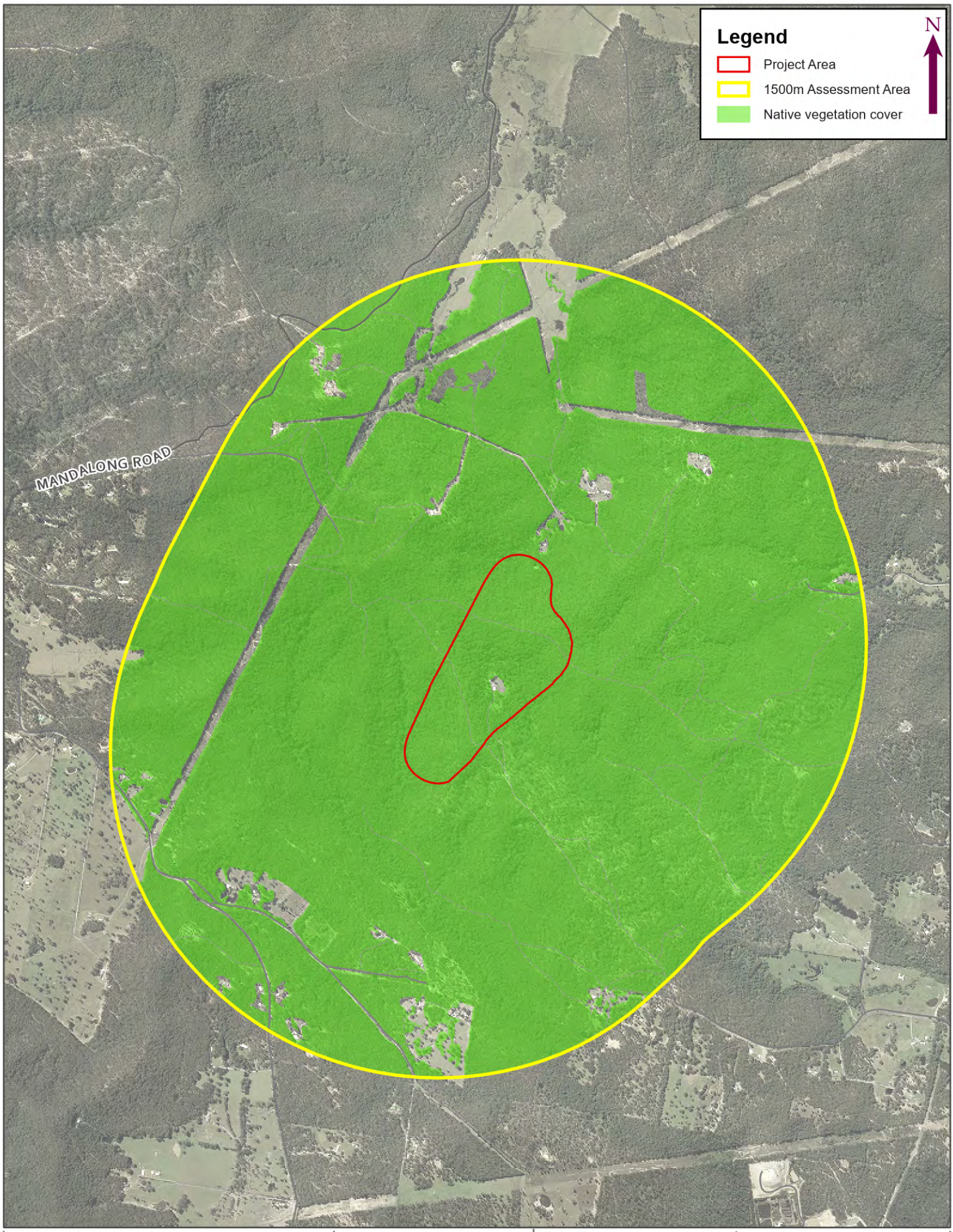


FIGURE 2-2
NATIVE VEGETATION MAPPING IN THE ASSESSMENT AREA

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LOCATION:
Mandalong

DATA SOURCES
Centennial, RPS,

0 200 400 600 800 m

SCALE 1:24,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**

PROJECT: **149823**

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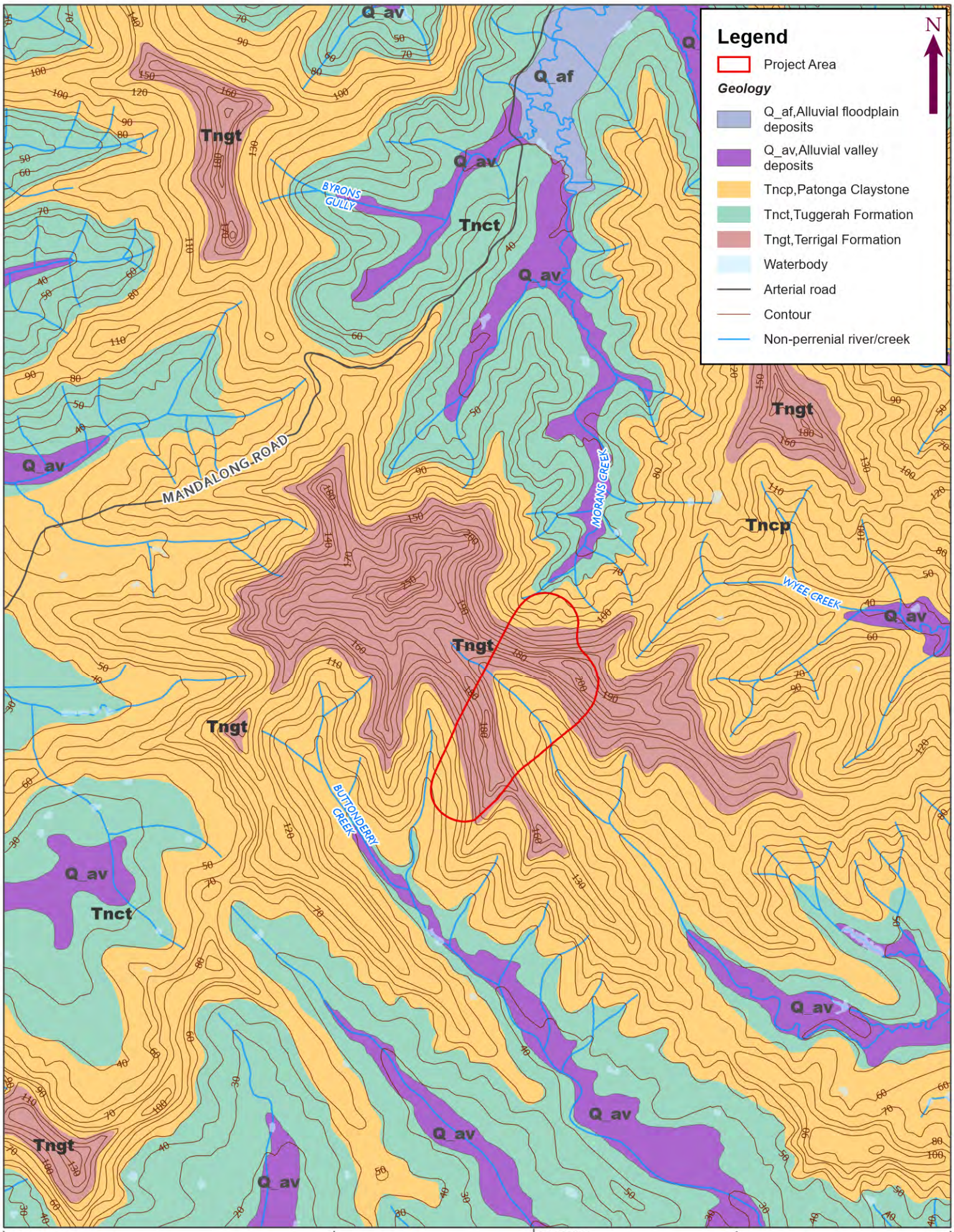


FIGURE 2-3
AREAS OF GEOLOGICAL SIGNIFICANCE

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TECHNICIAN: **Natalie.Wood**

LOCATION:
Mandalong

DATA SOURCES
Centennial, RPS,

0 200 400 600 800 m

SCALE 1:24,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**

PROJECT: **149823**

PURPOSE: **BDAR**

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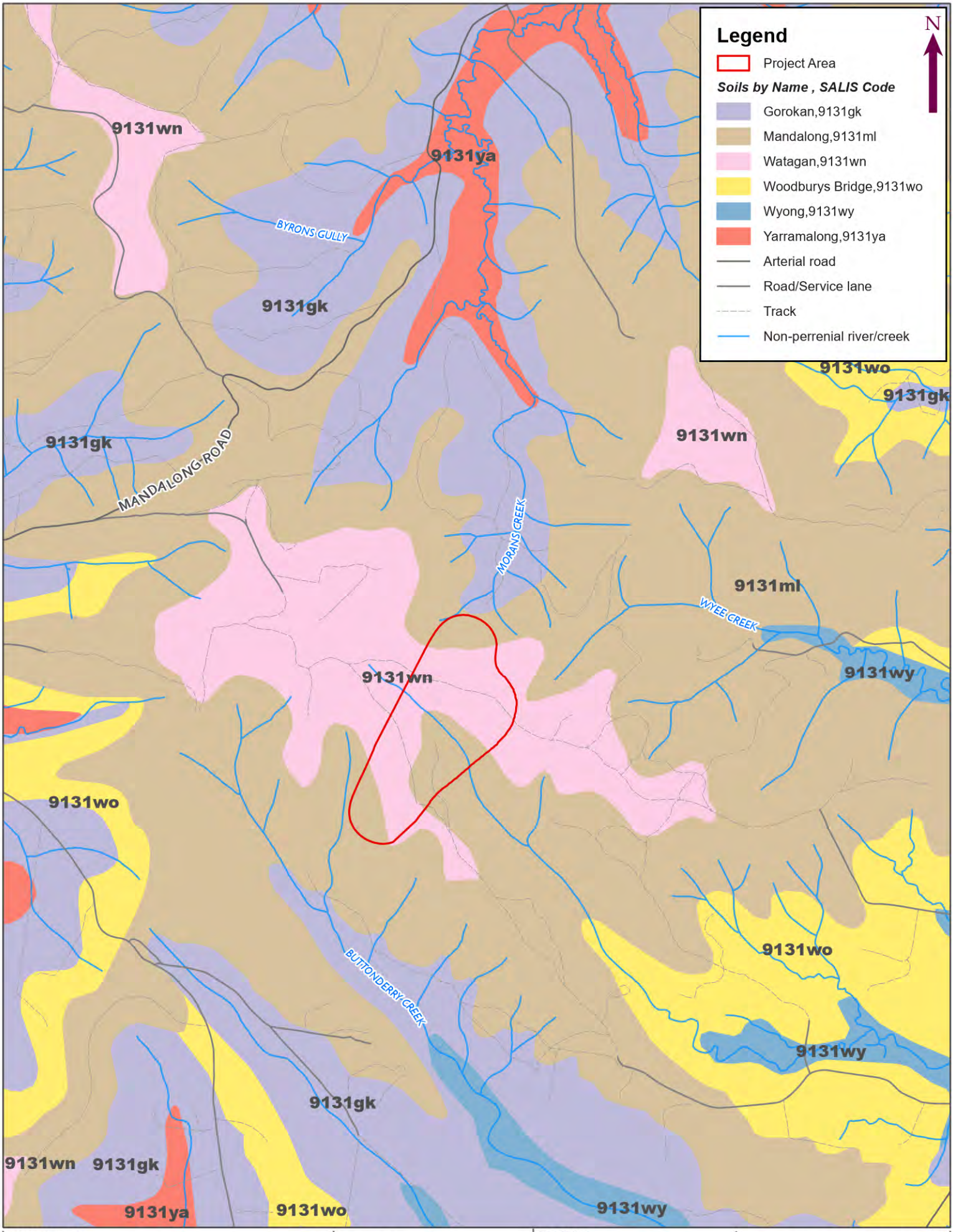


FIGURE 2-4
SOIL LANDSCAPE UNITS

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TECHNICIAN: **Natalie.Wood**

LOCATION:
Mandalong

DATA SOURCES
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0 200 400 600 800 m

SCALE 1:24,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**

PROJECT: **149823**

PURPOSE: **BDAR**

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3 NATIVE VEGETATION

3.1 Native Plant Species

In total, 263 flora species were detected within the BAM plots; 233 native and 30 exotic species. The following threatened species was detected within the Project Area:

- *Rhodamnia rubescens* (Scrub Turpentine; BC Act: Critically Endangered; EPBC Act: Critically Endangered).

For a full list of flora species recorded during the study see the BIR (**Appendix A)**.

3.2 High Threat Weeds

Six high threat weeds were found within the Project Area:

- *Ageratina Adenophora* (Crofton Weed);
- *Alternanthera philoxeroides* (Alligator Weed);
- *Bidens Pilosa* (Cobbler's Peg);
- *Cyperus eragrostis* (Umbrella Sedge);
- *Paspalum dilatatum*; and
- *Lantana camara* (Lantana).

Duties for management of these weeds under the *Biosecurity Act* (2015) are provided in the BIR (**Appendix A**).

3.3 Plant Community Types (PCTs)

Below is a summary of the vegetation communities assigned on the Project Area. For further information, including survey methods, photographs and datasheets, please refer to the BIR (**Appendix A**).

3.3.1 Method of assessing PCTs

3.3.1.1 Review of Existing Information

The Lake Macquarie Vegetation Community Mapping (Bell and Driscoll 2015) was used as the basis for a preliminary analysis of vegetation patterns within the Project Area. Mapping by Bell and Driscoll (2015) was updated following re-interpretation of mapped vegetation boundaries using the latest aerial photography (e.g. Google™ 2021) prior to survey stratification. Plant Community Types (PCTs) were assigned to Bell and Driscoll (2015) using a conversion table prepared by Bell (2016a). Updates also included the assigning of notional condition classes. PCTs were preliminarily assigned to areas of relatively homogenous land cover (i.e. vegetation zones). Additional revisions were performed following the completion of Rapid Data Points (RDPs) during field surveys (i.e. revision of zone boundaries and condition classes). PCT extent was calculated using ArcGIS™ to determine the number of BAM plots required and to stratify other survey methods.

3.3.1.2 Floristic survey

Prior to allocating the BAM plot location and replication requirements, RDPs were collected across the Project Area to ground-truth the Bell and Driscoll (2015) vegetation mapping. At each RDP point, species composition in the vicinity (i.e. 20 m radius) was recorded, focusing on the dominant species in each stratum (e.g. canopy, mid, shrub and ground layer) this process assists in aligning the vegetation with the PCTs and delineating the extent of the PCTs. Following confirmation of the PCT extent, GIS was used to determine required survey effort. Mapping by Bell and Driscoll (2015) was generally consistent with the RDPs, with the need to slightly shift the boundaries of this vegetation mapping following ground-truthing.

A total of 17 flora plots were carried out in accordance with the BAM to assess the composition, structure and function components of vegetation integrity (**Appendix A**). The locations of these BAM plots were selected on site to avoid ecotones and disturbed areas that were readily distinguishable from the broad condition state of the vegetation zone.

The following attributes were measured in each plot:

- One standard 20 x 20 m plot, to assess the composition and structure attributes, including trees, shrubs, grasses, forbs, ferns and other growth forms;
- One standard 20 x 50 m plot (1000 m^2) to assess the function attributes: number of large trees (i.e. > 50 cm DBH), stem size class, tree regeneration, length of fallen logs, high threat exotic vegetation cover and hollow-bearing trees; and
- Five 1 m^2 sub-plots to assess average litter cover for the plots.

The vegetation condition of each PCT was classified as good, moderate, derived, poor or disturbed/cleared based on the definitions provided in **Table 3-1**. Vegetation condition was then used to delineate vegetation zones, and subsequently stratify sampling, as required by the BAM (State of NSW 2020).

Where the number of BAM plots undertaken exceeded the required minimum number of BAM plots required based on the area of each zone, all BAM plots were entered into the BAM-C.

Table 3-1 Definitions of vegetation zones

Vegetation Condition Class	Definition
Good	Vegetation community generally resembles pre-European levels of condition, structure and overall integrity. Vegetation is resilient to weed invasion due to dominance of native species within the ground, shrub and canopy layers.
Moderate	Native canopy present. The understorey is dominated by natives (>50 % native cover). Vegetation condition is below benchmark value but above that defined for poor condition.
Derived	Native vegetation in a structurally modified state, exemplified by an unnatural dominance of species in a non-characteristic strata combined with the absence of characteristic species in the dominant strata (e.g. native grasslands derived from grassy woodlands, native shrublands derived from dry sclerophyll forests).
Poor	Native canopy largely absent. Understorey dominated by exotic species (i.e. > 50% exotic cover). Native shrub layer has largely been replaced by weeds.
Disturbed/ cleared	These areas have: • a vegetation integrity score <15 where the PCT is representative of an endangered or critically endangered ecological community, or • a vegetation zone has a vegetation integrity score <17 where the PCT is associated with threatened species habitat (as represented by ecosystem credits), or is representative of a vulnerable ecological community, or • a vegetation zone has a vegetation integrity score <20 where the PCT is not representative of a TEC or associated with threatened species habitat. Based on the vegetation integrity score for this vegetation group, assessment of native vegetation is not required beyond Section 5.4 of the BAM (State of NSW 2020).

3.3.2 PCTs identified within the Project Area

Five Plant Community Types (PCTs) were identified within the Project Area:

- PCT 1528 Jackwood – Lilly Pilly – Sassafras riparian warm temperate rainforest of the Central Coast;
- PCT 1556 Tallowwood – Smooth-barked Apple – Blackbutt grass tall open forest of the Central and lower North Coast;
- PCT 1568 Blackbutt - Turpentine - Sydney Blue Gum mesic tall open forest on ranges of the Central Coast;
- PCT 1573 Sydney Blue Gum - Lilly Pilly mesic tall open forest of coastal ranges and tablelands escarpment; and
- PCT 1588 Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast.

3.3.3 Zone allocation

The condition of native vegetation for most of the Project Area was moderate to good quality, generally impacted by edge effects associated with adjacent power easements and nearby rural properties (**Table 3-2**). There are also some highly disturbed areas, largely lacking native vegetation associated with land clearing for rural dwellings, agriculture and roads, which were not considered native vegetation as defined by BAM (State of NSW 2020). As such, this resulted in six vegetation zones across the Project Area (**Figure 3-1**).

Table 3-2 PCTs and zones present within the Project Area

Zone	PCT	Condition	Total area (ha)[2]	Potential ponding impact (ha)	No. plots undertaken	No. plots required
1	1528	Moderate	0.04	0	1	1
2	1556	Moderate	25.10	0.000083	5	4
3	1568	Moderate	7.20	0.00031	4	3
4	1573	Moderate	2.48	0.000078	2	2
5	1588	Moderate	15.44	0	3	3
6	Disturbed/cleared	Non-native	1.92	0.00022	2	1

1. The area of native vegetation to be impacted and hence offset is 0.00047 ha. As this value is too small for the BAM-C to recognise, it has been rounded up in BAM-C to the nearest accepted number (i.e. 0.01 ha). 2. Misalignment of listed Project Area size (e.g. **Section 2.3**) and total areas of zones in this table is due to rounding.

A map of the six zones is provided in **Figure 3-1**. A description of each of these zones, and justification for PCT selection, is provided in **Table 3-3** to **Table 3-8**. Further information regarding these vegetation communities, including photographs, is found in the BIR (**Appendix A**).

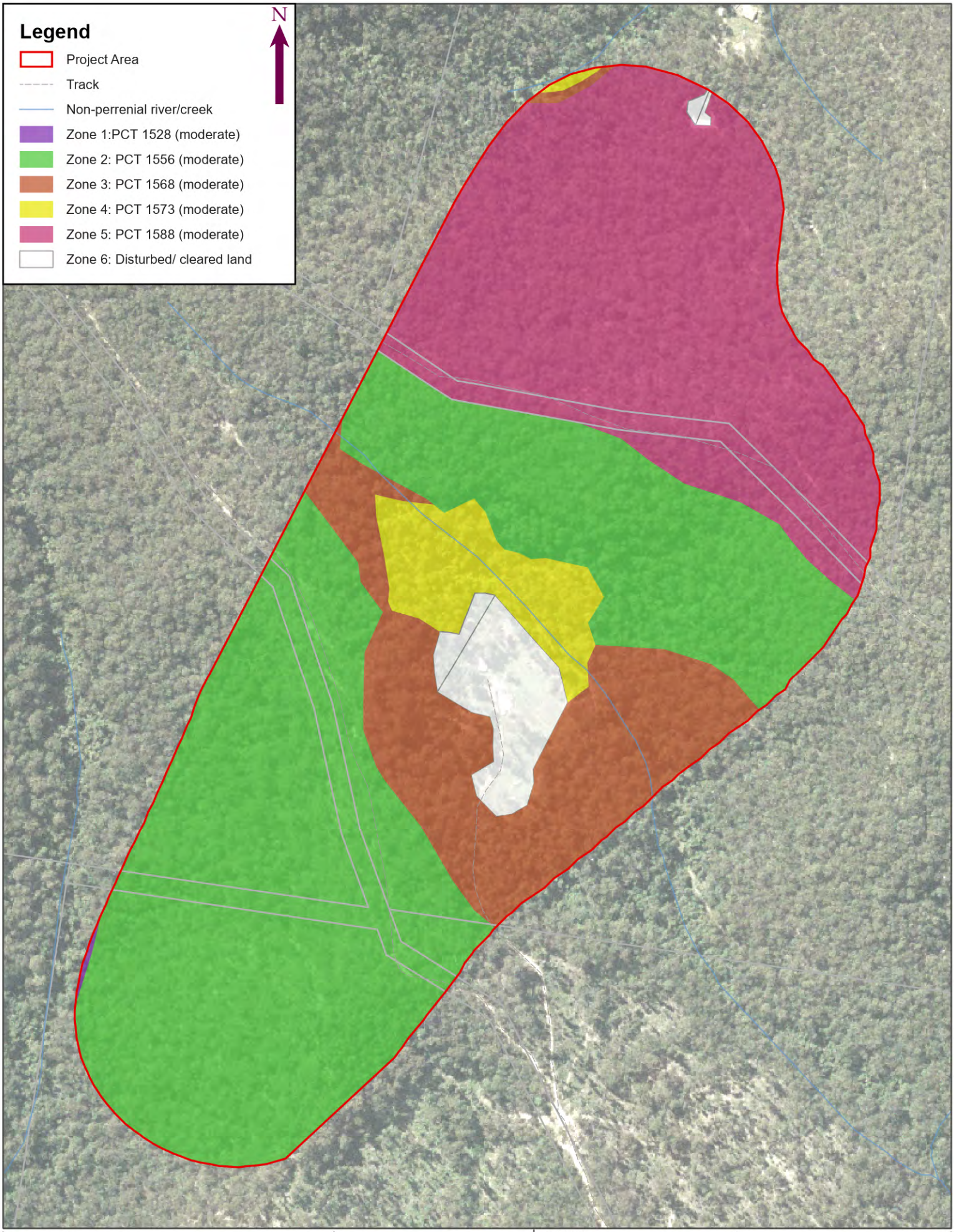


FIGURE 3-1
VEGETATION ZONES

VERSION: **A**

DATE EXPORTED: **10/08/2021 2:42 PM**

TECHNICIAN: **Natalie.Wood**

LOCATION:
Mandalong

DATA SOURCES
Centennial, RPS,

0 50 100 150 m

SCALE 1:5,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**

PROJECT: **149823**

PURPOSE: **BDAR**

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Table 3-3 Zone 1: PCT 1528 Jackwood – Lilly Pilly – Sassafras riparian warm temperate rainforest of the Central Coast

Jackwood – Lilly Pilly – Sassafras riparian warm temperate rainforest of the Central Coast		
Vegetation Formation	Rainforest	
Vegetation class	Northern Warm Temperate Rainforest	
Vegetation Type	**PCT ID**	1528
	Common Community Name	Jackwood – Lilly Pilly – Sassafras riparian warm temperate rainforest of the Central Coast
Condition	Moderate/ Good	
Approximate extent within the Project Area	~0.04 ha	
BAM Plot no.	LW 34-3	
Species relied upon for PCT identification	**Species Name**	**Mean relative abundance (400 m^2 BAM Plot)**
	Cryptocarya glaucescens	15.00
	Ficus coronata	0.20
	Alphitonia excelsa	8.00
	Archontophoenix cunninghamiana	15.00
	Alectryon subcinereus	0.30
	Wilkiea huegeliana	2.00
	Pittosporum multiflorum	2.00
	Morinda jasminoides	0.30
	Cissus antarctica	5.00
	Lastreopsis microsora	0.07
	Hypolepis muelleri	0.27
	Gymnostachys anceps	0.10
	Oplismenus imbecillis	0.20
Other consistent diagnostic features	Floodplains; valley floors; sheltered riparian sites of the Central Coast; mainly on sandstones; at elevations below 50 m.	
Justification of evidence used to identify the PCT	This vegetation community is in sheltered riparian areas on the valley floor within the Central Coast. The elevation in the location of this zone is low (~60 m asl). Vegetation was consistent with a rainforest growth formation, depicted by a high-density canopy and lower density understory. The vegetation aligns closest to MU1a under Bell (2016b), which has been allocated to PCT 1528 by Bell (2016a). Many of the diagnostic species listed in the BioNet Vegetation Classification System (DPIE 2021C) were present adjacent or inside plots, as indicated above.	
TEC Status	This PCT corresponds with BC Act-listed Lowland Rainforest in the NSW North Coast and Sydney Basin Bioregions TEC.	
Estimate of percentage cleared	32%	
Notes	No predicted ponding expected in this area.	

Table 3-4 Zone 2: PCT 1556 Tallowwood - Smooth-barked Apple - Blackbutt grass tall open forest of the Central and lower North Coast

Tallowwood - Smooth-barked Apple - Blackbutt grass tall open forest of the Central and lower North Coast		
Vegetation Formation	Wet Sclerophyll Forest (Grassy sub-formation)	
Vegetation class	Northern Hinterland Wet Sclerophyll Forest	
Vegetation Type	**PCT ID**	1556
	Common Community Name	Tallowwood - Smooth-barked Apple - Blackbutt grass tall open forest of the Central and lower North Coast
Condition	Moderate	
Approximate extent within the Project Area	~25.10 ha	
BAM Plot no.	LW34-8; LW34-9; LW34-10; LW34-11; LW34-12	
Species relied upon for PCT identification	**Species Name**	**Mean relative abundance (400 m^2 BAM Plot)**
	Eucalyptus microcorys	10.60
	Eucalyptus pilularis	15.00
	Allocasuarina torulosa	8.20
	Persoonia linearis	0.40
	Imperata cylindrica	0.16
	Entolasia stricta	0.10
	Themeda triandra	0.34
	Dianella caerulea	0.34
	Lomandra longifolia	2.28
	Lepidosperma laterale	0.10
	Lobelia purpurascens	0.20
Other consistent diagnostic features	Upper slopes & valleys in dissected terrain; coastal flats and rises; ranges of the lower North Coast at mid to lower elevations.	
Justification of evidence used to identify the PCT	This vegetation community is in upper slopes and valleys in the ranges of the Central Coast, located at mid to lower elevations above rainforests located at the valley floor. The vegetation aligns closest to MU9l under Bell (2016b), which has been allocated to PCT 1556 by Bell (2016a). Many of the diagnostic species listed in the BioNet Vegetation Classification System (DPIE 2021C) were present, as indicated above.	
TEC Status	Although this PCT can correspond with BC Act-listed River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions TEC, vegetation within the Project Area was inconsistent with this TEC since it was not positioned on a river flat of the coastal floodplain. That is, river flats are typically level landforms that occur below 20 m ASL (DECC 2007b), whilst the lowest point of the Project Area is approximately 60 m ASL with typically steep terrain. This PCT does not correspond to any EPBC Act-listed TEC.	
Estimate of percentage cleared	41%	
Notes	None	

Table 3-5 Zone 3: PCT 1568 Blackbutt - Turpentine - Sydney Blue Gum mesic tall open forest on ranges of the Central Coast (Moderate)

Blackbutt - Turpentine - Sydney Blue Gum mesic tall open forest on ranges of the Central Coast		
Vegetation Formation	Wet Sclerophyll Forest (Shrubby sub-formation)	
Vegetation class	Northern Coast Wet Sclerophyll Forest	
Vegetation Type	**PCT ID**	1568
	Common Community Name	Blackbutt - Turpentine - Sydney Blue Gum mesic tall open forest on ranges of the Central Coast
Condition	Moderate	
Approximate extent within the Project Area	~7.20 ha	
BAM Plot no.	LW 34-6; LW 34-13; PR144986 Plot 12; PR144986 Plot 19	
Species relied upon for PCT identification	**Species Name**	**Mean relative abundance (400 m^2 BAM Plot)**
	Eucalyptus pilularis	6.00
	Eucalyptus saligna	1.50
	Cryptocarya microneura	0.13
	Synoum glandulosum	23.33
	Pittosporum revolutum	0.35
	Dianella caerulea	0.03
	Doodia aspera	0.05
	Gymnostachys anceps	0.10
	Dianella caerulea	0.50
	Wilkiea huegeliana	0.20
Other consistent diagnostic features	Sandstones ranges of the Central Coast at elevations below 450 m.	
Justification of evidence used to identify the PCT	Located on sandstones ranges of the Central Coast at elevations below 450 m. Located toward the gully floor on typically alluvial sediments, coinciding with the occurrence of *Eucalyptus saligna*. The vegetation aligns closest to MU5 under Bell (2016b), which has been allocated to PCT 1568 by Bell (2016a). Many of the diagnostic species listed in the BioNet Vegetation Classification System (DPIE 2020C) were present adjacent or inside plots, as indicated above.	
TEC Status	Not Listed	
Estimate of percentage cleared	40%	
Notes	None	

Table 3-6 Zone 4: PCT 1573 Sydney Blue Gum – Lilly Pilly mesic tall open forest of coastal ranges and tablelands escarpment (Moderate)

Sydney Blue Gum – Lilly Pilly mesic tall open forest of coastal ranges and tablelands escarpment		
Vegetation Formation	Wet Sclerophyll Forest (Shrubby sub-formation)	
Vegetation class	Northern Coast Wet Sclerophyll Forest	
Vegetation Type	**PCT ID**	1573
	Common Community Name	Sydney Blue Gum – Lilly Pilly mesic tall open forest of coastal ranges and tablelands escarpment
Condition	Moderate/ Good	
Approximate extent within the Project Area	~2.48 ha	
BAM Plot no.	LW34-7; PR144986 Plot 20	
Species relied upon for PCT identification	**Species Name**	**Mean relative abundance (400 m^2 BAM Plot)**
	Acmena smithii	0.05
	Cryptocarya glaucescens	20.00
	Eupomatia laurina	12.50
	Schizomeria ovata	2.50
	Synoum glandulosum	1.25
	Adiantum formosum	0.50
	Cissus antarctica	1.00
	Oplismenus imbecillis	2.60
Other consistent diagnostic features	Occurred on lower slopes of coastal ranges, just below the 150 to 900 m elevation criteria (~120-130 m ASL).	
Justification of evidence used to identify the PCT	Located on footslopes of the Central Coast at elevations broadly consistent with this PCT description. The vegetation aligns closest to MU1 under Bell (2016b), which has been allocated to PCT 1573 by Bell (2016a). Many of the diagnostic species listed in the BioNet Vegetation Classification System (DPIE 2020C) were present adjacent or inside plots, as indicated above.	
TEC Status	Not Listed	
Estimate of percentage cleared	NA	
Notes	None	

Table 3-7 Zone 5: PCT 1588 Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast

Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast		
Vegetation Formation	Dry Sclerophyll Forest (Shrub/grass sub-formation)	
Vegetation class	Hunter-Macleay Dry Sclerophyll Forest	
Vegetation Type	**PCT ID**	1588
	Common Community Name	Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast
Condition	Moderate	
Approximate extent within the Project Area	~15.44 ha	
BAM Plot no.	LW 34-2; LW 34-4; LW 34-14	
Species relied upon for PCT identification	**Species Name**	**Relative abundance (400 m^2 BAM Plot)**
	Breynia oblongifolia	0.07
	Dianella caerulea	0.4
	Pandorea pandorana	0.03
	Themeda triandra	0.07
	Dianella caerulea	1.25
Other consistent diagnostic features	Low rises; upper slopes; coastal lowlands of the Central Coast mainly on sandstones.	
Justification of evidence used to identify the PCT	Located on upper slopes of Central Coast on sandstones range. vegetation aligns closest to MU15 Coastal Foothills Spotted Gum Ironbark Forest under Bell (2016b), which has been allocated to PCT 1588 by Bell (2016a). Specifically, vegetation best aligned with MU 15 due to dominance of *Allocasuarina torulosa*, *Corymbia maculata*, *Eucalyptus fergusonii* and *Eucalyptus punctata*, which occurred within each plot. *Eucalyptus pilularis* was also present, however the occurrence of this species did not fit any other MU given the presence of the three commonly occurring tree species just mentioned. Moreover, many of the diagnostic species listed in the BioNet Vegetation Classification System (DPIE 2020c) were present, as indicated above. As noted by Bell (2016a), best fit is PCT1216 Spotted Gum – Grey Ironbark open forest on the foothills of the Central Coast, Sydney Basin Bioregion, but that has been decommissioned.	
TEC Status	This PCT can correspond with BC Act-listed Subtropical Coastal Floodplain Forest of the New South Wales North Coast Bioregion TEC. However, this TEC extends north from Port Stephens, and hence this vegetation is not classified as this TEC. The Project Area is also above the coastal floodplain.	
Estimate of percentage cleared	56%	
Notes	No predicted ponding expected in this area.	

Table 3-8 Zone 6: Disturbed/cleared land

Disturbed/ cleared land		
Vegetation Formation	None	
Vegetation class	None	
Vegetation Type	**PCT ID**	None
	Common Community Name	None
Condition	Disturbed/ Cleared Land	
Approximate extent within the Project Area	~1.92 ha	
BAM Plot no.	LW34-1; LW 34-5	
Other consistent diagnostic features	This zone consists of: • cleared, gravel tracks (i.e. Kiar Ridge Road and Toepfers Road), as well as property access tracks; and • cleared associated with private dwellings and associated Asset Protection Zones (APZs).	
Justification of evidence used to identify the PCT	Not native vegetation so does not constitute a PCT. Heavily transformed vegetation zone due to historic clearing and is now dominated by exotics, including dominance of *Bouteloua dactyloides* (Buffalo Grass). Weeds were also common to these areas, which included *Alternanthera philoxeroides*, *Axonopus compressus*, *Cyperus eragrostis*, *Hypochaeris radicata*, *Lysimachia arvensis*, *Modiola caroliniana*, *Nasturtium officinale*, *Richardia humistrata*, *Trifolium repens*, *Setaria sphacelata*, *Sida rhombifolia*, *Stellaria media* and *Taraxacum officinale*. Some native forbs and grasses were present but only in small occurrences, including *Cynodon dactylon*, *Dichondra repens*, *Geranium* spp., *Hibiscus heterophyllus subsp. heterophyllus*, *Hydrocotyle tripartite*, *Lobelia pratioides*, *Oplismenus imbecillis*, *Plectranthus parviflorus*, *Stephania japonica* and *Viola betonicifolia*.	
TEC Status	None	
Estimate of percentage cleared	NA	
Notes	None	

3.3.4 Patch size

Patch sizes were assigned to vegetation zones within the Project Area using ArcGIS™ to select boundaries depicted in the existing mapping for the Project Area by Bell and Driscoll (2015), with reference to RDPs (strategically located across the Project Area) and aerial imagery.

In accordance with the BAM, patch size area was assigned to each vegetation zone as a class, being < 5ha, 5–24 ha, 25–100 ha or ≥ 100 ha. The patch size for all six zones was > 100 ha.

3.3.5 Vegetation integrity score

The vegetation integrity score for each vegetation zone is presented in **Table 3-9**. Note that only vegetation zones 2, 3 and 4 are predicted to be impacted by ponding. As such, these are the vegetation communities focused on when determining the offset liability for the Project.

Table 3-9 Vegetation integrity score for the vegetation zones

Zone	PCT	Condition	Composition	Structure	Function	Vegetation Integrity Score
1	1528	Moderate	89.7	49	63.6	65.4
2	1556	Moderate	84.8	58	97.4	78.2
3	1568	Moderate	86.8	86	65.5	78.8
4	1573	Moderate	89.8	68	74.7	76.9
5	1588	Moderate	90.6	55	65.1	68.7
6	-	Disturbed/ cleared	26.3	3.5	21	12.4

4 THREATENED SPECIES

4.1 Fauna habitat assessment

The habitat assessment aims to inform the assessment of ecosystem credit species predicted to occur within the Project Area and to assist in developing a list of Candidate species requiring further assessment (in accordance with Section 6.2 of the BAM and Section 6.4 of BAM respectively). A habitat-based fauna assessment was undertaken by identifying the following fauna habitat features:

- Habitat trees (including large hollow-bearing trees);
- Flowering shrubs and feed tree species, including winter flowering species;
- Sandstone rocky outcrops, including rock crevices/ caves and cliffs; and
- First order tributaries of Morans Creek, Mannering Creek and Buttonderry Creek.

The results of this fauna habitat assessment are further detailed in the BIR (**Appendix A**).

4.2 Ecosystem credit species assessment

Ecosystem credit species assigned by the BAM-C as being associated with the PCTs present within the Project Area are presented in **Table 4-1**. Although focus of the BAM-C final calculation was placed on vegetation zones to be impacted by ponding, the full suite of associated Ecosystem Credit Species across the Project Area was applied to inform assessment of indirect impacts.

Table 4-1 Ecosystem Credit Species

Ecosystem credit species	Vegetation type(s)	Sensitivity to gain class	BC Act listing	EPBC Act listing
Anthochaera phrygia Regent Honeyeater (Foraging)	PCT 1556	High Sensitivity to Potential Gain	Critically Endangered	Critically Endangered
Callocephalon fimbriatum Gang-gang Cockatoo (Foraging)	PCT 1556 PCT 1568 PCT 1573	Moderate Sensitivity to Potential Gain	Vulnerable	Not Listed
Calyptorhynchus lathami Glossy Black-Cockatoo (Foraging)	PCT 1556 PCT 1568 PCT 1573	High Sensitivity to Potential Gain	Vulnerable	Not Listed
Chthonicola sagittata Speckled Warbler	PCT 1588	High Sensitivity to Potential Gain	Vulnerable	Not Listed
Climacteris picumnus victoriae Brown Treecreeper (eastern subspecies)	PCT 1588	High Sensitivity to Potential Gain	Vulnerable	Not Listed
Daphoenositta chrysoptera Varied Sittella	PCT 1556 PCT 1568 PCT 1573 PCT 1588	Moderate Sensitivity to Potential Gain	Vulnerable	Not Listed
Dasyurus maculatus Spotted-tailed Quoll	PCT 1528 PCT 1556 PCT 1568 PCT 1573 PCT 1588	High Sensitivity to Potential Gain	Vulnerable	Endangered
Falsistrellus tasmaniensis Eastern False Pipistrelle	PCT 1556 PCT 1568 PCT 1573	High Sensitivity to Potential Gain	Vulnerable	Not Listed
Glossopsitta pusilla Little Lorikeet	PCT 1556 PCT 1568	High Sensitivity to Potential Gain	Vulnerable	Not Listed

Ecosystem credit species	Vegetation type(s)	Sensitivity to gain class	BC Act listing	EPBC Act listing
	PCT 1573 PCT 1588			
Haliaeetus leucogaster White-bellied Sea-Eagle (Foraging)	PCT 1556 PCT 1568 PCT 1588	High Sensitivity to Potential Gain	Vulnerable	Not Listed
Hirundapus caudacutus White-throated Needletail	PCT 1528 PCT 1556 PCT 1568 PCT 1573 PCT 1588	High	Not Listed	Vulnerable
Lathamus discolor Swift Parrot (Foraging)	PCT 1556 PCT 1568	Moderate Sensitivity to Potential Gain	Endangered	Critically Endangered
Lophoictinia isura Square-tailed Kite (Foraging)	PCT 1556 PCT 1568	Moderate Sensitivity to Potential Gain	Vulnerable	Not Listed
Micronomus norfolkensis Eastern Coastal Free-tailed Bat	PCT 1556 PCT 1568 PCT 1573	High Sensitivity to Potential Gain	Vulnerable	Not Listed
Miniopterus australis Little Bent-winged Bat (Foraging)	PCT 1556 PCT 1568 PCT 1573	High Sensitivity to Potential Gain	Vulnerable	Not Listed
Miniopterus orianae oceanensis Large Bent-winged Bat (Foraging)	PCT 1556 PCT 1568 PCT 1573	High Sensitivity to Potential Gain	Vulnerable	Not Listed
Neophema pulchella Turquoise Parrot	PCT 1556 PCT 1568	High Sensitivity to Potential Gain	Vulnerable	Not Listed
Ninox connivens Barking Owl (Foraging)	PCT 1528 PCT 1556 PCT 1568 PCT 1573 PCT 1588	High Sensitivity to Potential Gain	Vulnerable	Not Listed
Ninox strenua Powerful Owl (Foraging)	PCT 1556 PCT 1568 PCT 1573	High Sensitivity to Potential Gain	Vulnerable	Not Listed
Petaurus australis Yellow-bellied Glider	PCT 1556 PCT 1568 PCT 1573	High Sensitivity to Potential Gain	Vulnerable	Not Listed
Petroica boodang Scarlet Robin	PCT 1556	Moderate Sensitivity to Potential Gain	Vulnerable	Not Listed
Phascolarctos cinereus Koala (Foraging)	PCT 1556 PCT 1568 PCT 1573	High Sensitivity to Potential Gain	Vulnerable	Vulnerable
Phoniscus papuensis Golden-tipped Bat	PCT 1556 PCT 1568 PCT 1573	High Sensitivity to Potential Gain	Vulnerable	Not Listed
Pseudomys gracilicaudatus Eastern Chestnut Mouse	PCT 1556 PCT 1568 PCT 1573	High Sensitivity to Potential Gain	Vulnerable	Not Listed
Pteropus poliocephalus Grey-headed Flying-fox	PCT 1556 PCT 1568	High Sensitivity to Potential Gain	Vulnerable	Vulnerable

Ecosystem credit species	Vegetation type(s)	Sensitivity to gain class	BC Act listing	EPBC Act listing
(Foraging)	PCT 1573			
Ptilinopus magnificus Wompoo Fruit-Dove	PCT 1528 PCT 1568 PCT 1573	Moderate Sensitivity to Potential Gain	Vulnerable	Not Listed
Ptilinopus regina Rose-crowned Fruit-Dove	PCT 1528 PCT 1568 PCT 1573	Moderate Sensitivity to Potential Gain	Vulnerable	Not Listed
Ptilinopus superbus Superb Fruit-Dove	PCT 1528 PCT 1568 PCT 1573	Moderate Sensitivity to Potential Gain	Vulnerable	Not Listed
Saccolaimus flaviventris Yellow-bellied Sheathtail-bat	PCT 1556 PCT 1568 PCT 1573	High Sensitivity to Potential Gain	Vulnerable	Not Listed
Scoteanax rueppellii Greater Broad-nosed Bat	PCT 1556 PCT 1568 PCT 1573	High Sensitivity to Potential Gain	Vulnerable	Not Listed
Thylogale stigmatica Red-legged Pademelon	PCT 1573	High Sensitivity to Potential Gain	Vulnerable	Not Listed
Tyto novaehollandiae Masked Owl (Foraging)	PCT 1556 PCT 1568 PCT 1573	High Sensitivity to Potential Gain	Vulnerable	Not Listed
Tyto tenebricosa Sooty Owl (Foraging)	PCT 1573	High Sensitivity to Potential Gain	Vulnerable	Not Listed

4.2.1 Species excluded from assessment

No ecosystem credit species were excluded from assessment based on habitat constraints or geographic limitations.

4.3 Species Credit Species

The species credit species predicted by the BAM-C to occur within the Project Area are presented in **Table 4-2**.

Tetratheca juncea (Black-eyed Susan) was added as a species credit species due to its potential to occur within the Project Area (**Appendix A**). This species may occur within open forest/woodland below 200m elevation, preferring cooler southerly aspects. As such, PCT 1556 was considered potential habitat for this species.

A *Tyto tenebricosa* (Sooty Owl) was detected by call during the surveys. As such, it was included as a Species Credit Species. Although no PCTs were present that this species aligns with in BioNet (DPIE 2020b), it can occupy rainforest and most eucalypt forest. As such, it is considered possible to occur within PCTs 1528 and 1556. Although they are not predicted to be impacted by ponding, species associated only with PCT 1588 was also included here (as indicated by a footnote in **Table 4-2**), due to potential for indirect impacts associated with the Project. This encompassed only *Litoria aurea* (Green and Golden Bell Frog). Nevertheless, it is considered that the survey efforts were still sufficient to survey for this species, which was not detected (**Appendix A**).

Table 4-2 Candidate species credit species requiring assessment

Species Credit Species	BC Act	EPBC Act	Habitat components and geographic restrictions	Sensitivity to gain class	Habitat components on Project Area	Included or excluded	Reason for inclusion or exclusion
Anthochaera phrygia Regent Honeyeater (Breeding)	Critically Endangered	Critically Endangered	• As per mapped areas	High Sensitivity to Potential Gain	No	Excluded	Not in mapped areas for breeding
Callocephalon fimbriatum Gang-gang Cockatoo (Breeding)	Vulnerable	Not Listed	• Hollow bearing trees • Eucalypt tree species with hollows greater than 9cm diameter	High Sensitivity to Potential Gain	Yes	Included	Habitat components assumed present
Calyptorhynchus lathami Glossy Black-Cockatoo (Breeding)	Vulnerable	Not Listed	• Hollow bearing trees • Living or dead tree with hollows greater than 15cm diameter and greater than 5m above ground	High Sensitivity to Potential Gain	Yes	Included	Habitat components assumed present
Cercartetus nanus Eastern Pygmy-possum	Vulnerable	Not Listed	-	High Sensitivity to Potential Gain	Yes	Included	Habitat components present
Chalinolobus dwyeri Large-eared Pied Bat	Vulnerable	Vulnerable	• Cliffs • Within two kilometres of rocky areas containing caves, overhangs, escarpments, outcrops, or crevices, or within two kilometres of old mines or tunnels	Very High Sensitivity to Potential Gain	Yes	Included	Rocky outcrops/ crevices within 2km
Corybas dowlingii Red Helmet Orchid	Endangered	Not Listed	-	Moderate Sensitivity to Potential Gain	Yes	Included	Habitat components present
Cryptostylis hunteriana Leafless Tongue Orchid	Vulnerable	Vulnerable	-	Moderate Sensitivity to Potential Gain	Yes	Included	Habitat components present
Cynanchum elegans White-flowered Wax Plant[1]	Endangered	Endangered	-	High Sensitivity to Potential Gain	Yes	Included	Habitat components present
Diuris praecox Rough Doubletail	Vulnerable	Vulnerable	• Within the Parish boundaries of Newcastle, Kahibah,	Moderate Sensitivity to Potential Gain	No	Excluded	Project Area outside parish boundaries of Newcastle, Kahibah,

Species Credit Species	BC Act	EPBC Act	Habitat components and geographic restrictions	Sensitivity to gain class	Habitat components on Project Area	Included or excluded	Reason for inclusion or exclusion
			Wallarah, Tuggerah and Kincumber				Wallarah, Tuggerah and Kincumber
Haliaeetus leucogaster White-bellied Sea-Eagle (Breeding)	Vulnerable	Not Listed	• Living or dead mature trees within suitable vegetation within 1km of a rivers, lakes, large dams or creeks, wetlands and coastlines	High Sensitivity to Potential Gain	Yes	Included	Habitat components present
Hoplocephalus bitorquatus Pale-headed Snake	Vulnerable	Not Listed	-	High Sensitivity to Potential Gain	Yes	Included	Habitat components present
Hoplocephalus stephensii Stephens' Banded Snake	Vulnerable	Not Listed	• Hollow bearing trees or within 500m of this habitat • Within 500m of arboreal vine tangles, fallen/standing dead timber including logs or within 500m of this habitat	High Sensitivity to Potential Gain	Yes	Included	Habitat components present
Lathamus discolor Swift Parrot (Breeding)	Endangered	Critically Endangered	• As per mapped areas	Moderate Sensitivity to Potential Gain	No	Excluded	Not in mapped areas for breeding
Litoria aurea Green and Golden Bell Frog[1]	Endangered	Vulnerable	• Semi-permanent/ephemeral wet areas • Within 1km of wet areas/Swamps • Within 1km of swamp/Waterbodies • Within 1km of waterbody	High Sensitivity to Potential Gain	Yes	Included	Habitat components present
Litoria brevipalmata Green-thighed Frog	Vulnerable	Not Listed	-	Moderate Sensitivity to Potential Gain	Yes	Included	Habitat components present

Species Credit Species	BC Act	EPBC Act	Habitat components and geographic restrictions	Sensitivity to gain class	Habitat components on Project Area	Included or excluded	Reason for inclusion or exclusion
Litoria littlejohni Littlejohn's Tree Frog	Vulnerable	Vulnerable	-	High Sensitivity to Potential Gain	Yes	Included	Habitat components present
Lophoictinia isura Square-tailed Kite (Breeding)	Vulnerable	Not Listed	• Nest trees	Moderate Sensitivity to Potential Gain	Yes	Included	Habitat components present
Macropus parma Parma Wallaby	Vulnerable	Not Listed	-	High Sensitivity to Potential Gain	Yes	Included	Habitat components present
Melaleuca biconvexa Biconvex Paperbark	Vulnerable	Vulnerable		High Sensitivity to Potential Gain	Yes	Included	Habitat components present
Melaleuca groveana Grove's Paperbark	Vulnerable	Not Listed	-	High Sensitivity to Potential Gain	Yes	Included	Habitat components present
Miniopterus australis Little Bent-winged Bat (Breeding)	Vulnerable	Not Listed	• Caves • Cave, tunnel, mine, culvert or other structure known or suspected to be used for breeding including species records in BioNet with microhabitat code 'IC – in cave' • Observation type code 'E nest-roost' • with numbers of individuals >500 • or from the scientific literature	Very High Sensitivity to Potential Gain	Yes	Included	Habitat components present
Miniopterus orianae oceanensis Large Bent-winged Bat (Breeding)	Vulnerable	Not Listed	• Caves • Cave, tunnel, mine, culvert or other structure known or suspected to be used for breeding including species records in BioNet with	Very High Sensitivity to Potential Gain	Yes	Included	Habitat components present

Species Credit Species	BC Act	EPBC Act	Habitat components and geographic restrictions	Sensitivity to gain class	Habitat components on Project Area	Included or excluded	Reason for inclusion or exclusion
			microhabitat code 'IC – in cave' • Observation type code 'E nest-roost' • with numbers of individuals >500 • or from the scientific literature				
Mixophyes balbus Stuttering Frog	Endangered	Vulnerable	-	Very High Sensitivity to Potential Gain	Yes	Included	Habitat components present
Mixophyes iteratus Giant Barred Frog	Endangered	Endangered	• Land within 50m of semi permanent and permanent drainages	Moderate Sensitivity to Potential Gain	Yes	Included	Habitat components present
Myotis macropus Southern Myotis	Vulnerable	Not Listed	• Hollow bearing trees • Within 200 m of riparian zone • Bridges, caves or artificial structures within 200 m of riparian zone • This include rivers, creeks, billabongs, lagoons, dams and other waterbodies on or within 200m of the site	High Sensitivity to Potential Gain	Yes	Included	Habitat components present
Ninox connivens Barking Owl (Breeding)	Vulnerable	Not Listed	• Hollow bearing trees • Living or dead trees with hollows greater than 20 cm diameter and greater than 4m above the ground	High Sensitivity to Potential Gain	Yes	Included	Habitat components present
Ninox strenua Powerful Owl (Breeding)	Vulnerable	Not Listed	• Hollow bearing trees • Living or dead trees with hollow greater than 20cm diameter	High Sensitivity to Potential Gain	Yes	Included	Habitat components present

Species Credit Species	BC Act	EPBC Act	Habitat components and geographic restrictions	Sensitivity to gain class	Habitat components on Project Area	Included or excluded	Reason for inclusion or exclusion
Petauroides volans Greater Glider	Not Listed	Vulnerable	• Hollow bearing trees	High Sensitivity to Potential Gain	Yes	Included	Habitat components present
Petaurus norfolcensis Squirrel Glider	Vulnerable	Not Listed	-	High Sensitivity to Potential Gain	Yes	Included	Habitat components present
Petrogale penicillata Brush-tailed Rock-wallaby	Endangered	Vulnerable	• Land within 1 km of rocky escarpments, gorges, steep slopes, boulder piles, rock outcrops or clifflines	Very High Sensitivity to Potential Gain	Yes	Included	Habitat components present
Phascogale tapoatafa Brush-tailed Phascogale	Vulnerable	Vulnerable	-	High Sensitivity to Potential Gain	Yes	Included	Habitat components present
Phascolarctos cinereus Koala (Breeding)	Vulnerable	Vulnerable	• Areas identified via survey as important habitat	High Sensitivity to Potential Gain	Yes	Included	Habitat components present
Planigale maculata Common Planigale	Vulnerable	Not Listed	-	High Sensitivity to Potential Gain	Yes	Included	Habitat components present
Potorous tridactylus Long-nosed Potoroo	Vulnerable	Vulnerable	• Dense shrub layer or alternatively high canopy cover exceeding 70% (i.e. to capture populations inhabiting wet sclerophyll and rainforest)	High Sensitivity to Potential Gain	Yes	Included	Habitat components present
Pteropus poliocephalus Grey-headed Flying-fox (Breeding)	Vulnerable	Vulnerable	• Breeding camps	High Sensitivity to Potential Gain	Yes	Included	Habitat components present
Rhizanthella slateri Eastern Australian Underground Orchid	Vulnerable	Endangered	-	High Sensitivity to Potential Gain	Yes	Included	Habitat components present
Rhodamnia rubescens Scrub Turpentine	Critically Endangered	Not Listed	-	High Sensitivity to Potential Gain	Yes	Included	Habitat components present
Rhodomyrtus psidioides Native Guava	Critically Endangered	Not Listed	-	High Sensitivity to Potential Gain	Yes	Included	Habitat components present

Species Credit Species	BC Act	EPBC Act	Habitat components and geographic restrictions	Sensitivity to gain class	Habitat components on Project Area	Included or excluded	Reason for inclusion or exclusion
Tetratheca juncea Black-eyed Susan[2]	Vulnerable	Vulnerable	-	High Sensitivity to Potential Gain	Yes	Included	Habitat components present
Turnix maculosus Red-backed Button-quail	Vulnerable	Not Listed	-	High Sensitivity to Potential Gain	Yes	Included	Habitat components present
Tyto novaehollandiae Masked Owl (Breeding)	Vulnerable	Not Listed	• Hollow bearing trees • Living or dead trees with hollows greater than 20cm diameter	High Sensitivity to Potential Gain	Yes	Included	Habitat components present
Tyto tenebricosa Sooty Owl (Breeding)[3]	Vulnerable	Not Listed	• Caves • Caves or clifflines/ledges • Hollow bearing trees • Living or dead trees with hollows greater than 20cm diameter	Very High Sensitivity to Potential Gain	Yes	Included	Habitat components present

1. Species is associated only with PCT 1588, so it is not expected to be directly impacted by ponding-associated with the Project.

4.3.1 Exclusions based on habitat

The following species were excluded from assessment due to an absence of habitat components within the Project Area:

- *Anthochaera phrygia* (Regent Honeyeater; Breeding Habitat) - Not mapped in Regent Honeyeater 'Important Habitat Mapping';
- *Diuris praecox* (Rough Doubletail) - Project Area is outside parish boundaries of Newcastle, Kahibah, Wallarah, Tuggerah and Kincumber; and
- *Lathamus discolor* (Swift Parrot; Breeding Habitat) - Not mapped in Swift Parrot 'Important Habitat Mapping'.

4.3.2 Candidate species requiring confirmation of presence or absence

Species listed in **Table 4-3** are considered to have habitats present within the Project Area, which may be impacted by ponding associated with the Project. Specifically, this includes Zones 2, 3 and 4, where ponding is predicted. Results from surveys are summarised in **Table 4-3**. Rules for Species Polygon construction and references to relevant figures of Species Polygons are also provided in **Table 4-3**. Further details of the survey methodologies, locations and results for these surveys are provided in the BIR (**Appendix A**).

Table 4-3 Summary of species credit species surveyed within the Project Area

Species credit species	Biodiversity risk weighting	Survey Timing	Assumed to occur/ survey/ expert report	Habitat constraints measured	Unit	Detected in Project Area?	Detected in Predicted Impact Area?	Species polygon	Figure
Callocephalon fimbriatum Gang-gang Cockatoo (Breeding)	2	October to January	Assumed to occur	**Suitable nesting habitat recorded:** All hollow-bearing trees with >20 cm diameter entry recorded within 100 m of creeks (i.e. where ponding-related impacts are predicted).	Area	No	No	**Species Polygon:** 100 m buffer off all hollow-bearing trees with ≥10 cm diameter entry on or within 100m of the Project Area in associated PCTs. **Associated PCTs to define polygon:** 1556; 1568 and 1573. **Total Area:** 21.72 ha	**4-1**
Calyptorhynchus lathami Glossy Black-Cockatoo (Breeding)	2	April to August	Survey	**Suitable nesting habitat recorded:** All hollow-bearing trees with >20 cm diameter entry recorded within 100 m of creeks (i.e. where ponding-related impacts are predicted).	Area	Yes – foraging only but not breeding	No	None: Species not recorded during targeted surveys.	None
Cercartetus nanus Eastern Pygmy-possum	2	October to March	Assumed to occur	-	Area	No	No	**Species Polygon:** All of associated PCTs. **Associated PCTs to define polygon:** 1556; 1568 and 1573. **Total Area:** 34.78 ha	**4-2**
Chalinolobus dwyeri Large-eared Pied Bat	3	November to January	Assumed to occur	**Suitable roosting habitat recorded:** All caves within 100 m of creeks (i.e. where ponding-related impacts are predicted).	Area	No[2]	No	**Species Polygon:** 50 m radius buffer off marked-up caves in associated PCTs on or within 100 m of the Project Area in associated PCTs. **Associated PCTs to define polygon:** 1556; 1568 and 1573. **Total Area:** 7.96 ha	**4-3**

Species credit species	Biodiversity risk weighting	Survey Timing	Assumed to occur/ survey/ expert report	Habitat constraints measured	Unit	Detected in Project Area?	Detected in Predicted Impact Area?	Species polygon	Figure
Corybas dowlingii Red Helmet Orchid	2	June to July	Survey	-	Area	No	No	None: Species not recorded during targeted surveys.	None
Cryptostylis hunteriana Leafless Tongue Orchid	1.5	November to January	Assumed to occur	-	Area	No	No	**Species Polygon:** All of associated PCTs. **Associated PCTs to define polygon:** 1556 and 1568. **Total Area:** 32.30 ha	**4-4**
Cynanchum elegans White-flowered Wax Plant	2	All months	Surveyed	-	Area	No	No	None: Species not recorded during targeted surveys.	None
Haliaeetus leucogaster White-bellied Sea-Eagle (Breeding)	2	July to December	Assumed to occur	-	Area	No[2]	No	**Species Polygon:** All of associated PCTs. **Associated PCTs to define polygon:** 1556; 1568 and 1588. **Total Area:** 47.74 ha	**4-5**
Hoplocephalus bitorquatus Pale-headed Snake	2	November to March	Assumed to occur	-	Area	No	No	**Species Polygon:** All of associated PCTs. **Associated PCTs to define polygon:** 1556; 1568 and 1573. **Total Area:** 34.82 ha	**4-2**
Hoplocephalus stephensii Stephens' Banded Snake	2	October to March	Assumed to occur	-	Area	No	No	**Species Polygon:** All of associated PCTs. **Associated PCTs to define polygon:** 1528; 1556; 1568 and 1573. **Total Area:** 34.82 ha	**4-6**
Litoria aurea Green and Gold Bell Frog[1]	2	November to March	Assumed to occur	-	Area	No	No	**Species Polygon:** All of associated PCTs.	**4-7**

Species credit species	Biodiversity risk weighting	Survey Timing	Assumed to occur/ survey/ expert report	Habitat constraints measured	Unit	Detected in Project Area?	Detected in Predicted Impact Area?	Species polygon	Figure
								Associated PCTs to define polygon: 1588. **Total Area:** 15.44 ha	
Litoria brevipalmata Green-thighed Frog	1.5	October to March	Assumed to occur	-	Area	No	No	**Species Polygon:** All of associated PCTs. **Associated PCTs to define polygon:** 1528; 1556; 1568 and 1588. **Total Area:** 47.78 ha	**4-8**
Litoria littlejohni Littlejohn's Tree Frog	2	July to November	Assumed to occur	-	Area	No	No	**Species Polygon:** All of associated PCTs. **Associated PCTs to define polygon:** 1568. **Total Area:** 7.20 ha	**4-9**
Lophoictinia isura Square-tailed Kite (Breeding)	1.5	September to January	Assumed to occur	-	Area	No	No	**Species Polygon:** All of associated PCTs. **Associated PCTs to define polygon:** 1556 and 1568. **Total Area:** 32.30 ha	**4-4**
Macropus parma Parma Wallaby	2	All months	Surveyed	-	Area	No	No	None: Species not recorded during targeted surveys.	None
Melaleuca biconvexa Biconvex Paperbark	2	All months	Surveyed	-	Area	No	No	None: Species not recorded during targeted surveys.	None
Melaleuca groveana Grove's Paperbark	2	All months	Surveyed	-	Area	No	No	None: Species not recorded during targeted surveys.	None
Miniopterus australis Little Bent-winged Bat	3	December to February	Assumed to occur	**Suitable roosting habitat recorded:** All caves within 100 m of creeks (i.e. where ponding-related impacts are predicted).	Area	No[2]	No	**Species Polygon:** 100 m radius buffer off marked-up caves in associated PCTs on or within 100 m of the	**4-10**

Species credit species	Biodiversity risk weighting	Survey Timing	Assumed to occur/ survey/ expert report	Habitat constraints measured	Unit	Detected in Project Area?	Detected in Predicted Impact Area?	Species polygon	Figure
(Breeding)								Project Area in associated PCTs. **Associated PCTs to define polygon:** 1556; 1568 and 1573. **Total Area:** 17.62 ha	
Miniopterus orianae oceanensis Large Bent-winged Bat (Breeding)	3	December to February	Assumed to occur	**Suitable roosting habitat recorded:** All caves within 100 m of creeks (i.e. where ponding-related impacts are predicted).	Area	No	No	**Species Polygon:** 100 m radius buffer off marked-up caves in associated PCTs on or within 100 m of the Project Area in associated PCTs. **Associated PCTs to define polygon:** 1556; 1568 and 1573. **Total Area:** 17.62 ha	**4-10**
Mixophyes balbus Stuttering Frog	3	September to March	Assumed to occur	-	Area	No	No	**Species Polygon:** All of associated PCTs. **Associated PCTs to define polygon:** 1528; 1556; 1568 and 1573. **Total Area:** 34.82 ha	**4-6**
Mixophyes iteratus Giant Barred Frog	2	October to March	Assumed to occur	-	Area	No	No	**Species Polygon:** All of associated PCTs. **Associated PCTs to define polygon:** 1528; 1556; 1568 and 1573. **Total Area:** 34.82 ha	**4-6**
Myotis macropus Southern Myotis	2	October to March	Assumed to occur	**Suitable roosting habitat recorded:** All caves and hollow-bearing trees within 200 m of creeks (i.e. where ponding-related impacts are predicted).	Area	No[2]	No	**Species Polygon:** 200 m radius buffer off pools/stretches 3 m or wider on or within 200 m of Project Area in associated PCTs.	**4-11**

Species credit species	Biodiversity risk weighting	Survey Timing	Assumed to occur/ survey/ expert report	Habitat constraints measured	Unit	Detected in Project Area?	Detected in Predicted Impact Area?	Species polygon	Figure
								Associated PCTs to define polygon: 1556; 1568 and 1573. **Total Area:** 37.05 ha	
Ninox connivens Barking Owl (Breeding)	2	May to December	Assumed to occur	**Suitable nesting habitat recorded:** All hollow-bearing trees with >20 cm diameter entry recorded within 100 m of creeks (i.e. where ponding-related impacts are predicted).	Area	No	No	**Species Polygon:** 100 m buffer off all hollow-bearing trees with ≥20 cm diameter entry on or within 100 m of the Project Area in associated PCTs. **Associated PCTs to define polygon:** 1528; 1556; 1568; 1573 and 1588. **Total Area:** 19.10 ha	**4-12**
Ninox strenua Powerful Owl (Breeding)	2	May to August	Assumed to occur	**Suitable nesting habitat recorded:** All hollow-bearing trees with >20 cm diameter entry recorded within 100 m of creeks (i.e. where ponding-related impacts are predicted).	Area	No	No	**Species Polygon:** 100 m buffer off all hollow-bearing trees with ≥20 cm diameter entry on or within 100 m of the Project Area in associated PCTs. **Associated PCTs to define polygon:** 1556; 1568 and 1573. **Total Area:** 18.30 ha	**4-13**
Petauroides volans Greater Glider	2	All months	Surveyed	-	Area	No[2]	No	None: Species not recorded during targeted surveys.	None
Petaurus norfolcensis Squirrel Glider	2	All months	Assumed to occur	-	Area	No[2]	No	**Species Polygon:** All of associated PCTs. **Associated PCTs to define polygon:** 1556 and 1568. **Total Area:** 32.30 ha	**4-4**

Species credit species	Biodiversity risk weighting	Survey Timing	Assumed to occur/ survey/ expert report	Habitat constraints measured	Unit	Detected in Project Area?	Detected in Predicted Impact Area?	Species polygon	Figure
Petrogale penicillata Brush-tailed Rock-wallaby	3	All months	Surveyed	-	Area	No	No	None: Species not recorded during targeted surveys.	None
Phascogale tapoatafa Brush-tailed Phascogale	2	December to June	Assumed to occur	-	Area	No	No	**Species Polygon:** All of associated PCTs. **Associated PCTs to define polygon:** 1556 and 1568. **Total Area:** 32.30 ha	**4-4**
Phascolarctos cinereus Koala	2	All months	Assumed to occur	-	Area	No	No	None: Species not recorded during targeted surveys.	None
Planigale maculata Common Planigale	2	All months	Surveyed	-	Area	No	No	None: Species not recorded during targeted surveys.	None
Potorous tridactylus Long-nosed Potoroo	2	All months	Surveyed	-	Area	No	No	None: Species not recorded during targeted surveys.	None
Pteropus poliocephalus Grey-headed Flying-fox (Breeding)	2	October to December	Surveyed	-	Area	No[2]	No	**Species Polygon:** All of associated PCTs. **Associated PCTs to define polygon:** 1556; 1568 and 1573. **Total Area:** 34.78 ha	**4-2**
Rhizanthella slateri Eastern Australian Underground Orchid	3	September to November	Assumed to occur	-	Area	No	No	**Species Polygon:** All of associated PCTs. **Associated PCTs to define polygon:** 1556; 1568 and 1573. **Total Area:** 34.78 ha	**4-2**

Species credit species	Biodiversity risk weighting	Survey Timing	Assumed to occur/ survey/ expert report	Habitat constraints measured	Unit	Detected in Project Area?	Detected in Predicted Impact Area?	Species polygon	Figure
Rhodamnia rubescens Scrub Turpentine	3	All months	Surveyed	-	Count	Yes	Yes	**Species Polygon:** 30 m buffer off recorded individuals. **Total Area:** 1.46 ha	**4-14**
Rhodomyrtus psidioides Native Guava	3	All months	Surveyed	-	Area	No	No	None: Species not recorded during targeted surveys.	None
Tetratheca juncea Black-eyed Susan	2	September to November	Assumed to occur	-	Area	No	No	**Species Polygon:** All of associated PCTs. **Associated PCTs to define polygon:** 1568. **Total Area:** 7.20 ha	**4-9**
Turnix maculosus Red-backed Button-quail	2	All months	Surveyed	-	Area	No	No	None: Species not recorded during targeted surveys.	None
Tyto novaehollandiae Masked Owl (Breeding)	2	May to August	Assumed to occur	**Suitable nesting habitat recorded:** All hollow-bearing trees with >20 cm diameter entry recorded within 100 m of creeks (i.e. where ponding-related impacts are predicted).	Area	Yes – foraging only but not breeding	No	**Species Polygon:** 100 m buffer off all hollow-bearing trees with ≥20 cm diameter entry on or within 100 m of the Project Area in associated PCTs. **Associated PCTs to define polygon:** 1556; 1568 and 1573. **Total Area:** 18.30 ha	**4-13**
Tyto tenebricosa Sooty Owl (Breeding)	2	April to August	Assumed to occur	**Suitable nesting habitat recorded:** All caves and hollow-bearing trees within 100m of creeks (i.e. where ponding-related impacts are predicted).	Area	No[2]	No	**Species Polygon:** 100 m buffer off all hollow-bearing trees with ≥20 cm diameter entry and caves. **Associated PCTs to define polygon:** 1573. **Total Area:** 13.52 ha	**4-15**

1. This species is not part of final Candidate species list as associated with PCT 1588 (Zone 5), which is not subject to ponding impacts. 2. Located nearby Project Area – foraging detected only.

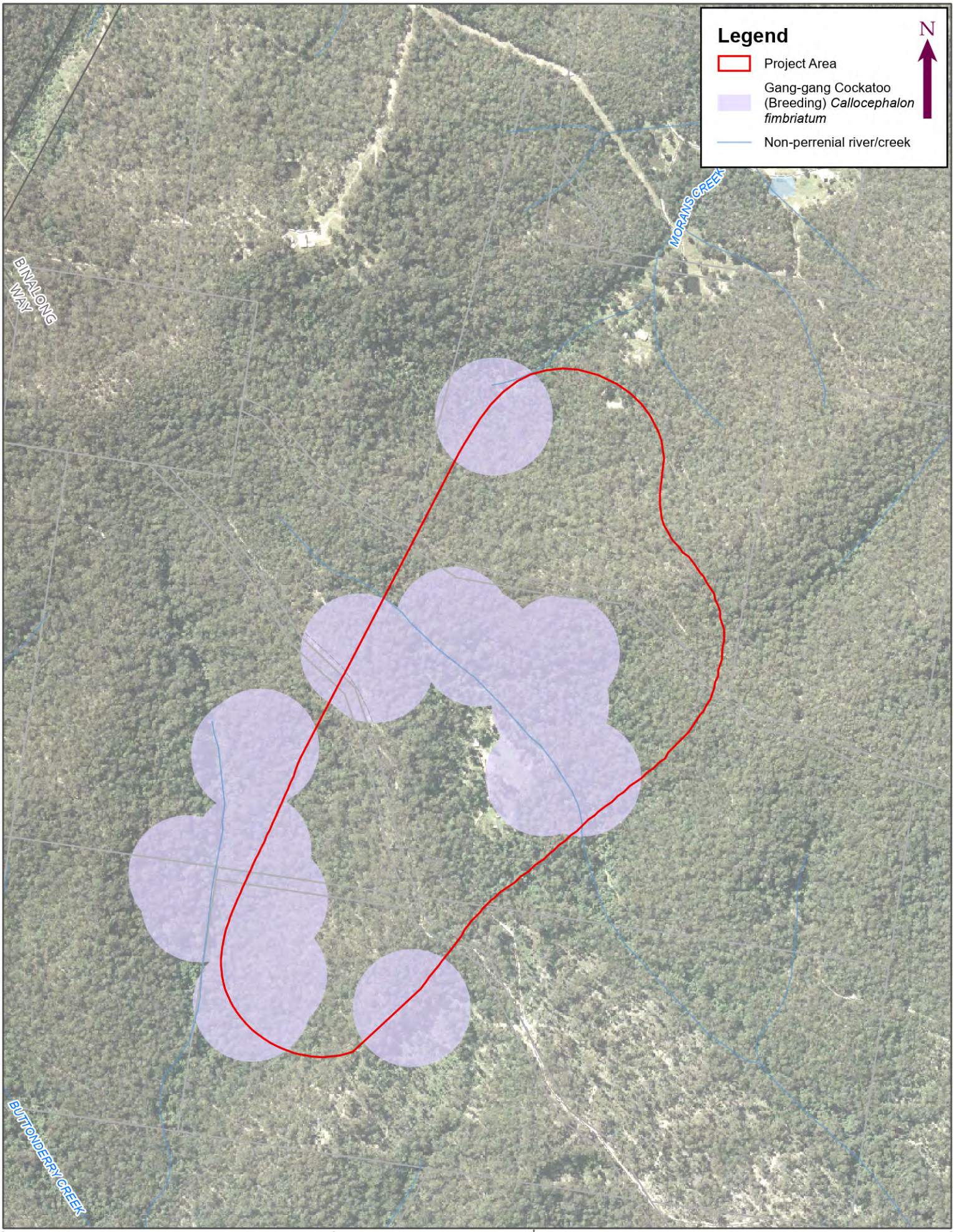


FIGURE 4-1
THREATENED SPECIES - CALLOCEPHALON FIMBRIATUM
GANG-GANG COCKATOO (BREEDING)

VERSION: **A**

DATE EXPORTED: **3/08/2021 8:25 AM**

TECHNICIAN: **Natalie.Wood**

LOCATION: **Mandalong**

DATA SOURCES
Centennial, RPS,

0 100 200 m

SCALE 1:8,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**

PROJECT: **149823**

PURPOSE: **BDAR**

IMPORTANT NOTE

1. This plan was prepared for the sole purposes of the client for the specific purpose of producing a photographic overlay plan. This plan is strictly limited to the Purpose and does not apply directly or indirectly and will not be used for any other application, purpose, use or matter. The plan is presented without the assumption of a duty of care to any other person (other than the Client) ("Third Party") and may not be relied on by Third Party.

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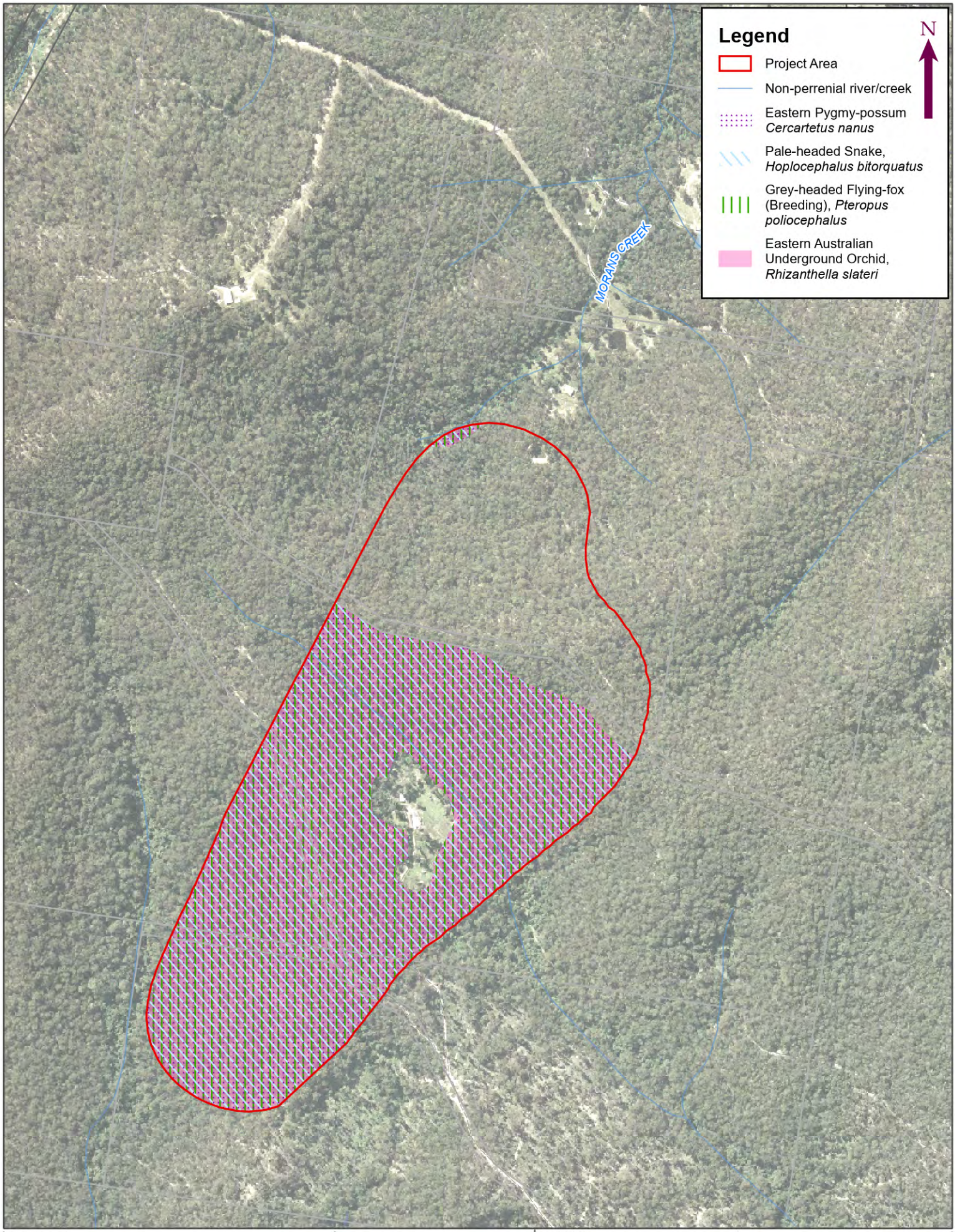


FIGURE 4-2
THREATENED SPECIES - CERCARTETUS NANUS
EASTERN PYGMY-POSSUM, HOPLOCEPHALUS BITORQUATUS
PALE-HEADED SNAKE, PTEROPUS POLIOCEPHALUS
GREY-HEADED FLYING-FOX (BREEDING) AND RHIZANTHELLA SLATERI
EASTERN AUSTRALIAN UNDERGROUND ORCHID

VERSION: **A**

DATE EXPORTED: **3/08/2021 9:53 AM**

TECHNICIAN: **Natalie.Wood**

LOCATION:
Mandalong

DATA SOURCES
Centennial, RPS,

0 50 100 150 200 250 m

SCALE 1:8,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**

PROJECT: **149823**

PURPOSE: **BDAR**

IMPORTANT NOTE
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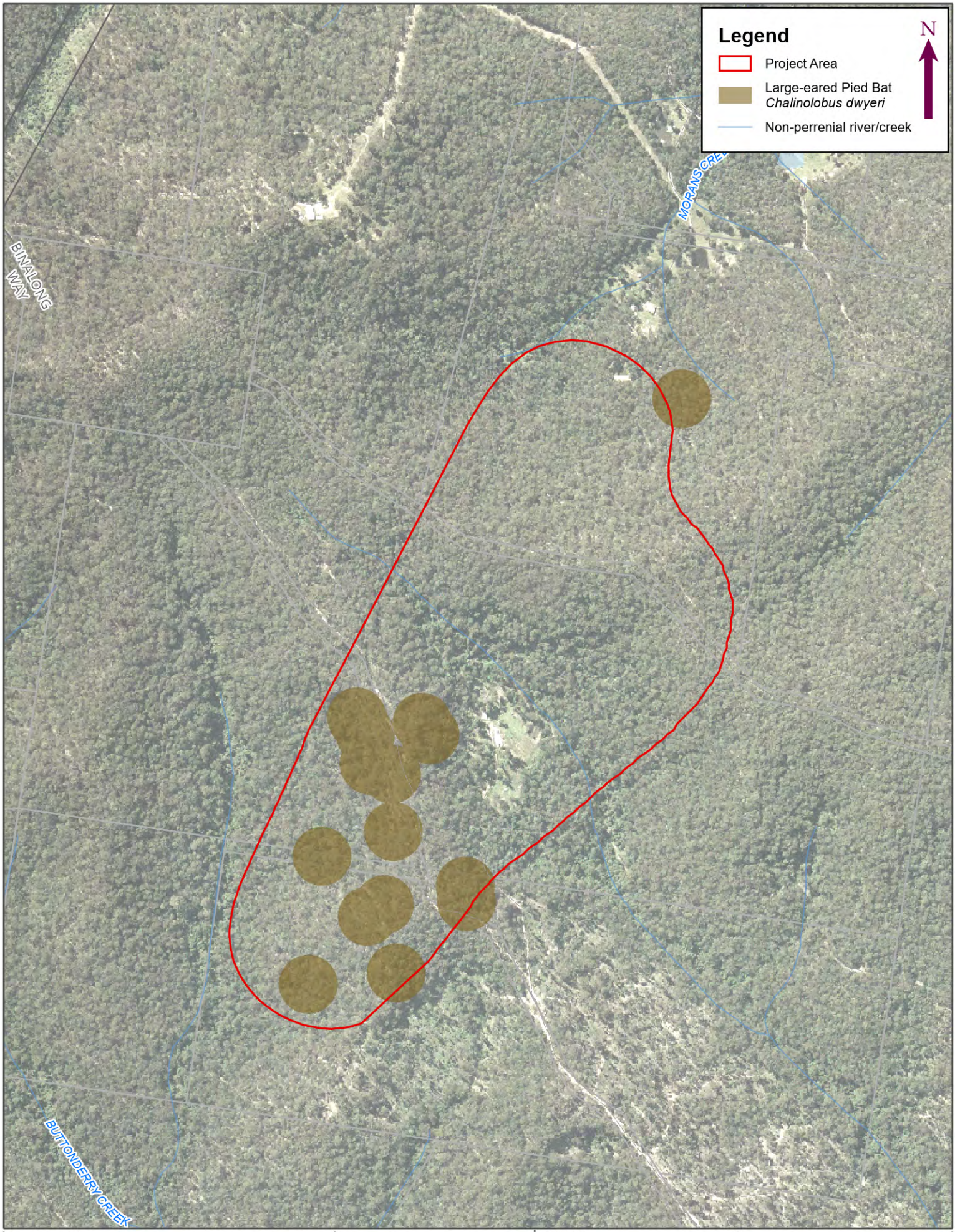


FIGURE 4-3
THREATENED SPECIES - CHALINOLOBUS DWYERI
LARGE-EARED PIED BAT

VERSION: **A**

DATE EXPORTED: **3/08/2021 10:02 AM**

TECHNICIAN: **Natalie.Wood**

LOCATION:
Mandalong

DATA SOURCES
Centennial, RPS,

0 50 100 150 200 250 m

SCALE 1:8,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**

PROJECT: **149823**

PURPOSE: **BDAR**

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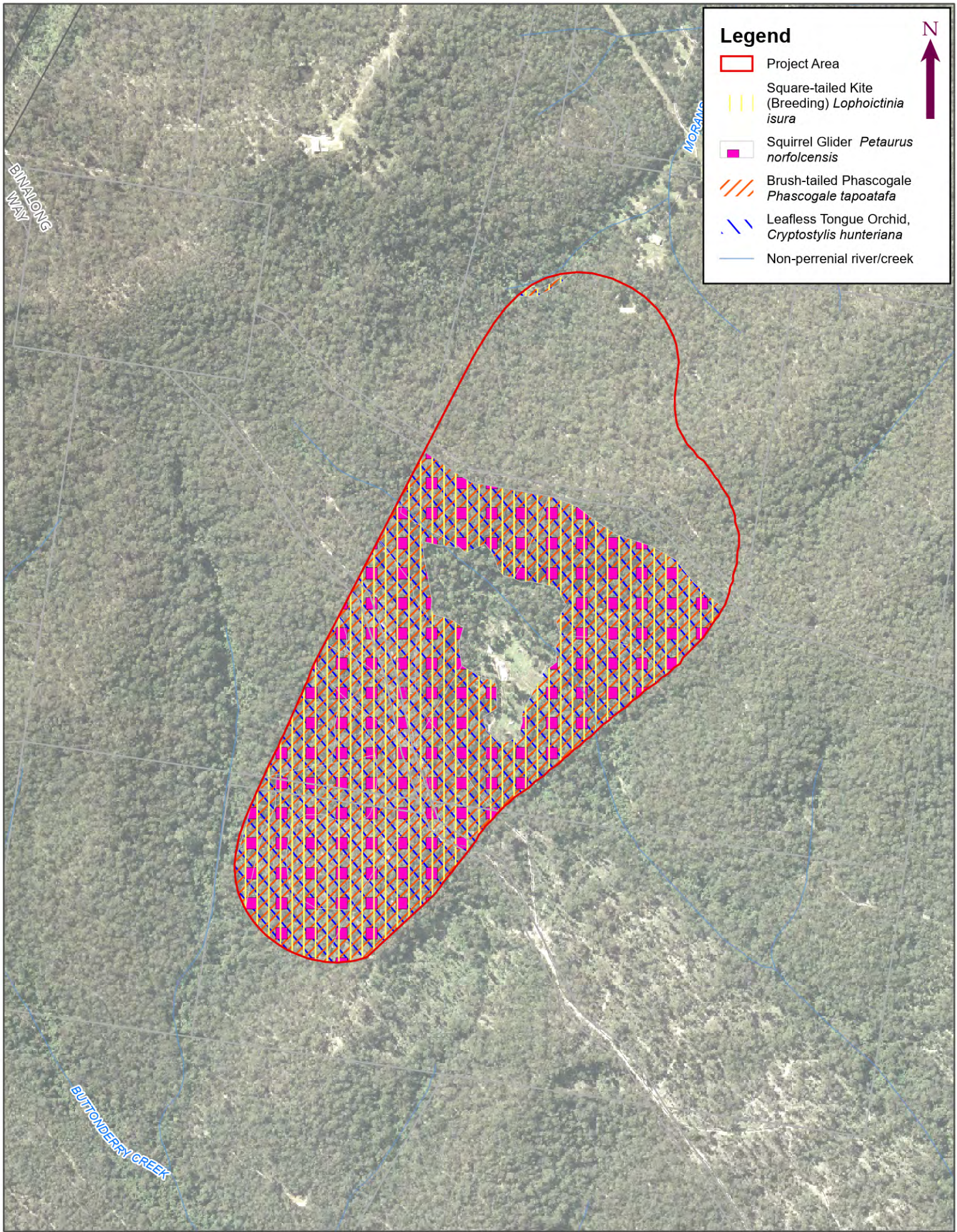


FIGURE 4-4
THREATENED SPECIES - CRYPTOSTYLIS HUNTERIANA
LEAFLESS TONGUE ORCHID, LOPHOICTINIA ISURA
SQUARE-TAILED KITE (BREEDING), PETAURUS NORFOLCENSIS
SQUIRREL GLIDER AND PHASCOGALE TAPOATAFA
BRUSH-TAILED PHASCOGALE

VERSION: **A**

DATE EXPORTED: **3/08/2021 10:30 AM**

TECHNICIAN: **Natalie.Wood**

LOCATION: **Mandalong**

DATA SOURCES
Centennial, RPS,

0 50 100 150 200 250 m

SCALE 1:8,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**

PROJECT: **149823**

PURPOSE: **BDAR**

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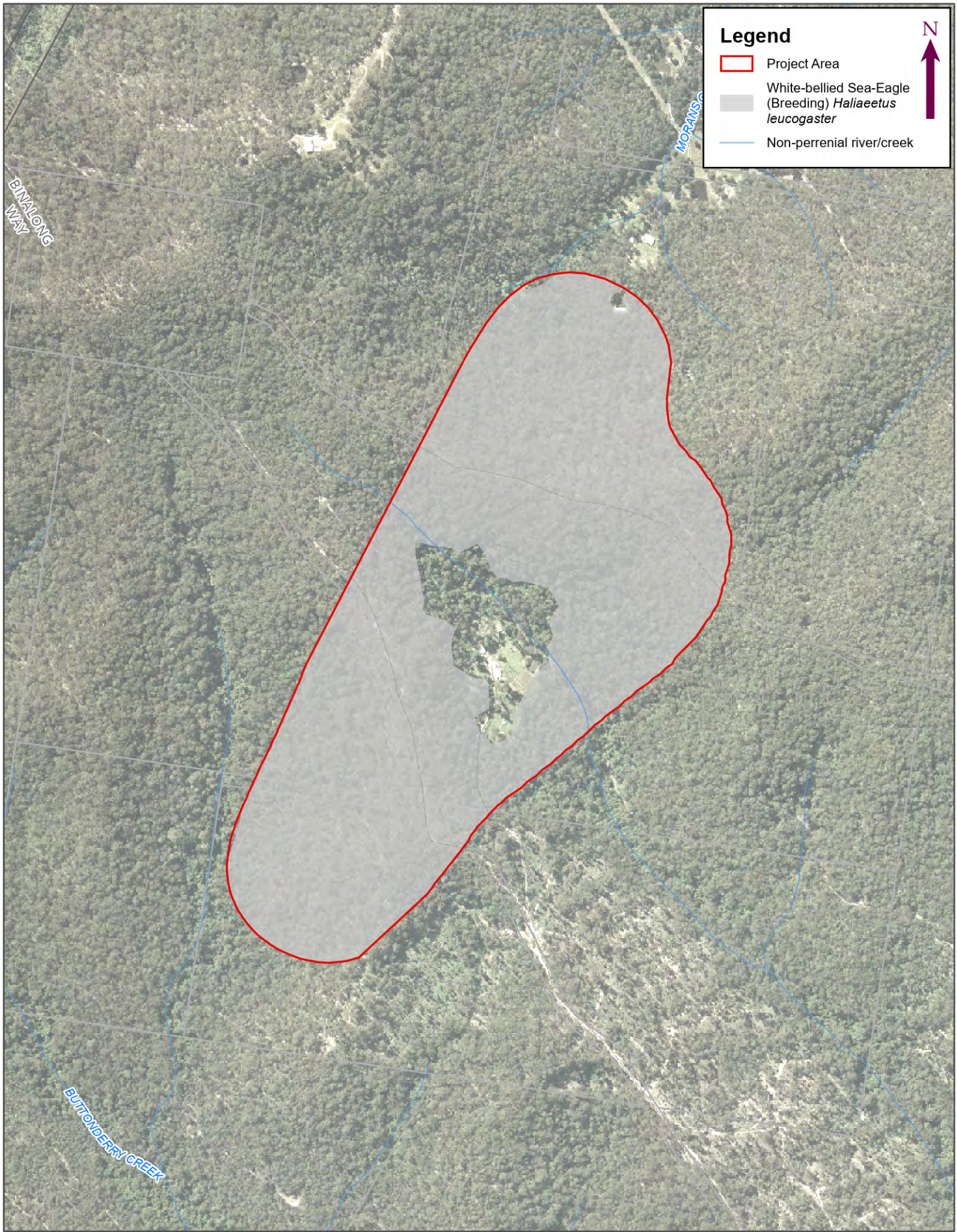


FIGURE 4-5
THREATENED SPECIES - HALIAEETUS LEUCOGASTER
WHITE-BELLIED SEA-EAGLE (BREEDING)

VERSION: **A**

DATE EXPORTED: **3/08/2021 10:54 AM**

TECHNICIAN: **Natalie.Wood**

LOCATION: **Mandalong**

DATA SOURCES
Centennial, RPS,

0 50 100 150 200 250 m

SCALE 1:8,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**

PROJECT: **149823**

PURPOSE: **BDAR**

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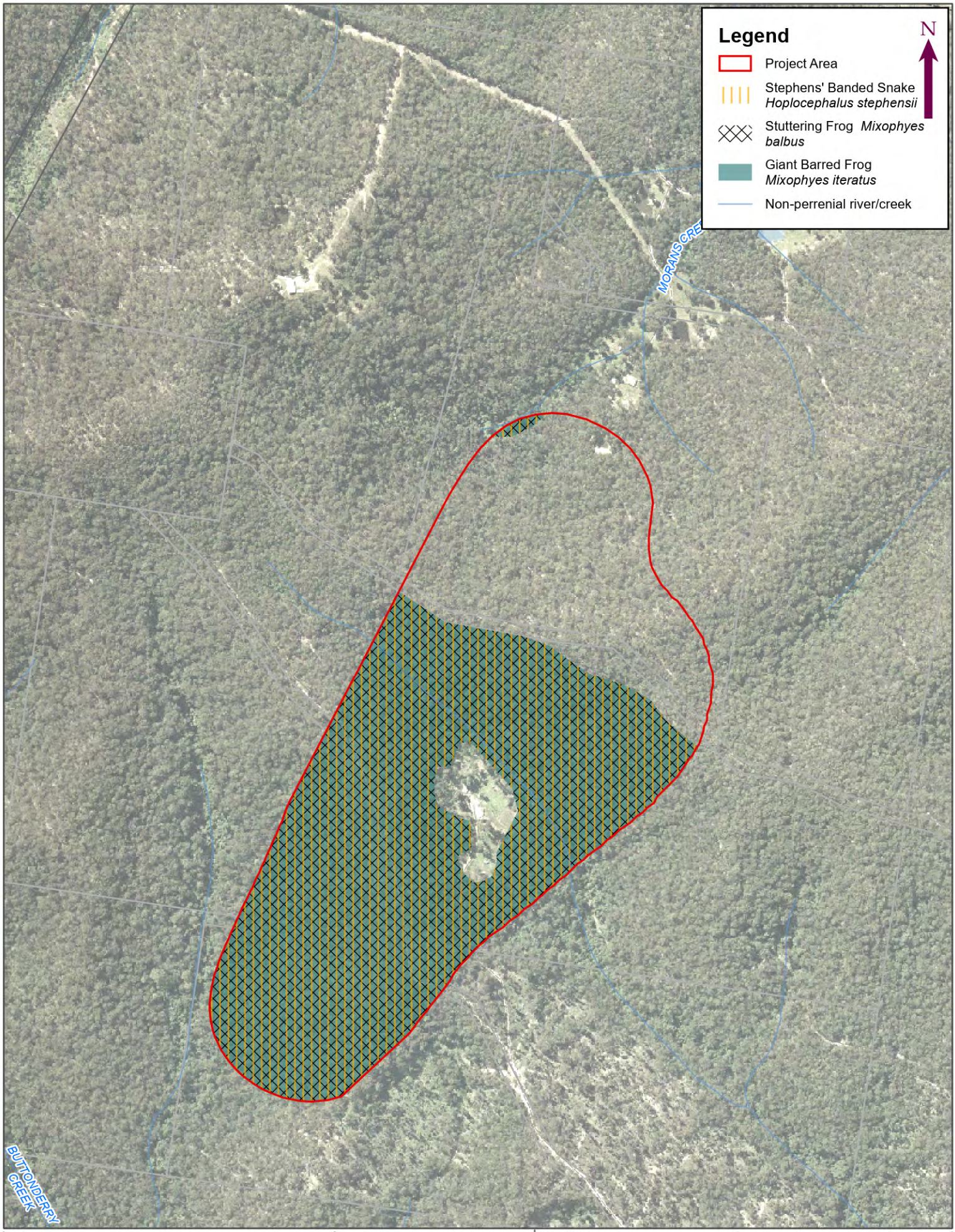


FIGURE 4-6
THREATENED SPECIES - HOPLOCEPHALUS STEPHENSII STEPHENS' BANDED SNAKE, MIXOPHYES BALBUS STUTTERING FROG AND MIXOPHYES ITERATUS GIANT BARRED FROG

VERSION: **A**

DATE EXPORTED: **3/08/2021 11:14 AM**

TECHNICIAN: **Natalie.Wood**

LOCATION: **Mandalong**

DATA SOURCES
Centennial, RPS,

0 50 100 150 200 250 m

SCALE 1:8,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**

PROJECT: **149823**

PURPOSE: **BDAR**

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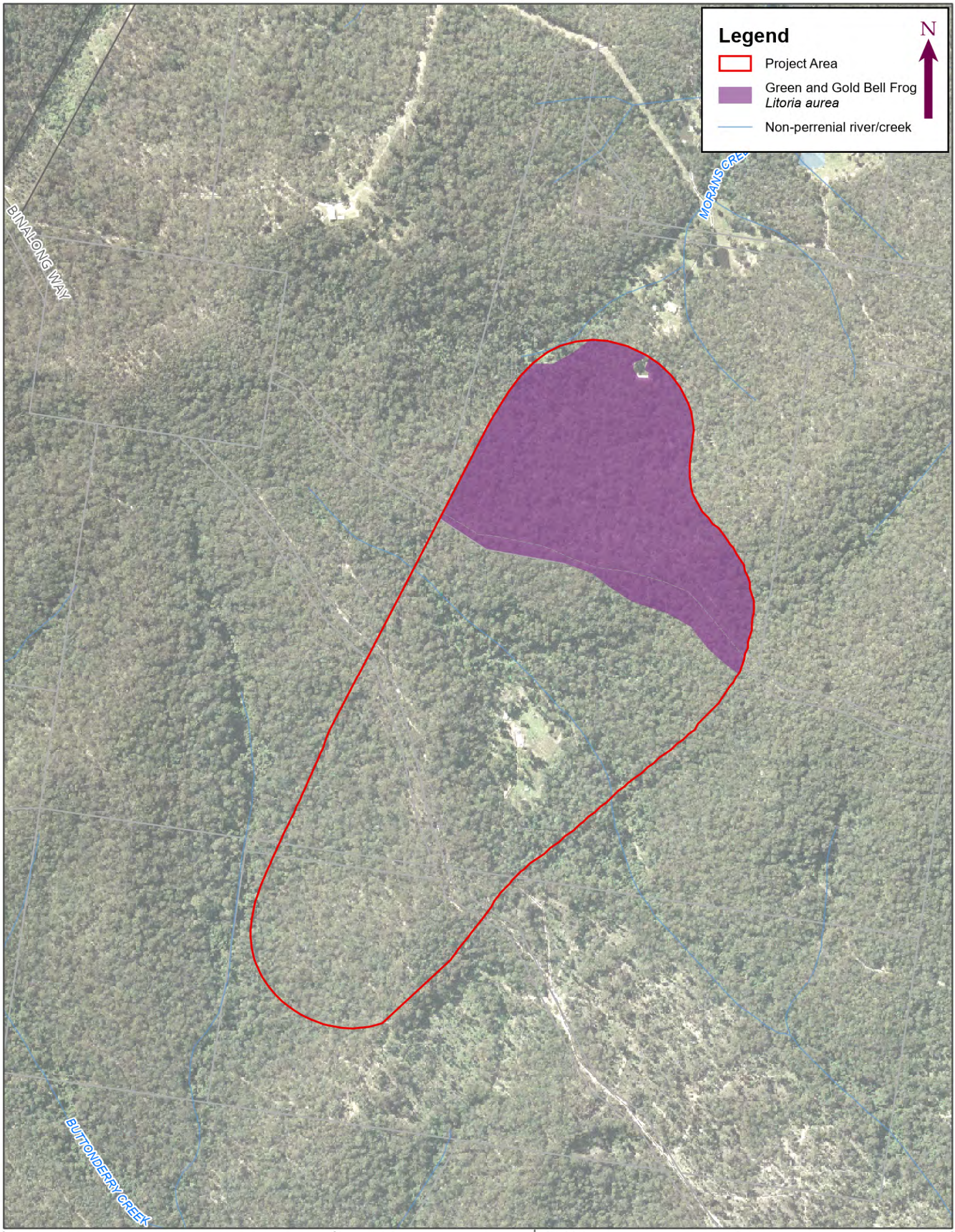


FIGURE 4-7
THREATENED SPECIES - LITORIA AUREA
GREEN AND GOLD BELL FROG

VERSION: **A**

DATE EXPORTED: **3/08/2021 11:41 AM**

TECHNICIAN: **Natalie.Wood**

LOCATION:
Mandalong

DATA SOURCES
Centennial, RPS,

0 50 100 150 200 250 m

SCALE 1:8,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**

PROJECT: **149823**

PURPOSE: **BDAR**

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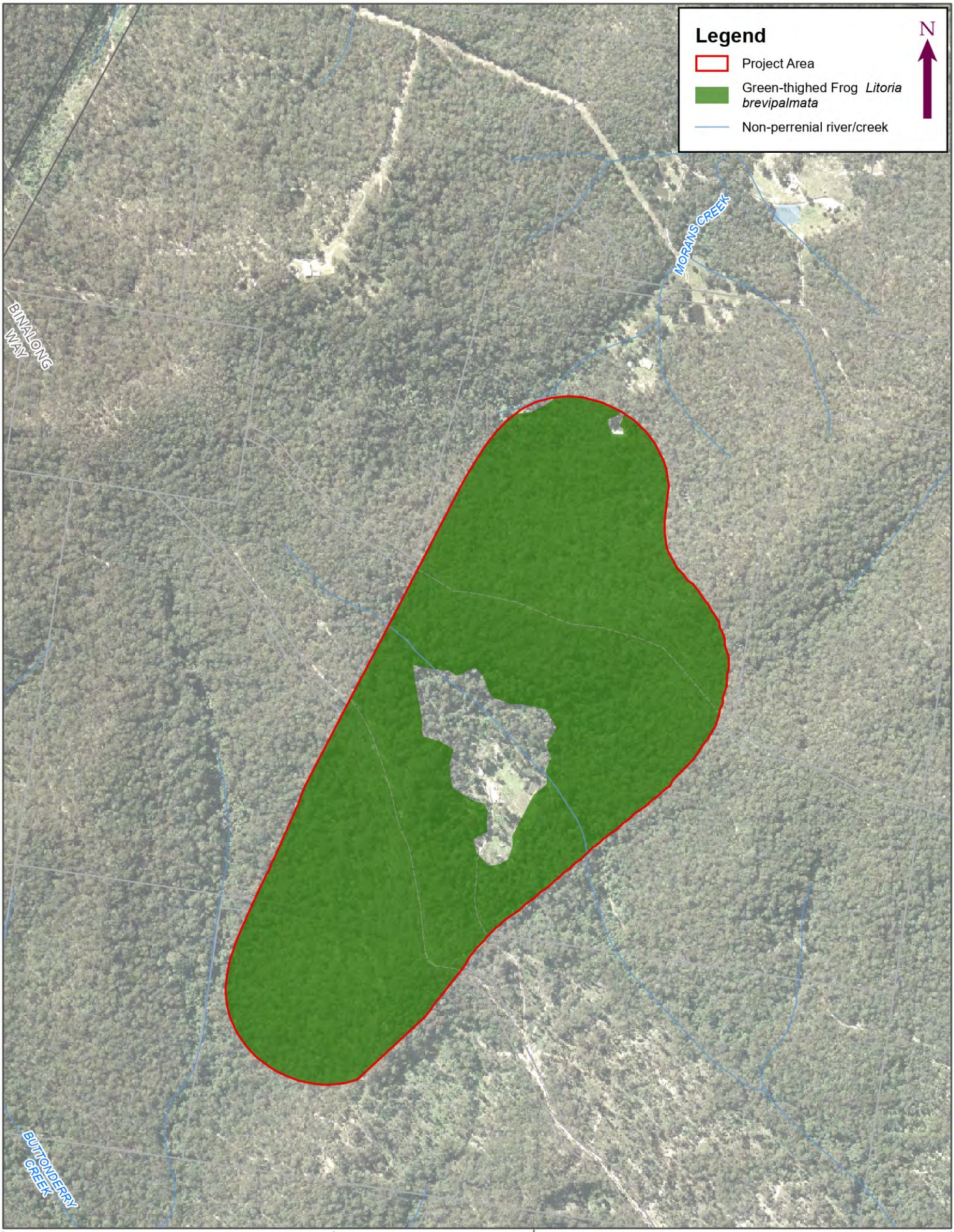


FIGURE 4-8
THREATENED SPECIES - LITORIA BREVIPALMATA GREEN-THIGHED FROG

VERSION: **A**

DATE EXPORTED: **3/08/2021 11:54 AM**

TECHNICIAN: **Natalie.Wood**

LOCATION: **Mandalong**

DATA SOURCES
Centennial, RPS,

0 50 100 150 200 250 m

SCALE 1:8,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**

PROJECT: **149823**

PURPOSE: **BDAR**

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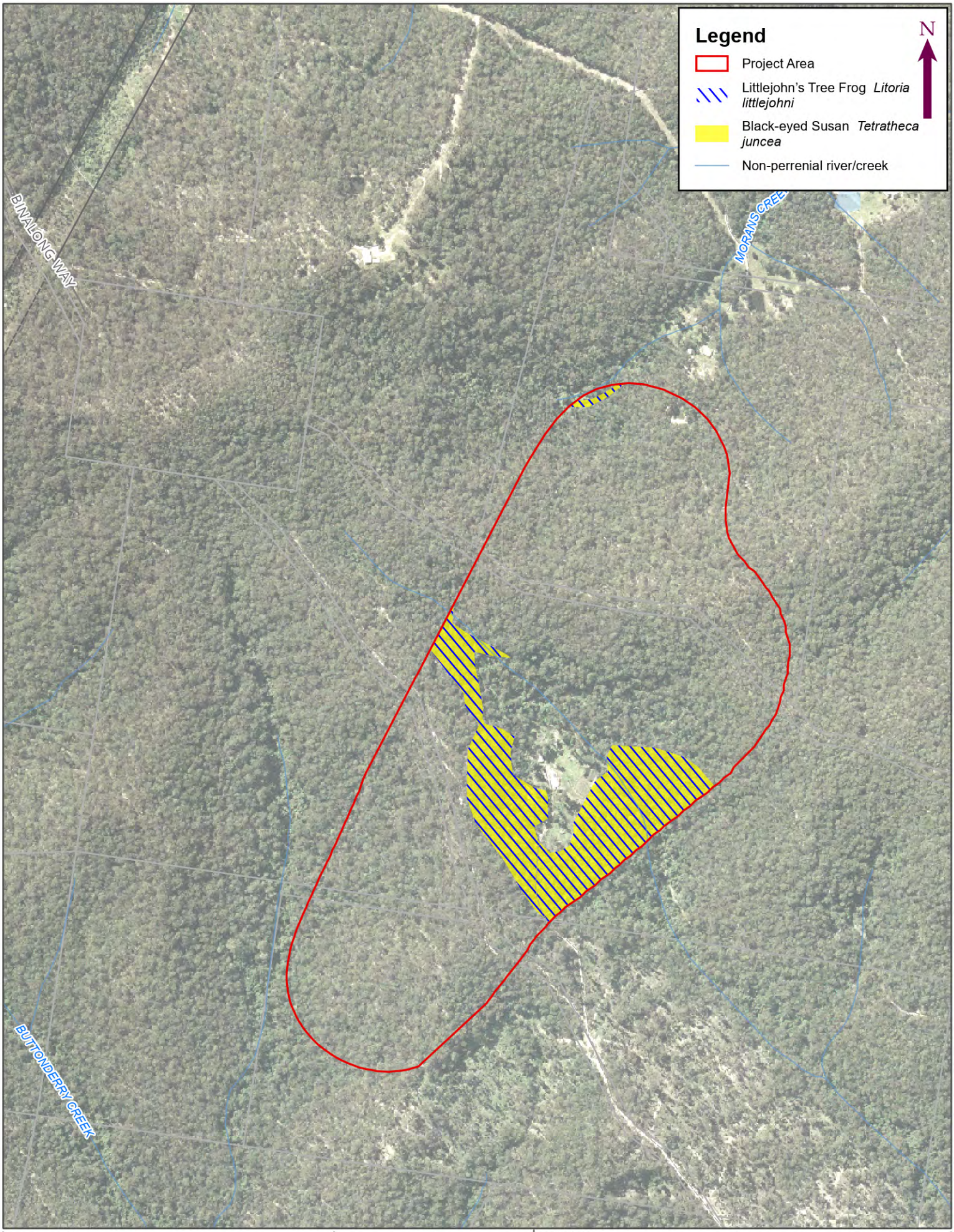


FIGURE 4-9

THREATENED SPECIES - LITORIA LITTLEJOHNI LITTLEJOHN'S TREE FROG AND TETRATHECA JUNCEA BLACK-EYED SUSAN

VERSION: **A**

DATE EXPORTED: **3/08/2021 12:06 PM**

TECHNICIAN: **Natalie.Wood**

LOCATION: **Mandalong**

DATA SOURCES
Centennial, RPS,

0 50 100 150 200 250 m

SCALE 1:8,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**

PROJECT: **149823**

PURPOSE: **BDAR**

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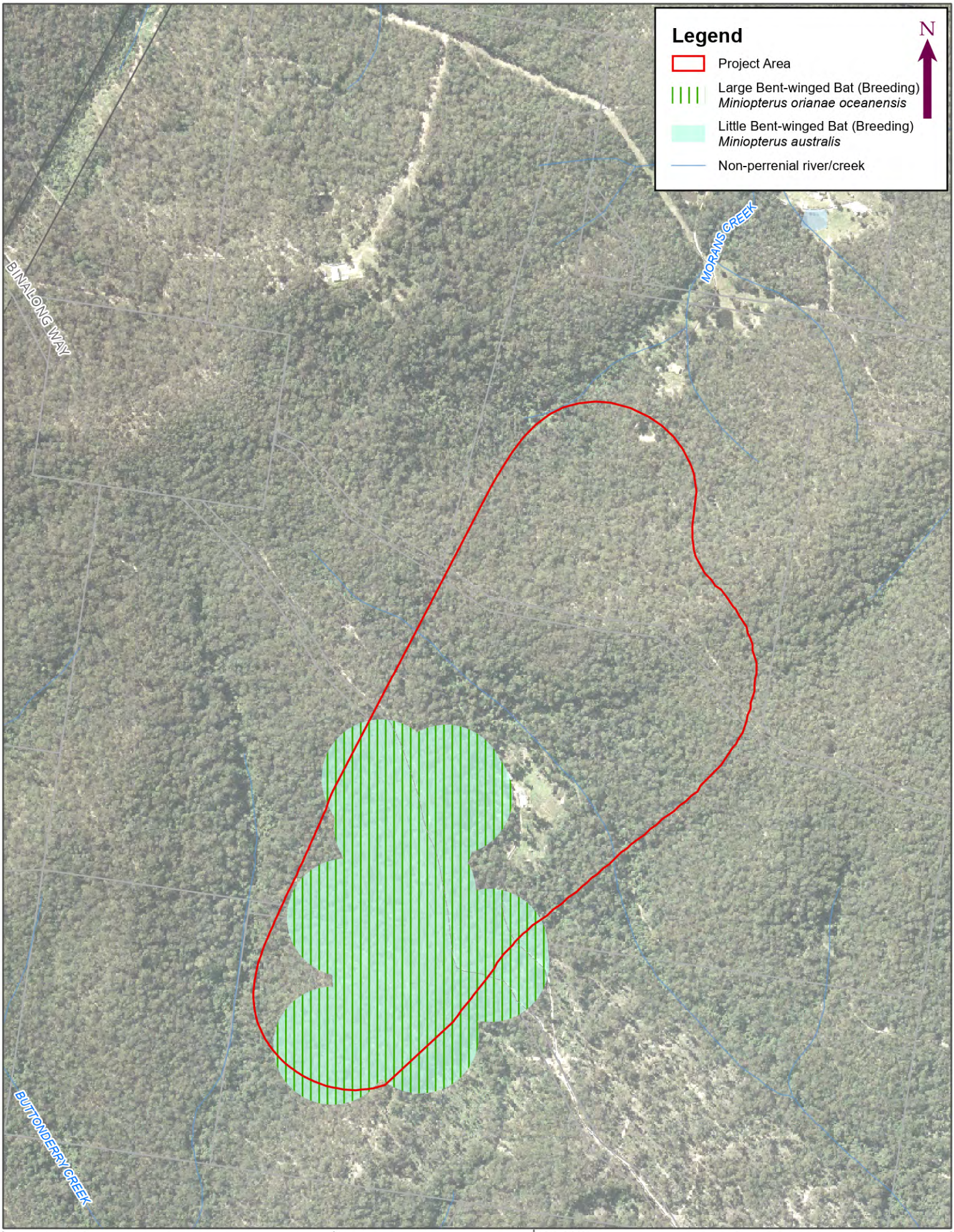


FIGURE 4-10

THREATENED SPECIES - MINIOPTERUS AUSTRALIS LITTLE BENT-WINGED BAT (BREEDING) AND MINIOPTERUS ORIANAE OCEANENSIS LARGE BENT-WINGED BAT (BREEDING)

VERSION: **A**

DATE EXPORTED: **3/08/2021 12:20 PM**

TECHNICIAN: **Natalie.Wood**

LOCATION: **Mandalong**

DATA SOURCES
Centennial, RPS,

0 50 100 150 200 250 m

SCALE 1:8,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**

PROJECT: **149823**

PURPOSE: **BDAR**

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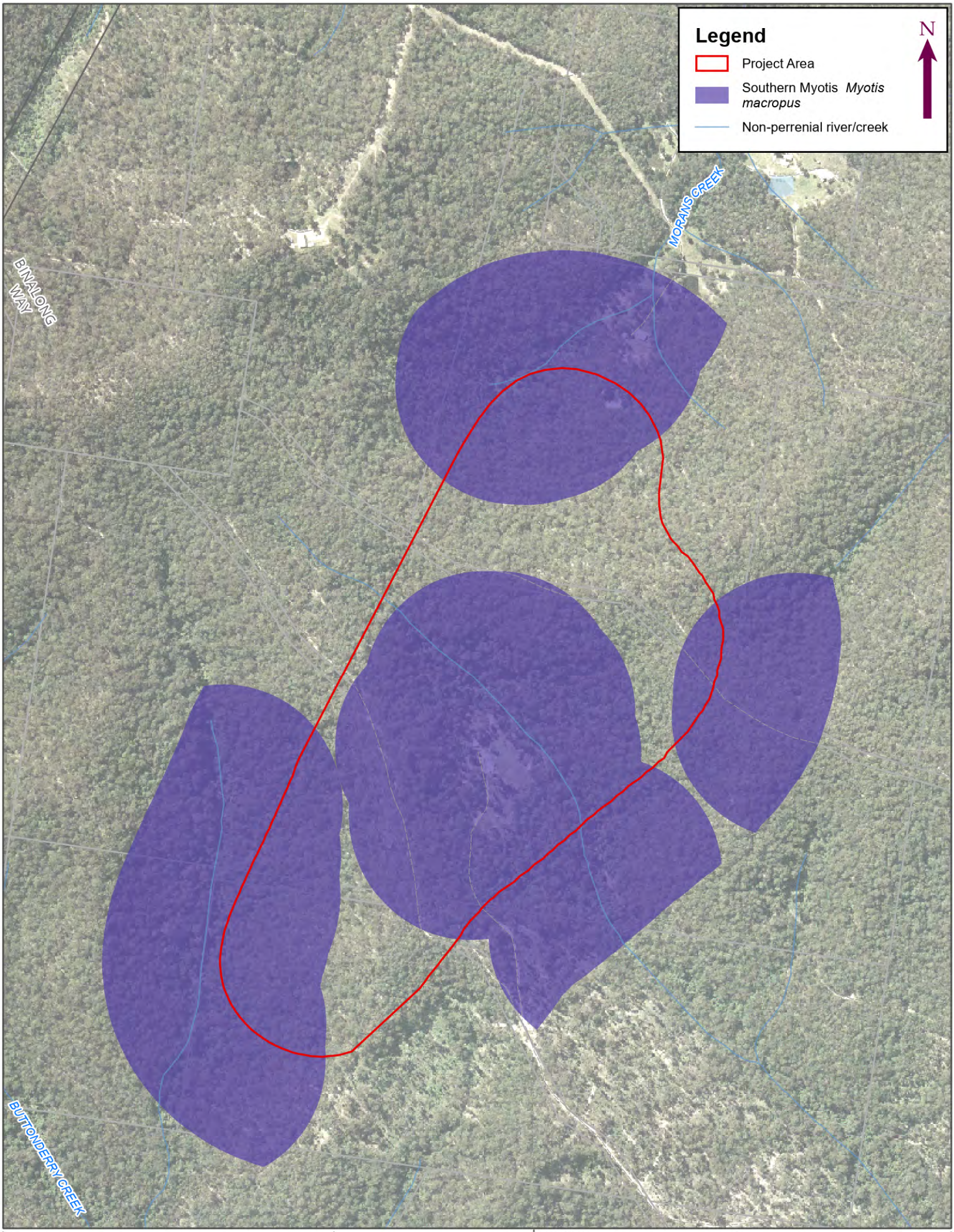


FIGURE 4-11
THREATENED SPECIES - MYOTIS MACROPUS SOUTHERN MYOTIS

VERSION: **A**

DATE EXPORTED: **3/08/2021 1:15 PM**

TECHNICIAN: **Natalie.Wood**

LOCATION: **Mandalong**

DATA SOURCES
Centennial, RPS,

0 50 100 150 200 250 m

SCALE 1:8,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**

PROJECT: **149823**

PURPOSE: **BDAR**

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FIGURE 4-12
THREATENED SPECIES - NINOX CONNIVENS BARKING OWL (BREEDING)

VERSION: **A**

DATE EXPORTED: **3/08/2021 1:22 PM**

TECHNICIAN: **Natalie.Wood**

LOCATION: **Mandalong**

DATA SOURCES
Centennial, RPS,

0 50 100 150 200 250 m

SCALE 1:8,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**

PROJECT: **149823**

PURPOSE: **BDAR**

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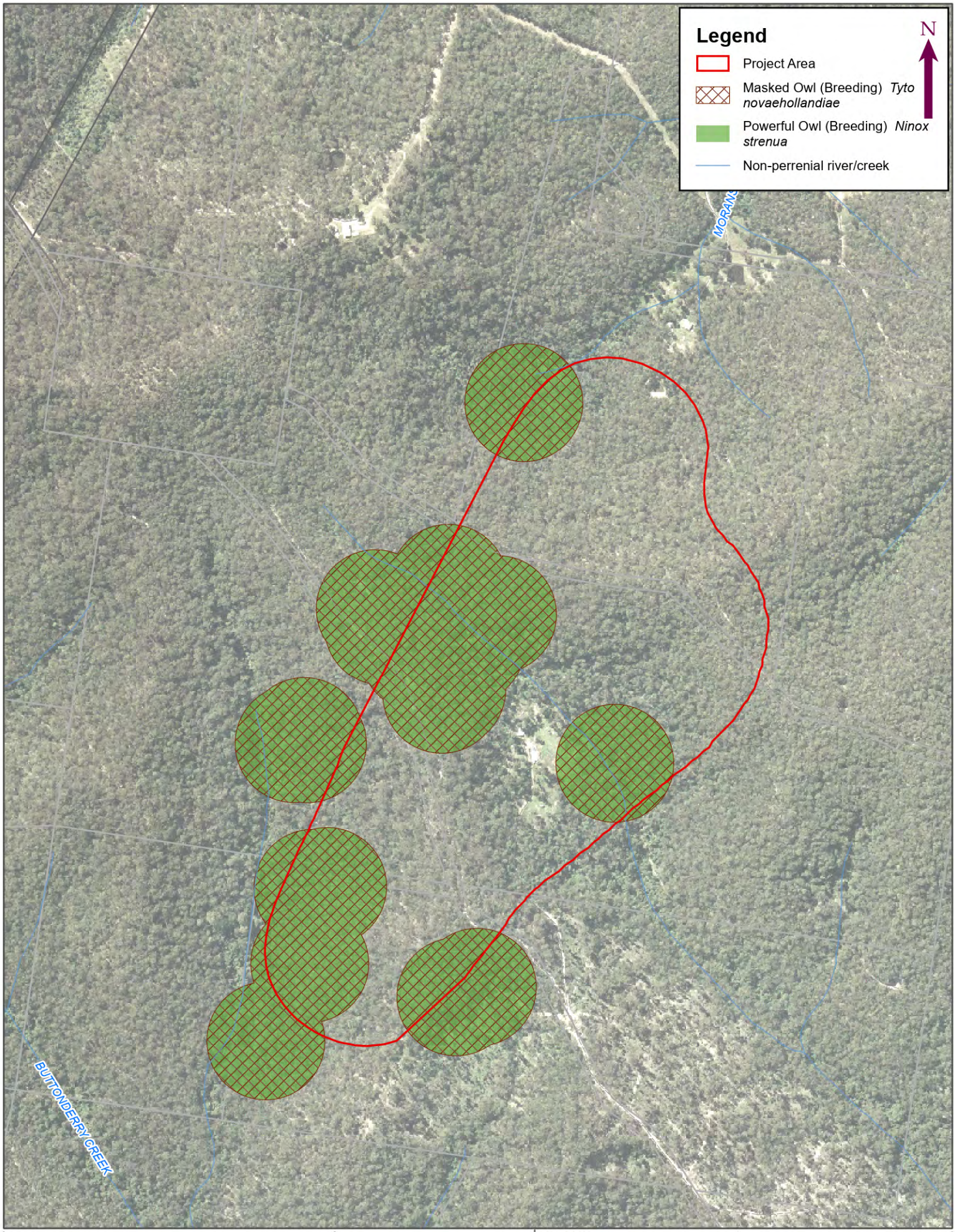


FIGURE 4-13

THREATENED SPECIES - NINOX STRENUA POWERFUL OWL (BREEDING) AND TYTO NOVAEHOLLANDIAE MASKED OWL (BREEDING)

VERSION: **A**

DATE EXPORTED: **3/08/2021 1:30 PM**

TECHNICIAN: **Natalie.Wood**

LOCATION: **Mandalong**

DATA SOURCES
Centennial, RPS,

0 50 100 150 200 250 m

SCALE 1:8,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**

PROJECT: **149823**

PURPOSE: **BDAR**

IMPORTANT NOTE

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Project path: S:\Centennial\All Jobs\149823 Mandalong Revised MOD 10 BDAR\10 - Drafting\149823_Mandalong_MOD10_BDAR_figures.aprx

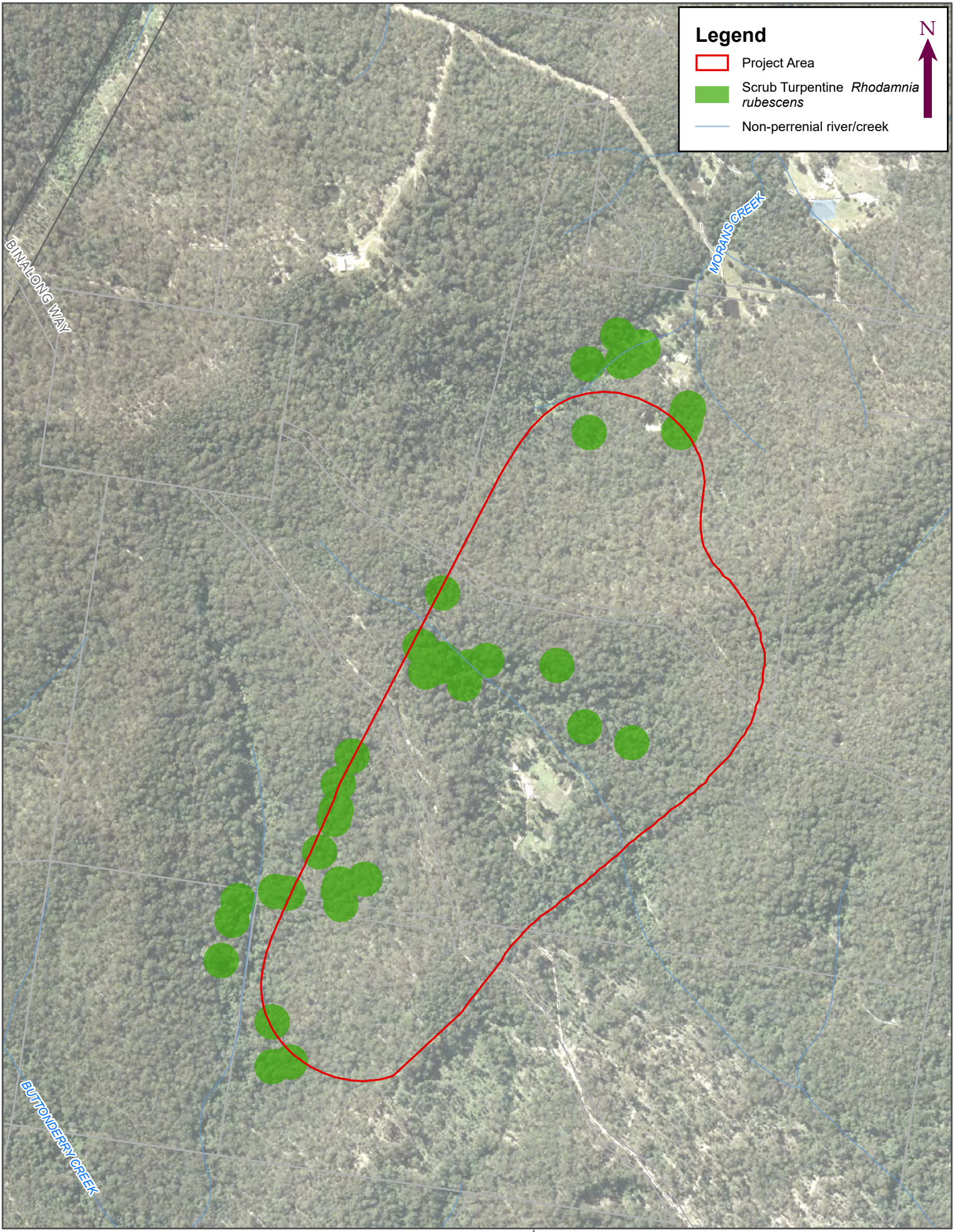


FIGURE 4-14
THREATENED SPECIES - RHODAMNIA RUBESCENS
SCRUB TURPENTINE

VERSION: **B**

DATE EXPORTED: **24/08/2021 8:44 AM**

TECHNICIAN: **Natalie.Wood**

LOCATION: **Mandalong**

DATA SOURCES
Centennial, RPS,

0 50 100 150 200 250 m

SCALE 1:8,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**

PROJECT: **149823**

PURPOSE: **BDAR**

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Project path: S:\Centennial\All Jobs\149823 Mandalong Revised MOD 10 BDAR\10 - Drafting\149823_Mandalong_MOD10_BDAR_figures_.aprx

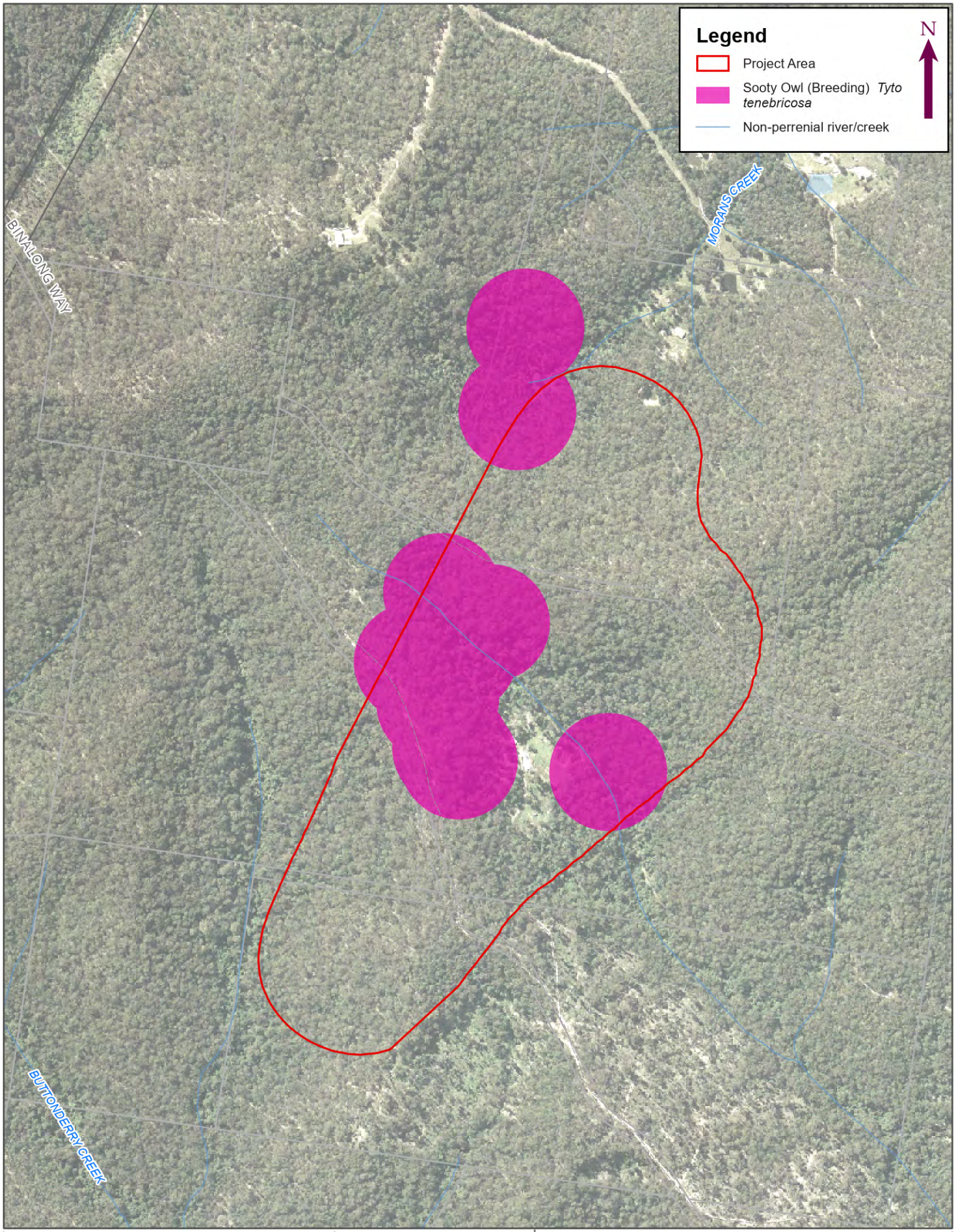


FIGURE 4-15
THREATENED SPECIES - TYTO TENEBRICOSA SOOTY OWL (BREEDING)

VERSION: **A**

DATE EXPORTED: **3/08/2021 1:48 PM**

TECHNICIAN: **Natalie.Wood**

LOCATION: **Mandalong**

DATA SOURCES
Centennial, RPS,

0 50 100 150 200 250 m

SCALE 1:8,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**

PROJECT: **149823**

PURPOSE: **BDAR**

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Project path: S:\Centennial\All Jobs\149823 Mandalong Revised MOD 10 BDAR\10 - Drafting\149823_Mandalong_MOD10_BDAR_figures.aprx

4.4 Potential prescribed biodiversity Impacts

Prescribed impacts are the impacts on biodiversity values which are not related to, or are in addition to, native vegetation clearing and habitat loss (Section 6.7 of the BAM). Based on the Candidate species listed in **Table 4-3**, potential prescribed biodiversity impacts on threatened species identified within the Project Area are:

- Occurrences of karst, caves, crevices and cliffs;
- Occurrences of rock; and
- Hydrological processes that sustain and interact with the rivers, streams and wetlands.

The occurrence of these potential prescribed impacts is detailed in **Sections 4.4.1** to **4.4.3** below.

4.4.1 Occurrences of karst, caves, crevices and cliffs

There are several sandstone crevices and cliffs within the Project Area. During caves surveys, 19 sandstone caves were recorded. Locations of these geological features are detailed further in **Appendix A**.

Cave-dwelling microbats may occupy these rocky outcrops and or cliffs, which may include *Chalinolobus dwyeri* (Large-eared Pied Bat), *Miniopterus australis* (Little Bent-winged Bat), *Miniopterus orianae oceanensis* (Large Bent-winged Bat) and *Myotis macropus* (Southern Myotis). Not however, that Anabat surveys within the Project Area failed to detect these species, however *Chalinolobus dwyeri* (Large-eared Pied Bat) and *Miniopterus australis* (Little Bent-winged Bat) were recorded nearby (approximately 500 m north of the Project Area). Nevertheless, survey effort failed to meet guideline survey requirements (four nights effort), breeding habitat was assumed to be present in the Project Area.

Caves within the Project Area may also provide potential breeding habitat of *Tyto tenebriocosa* (Sooty Owl). However, no nesting material was observed during cave surveys that may suggest past breeding of this species in the Project Area.

4.4.2 Occurrences of rock

Toward the ridges throughout the Project Area, there are occurrences of sandstone rocks and isolated rocky outcrops exposed on some steep hill slopes. *Hoplocephalus stephensii* (Stephens' Banded Snake) may shelter under rock slabs or within rock crevices within the Project Area during the day, amongst other sheltering options including loose bark and tree trunks, amongst vines or hollow trunks limbs. Nevertheless, species was not recorded during spotlight surveys.

4.4.3 Hydrological processes that sustain and interact with the rivers, streams and wetlands

The Project Area is in the headwaters of Morans, Mannering and Buttonderry Creeks. These tributaries discharge into Lake Macquarie, Lake Mannering and Tuggerah Lake, respectively (**Figure 1-1**). Threatened frogs that may associate with hydrological processes in these tributaries, and hence potentially associated with this sensitive receiver are *Litoria aurea* (Green and Golden Bell Frog), *Litoria brevipalmata* (Green-thighed Frog), *Litoria littlejohni* (Littlejohn's Tree Frog), *Mixophyes balbus* (Stuttering Frog) and or *Mixophyes iteratus* (Giant Barred Frog). Threatened plants may occur within the ephemeral extents of these drainage lines, with varying degrees of dependence on groundwater. These species may include *Rhizanthella slateri* (Eastern Australian Underground Orchid), *Cryptostylis hunteriana* (Leafless Tongue Orchid), *Rhodamnia rubescens* (Scrub Turpentine) and *Tetratheca juncea* (Black-eyed Susan). Note however that *Rhodamnia rubescens* (Scrub Turpentine) was the only threatened plant observed, with presence assumed for the other above species since survey was not conducted during the prescribed survey period.

STAGE 2
IMPACT ASSESSMENT

5 INTRODUCTION TO STAGE 2 – IMPACT ASSESSMENT

5.1 Avoiding and Minimising Impacts on Native Vegetation and Habitat

Clearing of native vegetation will not be required by the Project. Moreover, extraction will use existing surface infrastructure at approved facilities [e.g. Mandalong Mine Access Site (MMAS) and Mandalong South Surface Site (MSSS)], and as such, no vegetation needs to be cleared to install additional surface infrastructure as part of the Project.

The following steps were also undertaken to reduce impacts associated with MOD 10:

- LW33 (as part of MOD 9) will no longer be extracted. The potential impacts on biodiversity associated with this longwall (including *R. rubescens* recorded in the vicinity) would be avoided;
- An original version of MOD 10 included the extension of LW30-33. By avoiding this extension, potential impacts to biodiversity in this area was avoided; and
- The original version of MOD 10 and addition of LW34 (MOD 10; Project) initially extended into Lot 502 DP730395. This land parcel was inaccessible for survey. To avoid uncertain impacts on biodiversity values on that property, LW34 was shortened to avoid potential impacts on this property.

5.2 Avoiding and Minimising Prescribed Biodiversity Impacts

5.2.1 Impacts of development on the habitat of threatened species associated with karst, caves, crevices and cliffs

The Project may impact upon habitat for cave, crevice and or cliff habitat associated threatened species due to structural damage or noise/vibration associated with mining in the Project Area. These findings were presented within the Subsidence Prediction Report for the Project by DgS (2021); which state:

- ‘Cracks ranging from 30 mm to 70 mm width may occur in relatively flat terrain where shallow or exposed rock exists (i.e. along creek beds)’;
- ‘Cracking is unlikely to occur where deep soil or alluvium profiles exist, as the strain will be more uniformly distributed and absorbed’;
- ‘The predicted subsidence and associated tilt and strains could result in minor cracking along the existing rock faces or rock outcrops and talus boulders on steep slopes’; and
- ‘The release of sandstone boulders down slope is ‘possible’ due to the presence of several cliff lines > 5 m high’.

However, it should be noted that the expression of above predictions have some level of uncertainty due to the unique geological nature of the Mandalong area. DgS (2021) state that the occurrence of cracking is strongly influenced by near surface lithology and differential subsidence effects and should not be ruled out above the steep slopes in the Mandalong South Area. For instance, surface cracking has been rare above the Mandalong LW1 to 24a, and it was likely to be due to the presence of thinly bedded, near surface strata of the Tuggerah and Patonga Claystone Formations that tend to ‘shear’ into thinner beams during subsidence development instead of generating fresh vertical cracks (DgS 2020). The above potential impacts are expected to be pertaining to the Project Area only, with DgS (2021) predicting ‘no impacts to surface features are predicted due to far-field movements caused by LW34’.

Given the limited and minor extent of cracking and the low chance for dislodgement of rock structures by the predicted subsidence, it is not expected that the Project would have a more than negligible impact on habitat of threatened species associated with caves, crevices and or cliff habitat.

5.2.2 Impacts of development on the habitat of threatened species associated with rocks

The Project may impact upon habitat for rock-associated threatened species due to subsidence related cracking and or release of sandstone boulders downslope, particularly in steep terrain. However, so far surface cracking has been rare above steep slopes and ridges above Mandalong LW1 to 24a after subsidence of up to 1.2 m. According to DGS (2020), minor cracking of rock structures is expected in steep terrain; surface cracks ranging from 150 mm to 320 mm width are predicted to occur on the slopes above LW30-33 (including the proposed extension areas; DGS 2020). Moreover, it is considered very unlikely that boulders will be dislodged and released downslope because of subsidence.

These findings were presented within the Subsidence Prediction Report for the Project by DGS (2021), which states:

- 'The predicted subsidence and associated tilt and strains could result in minor cracking along the existing rock faces or rock outcrops and talus boulders on steep slopes'; and
- 'The release of sandstone boulders down slope is 'possible' due to the presence of several cliff lines > 5 m high'.'

Given the limited and minor extent of cracking and the low chance for dislodgement of rock structures by the predicted subsidence, it is not expected that the Project would have a more than negligible impact on habitat of threatened species associated with rocks.

5.2.3 Impacts of development on water quality, water bodies and hydrological processes that sustain threatened species and threatened ecological communities

The Project may impact upon behaviour of ephemeral surface waters in the Morans, Mannering and Buttonderry Creek catchments through subsidence resulting from underground mining. Potential landform changes that may impact flows within these tributaries are catchment boundaries, watercourse stability/water quality, remnant ponding and flooding regimes.

To date, the potential impacts of the Mandalong Southern Extension Project on flooding have been minimised by the iterative process Centennial Mandalong has undertaken over time to develop mine designs that minimise potential impacts on surface waters, including catchment areas, watercourse impacts, flood regimes, regional infrastructure and annual flows.

A Flood Impact Assessment (FIA) for the Project was undertaken by Umwelt (2021) and concluded that:

- 'MOD 10 will not materially change the watercourse stability impacts for Morans Creek and Buttonderry Creek identified for the approved SSD-5144 MOD 9';
- When compared with the remnant ponding (ponding that occurs after prolonged rainfall and/or flooding) for the approved landform indicates:
  - 'Remnant ponding is typically confined to existing flow paths';
  - 'Negligible change in remnant ponding along Morans Creek';
  - 'Minor increased in remnant ponding along Buttonderry Creek';
- 'Compared to the approved scenario, a slight increase in total remnant ponding area of 0.01 ha is predicted (i.e. less than 1%)'; and
- 'MOD 10 will not materially change the flood regime impacts (depth, extent, velocity, duration or hazard) for Morans Creek and Buttonderry Creek identified for the approved SSD-5144 MOD 9'.

Based on Mandalong Mine's impact experience to-date, the proposed subsidence beneath the watercourses and Groundwater Dependent Ecosystems (GDEs) areas above the proposed mining layout is unlikely to cause significant, long-term impacts due to the presence of strain-absorbing alluvium and low levels of surface cracking experienced to-date (DGS 2021).

5.2.4 Impacts of vehicle strikes on threatened species of animals or on animals that are part of a TEC

Being an underground mine (connected underground to the MMAS), the Project is not expected to considerably modify the threats vehicles pose to threatened species. That is, vehicle movements pertaining to extraction are underground. However, the Project will require ongoing surface monitoring activities requiring vehicular access for environmental and geotechnical surveys. Risk of vehicle strike to fauna when travelling off public roads will be reduced by pertaining to the speed limit.

The risk of vehicle strike from these activities on relevant threatened species is assessed in **Table 5-1**. It was concluded that the risk of vehicle strike associated with Project would be unlikely/negligible.

Table 5-1 Assessment of impacts of vehicle strike on threatened fauna

Species	Likelihood of strike	Predicted impacts
Callocephalon fimbriatum Gang-gang Cockatoo	**Low** – species generally flies near canopy	Unlikely to be struck by vehicles
Calyptorhynchus lathami Glossy Black-Cockatoo	**Low** – species generally flies near canopy	Unlikely to be struck by vehicles
Cercartetus nanus Eastern Pygmy-possum	**Low** – species forages at night, when vehicular movements associated with the Project will be highly irregular.	Unlikely to be struck by vehicles
Chalinolobus dwyeri Large-eared Pied Bat	**Low** – species is nocturnal and generally flies near canopy.	Unlikely to be struck by vehicles
Chthonicola sagittata Speckled Warbler	**Moderate** – species forages diurnally potentially along access tracks. .	Potential to be struck by vehicles, however low frequency of vehicle passage and speed limits (<40 km/hr on private roads) should lead to a negligible increase in risk of strike associated with the Project.
Climacteris picumnus victoriae Brown Treecreeper (eastern subspecies)	**Moderate** – species forages diurnally potentially along access tracks. .	Potential to be struck by vehicles, however low frequency of vehicle passage and speed limits (<40 km/hr on private roads) should lead to a negligible increase in risk of strike associated with the Project.
Daphoenositta chrysoptera Varied Sittella	**Moderate** – species forages diurnally potentially along access tracks. .	Potential to be struck by vehicles, however low frequency of vehicle passage and speed limits (<40 km/hr on private roads) should lead to a negligible increase in risk of strike associated with the Project.
Dasyurus maculatus Spotted-tailed Quoll	**Low** – species forages at night, when vehicular movements associated with the Project will be highly irregular.	Unlikely to be struck by vehicles
Falsistrellus tasmaniensis Eastern False Pipistrelle	**Low** – species is nocturnal and generally flies near canopy.	Unlikely to be struck by vehicles
Glossopsitta pusilla Little Lorikeet	**Low** – species generally flies near canopy	Unlikely to be struck by vehicles
Haliaeetus leucogaster White-bellied Sea-Eagle	**Low** – species generally flies near canopy	Unlikely to be struck by vehicles
Hoplocephalus bitorquatus Pale-headed Snake	**Low** – species forages at night, when vehicular movements associated with the Project will be highly irregular.	Unlikely to be struck by vehicles
Hoplocephalus stephensii Stephens' Banded Snake	**Low** – species forages at night, when vehicular movements associated with the Project will be highly irregular.	Unlikely to be struck by vehicles

Species	Likelihood of strike	Predicted impacts
Litoria aurea Green and Golden Bell Frog	**Low** – species forages at night, when vehicular movements associated with the Project will be highly irregular.	Unlikely to be struck by vehicles
Litoria brevipalmata Green-thighed Frog	**Low** – species forages at night, when vehicular movements associated with the Project will be highly irregular.	Unlikely to be struck by vehicles
Litoria littlejohni Littlejohn's Tree Frog	**Low** – species forages at night, when vehicular movements associated with the Project will be highly irregular.	Unlikely to be struck by vehicles
Lophoictinia isura Square-tailed Kite	**Low** – species generally flies near canopy	Unlikely to be struck by vehicles
Macropus parma Parma Wallaby	**Low** – species forages at night, when vehicular movements associated with the Project will be highly irregular.	Unlikely to be struck by vehicles
Micronomus norfolkensis Eastern Coastal Free-tailed Bat	**Low** – species is nocturnal and generally flies near canopy.	Unlikely to be struck by vehicles
Miniopterus australis Little Bent-winged Bat	**Low** – species is nocturnal and generally flies near canopy.	Unlikely to be struck by vehicles
Miniopterus orianae oceanensis Large Bent-winged Bat	**Low** – species is nocturnal and generally flies near canopy.	Unlikely to be struck by vehicles
Mixophyes balbus Stuttering Frog	**Low** – species forages at night, when vehicular movements associated with the Project will be highly irregular.	Unlikely to be struck by vehicles
Mixophyes iteratus Giant Barred Frog	**Low** – species forages at night, when vehicular movements associated with the Project will be highly irregular.	Unlikely to be struck by vehicles
Myotis macropus Southern Myotis	**Low** – species is nocturnal and generally flies near canopy.	Unlikely to be struck by vehicles
Neophema pulchella Turquoise Parrot	**Low** – species generally flies near canopy	Unlikely to be struck by vehicles
Ninox connivens Barking Owl	**Low** – species forages at night, when vehicular movements associated with the Project will be highly irregular.	Unlikely to be struck by vehicles
Ninox strenua Powerful Owl	**Low** – species forages at night, when vehicular movements associated with the Project will be highly irregular.	Unlikely to be struck by vehicles
Tyto tenebriocosa Sooty Owl	**Low** – species forages at night, when vehicular movements associated with the Project will be highly irregular.	Unlikely to be struck by vehicles
Petaurus australis Yellow-bellied Glider	**Low** – species is nocturnal and requires vegetation to glide between trees and is unlikely to be moving across the path of a vehicle.	Unlikely to be struck by vehicles
Petroica boodang Scarlet Robin	**Moderate** – species forages diurnally potentially along access tracks. .	Potential to be struck by vehicles, however low frequency of vehicle passage and speed limits (<40 km/hr on private roads) should lead to a negligible increase in risk of strike associated with the Project.
Phascolarctos cinereus Koala	**Low** – species forages at night, when vehicular movements associated with the Project will be highly irregular.	Unlikely to be struck by vehicles
Petaurus norfolcensis Squirrel Glider	**Low** – species is nocturnal and requires vegetation to glide between trees and is unlikely to be moving across the path of a vehicle.	Unlikely to be struck by vehicles

Species	Likelihood of strike	Predicted impacts
Phoniscus papuensis Golden-tipped Bat	**Low** – species is nocturnal and generally flies near canopy.	Unlikely to be struck by vehicles
Pseudomys gracilicaudatus Eastern Chestnut Mouse	**Low** – species forages at night, when vehicular movements associated with the Project will be highly irregular.	Unlikely to be struck by vehicles
Planigale maculata Common Planigale	**Low** – species forages at night, when vehicular movements associated with the Project will be highly irregular.	Unlikely to be struck by vehicles
Potorous tridactylus Long-nosed Potoroo	**Low** – species forages at night, when vehicular movements associated with the Project will be highly irregular.	Unlikely to be struck by vehicles
Pteropus poliocephalus Grey-headed Flying-fox	**Low** – species is nocturnal and generally flies near canopy.	Unlikely to be struck by vehicles
Ptilinopus magnificus Wompoo Fruit-Dove	**Low** – species typically associates with rainforest and similar closed forests. Most of the access tracks are located along ridge tops and away from these heavily vegetated areas.	Unlikely to be struck by vehicles
Ptilinopus regina Rose-crowned Fruit-Dove	**Low** – species typically associates with rainforest and similar closed forests. Most of the access tracks are located along ridge tops and away from these heavily vegetated areas.	Unlikely to be struck by vehicles
Ptilinopus superbus Superb Fruit-Dove	**Low** – species typically associates with rainforest and similar closed forests. Most of the access tracks are located along ridge tops and away from these heavily vegetated areas.	Unlikely to be struck by vehicles
Saccolaimus flaviventris Yellow-bellied Sheathtail-bat	**Low** – species is nocturnal and generally flies near canopy.	Unlikely to be struck by vehicles
Scoteanax rueppellii Greater Broad-nosed Bat	**Low** – species is nocturnal and generally flies near canopy.	Unlikely to be struck by vehicles
Turnix maculosus Red-backed Button-quail	**Low** – species forages at night, when vehicular movements associated with the Project will be highly irregular.	Unlikely to be struck by vehicles
Tyto novaehollandiae Masked Owl	**Low** – species forages at night, when vehicular movements associated with the Project will be highly irregular.	Unlikely to be struck by vehicles

6 IMPACTS UNABLE TO BE AVOIDED

6.1 Direct Impacts

The Project uses existing surface infrastructure so avoids clearance of native vegetation.

6.1.1 Impacts to Native Vegetation

There will be no clearing of native vegetation by the Project. However, based on modelled remnant ponding by Umwelt (2021), there is potential for a very minor impact to native vegetation due to an increase in remnant ponding (i.e. ponding that occurs after prolonged rainfall and/or flooding) arising from subsidence associated with MOD 10. Modelling undertaken by Umwelt (2021) suggests an increased ponding of < 10 m^2 that is confined to existing flow paths. This change is <1% of existing conditions. They conclude that negligible change in remnant ponding is expected along Morans Creek and only minor increases expected along Buttonderry Creek.

The modelled extent of increased remnant ponding on PCTs 1556, 1568 and 1573 is detailed in **Table 6-1**.

Table 6-1 Impacts to native vegetation

PCT	Area (ha)	Area rounded up to minimum BAM-C input (ha)
PCT 1556 Tallowwood - Smooth-barked Apple - Blackbutt grass tall open forest of the Central and lower North Coast (Moderate)	0.000083	0.01
PCT 1568 Blackbutt - Turpentine - Sydney Blue Gum mesic tall open forest on ranges of the Central Coast (Moderate)	0.00031	0.01
PCT 1573 Sydney Blue Gum – Lilly Pilly mesic tall open forest of coastal ranges and tablelands escarpment (Moderate)	0.000078	0.01
Total impact to native vegetation	**0.00047**	**0.01**

Note: the area of native vegetation to be impacted is 0.00047 ha. As this value is too small for the BAM-C to recognise, it has been rounded up in the BAM-C to the nearest accepted number (i.e. 0.01 ha). This matter was raised with BCD on 9 August 2021 (see **Appendix E**), with no response received to date.

It is important to note that Umwelt (2021) attribute much of this change in remnant ponding to the data used in the model (i.e. use of different LiDAR datasets in the modelling). As such, Umwelt (2021) conclude that the MOD 10 remnant ponding is essentially unchanged relative to the approved SSD-5144 MOD 9. Hence, the expression of ponding impacts associated with MOD 10 on biodiversity values are considered unlikely and calls for an Adaptive Management Approach implemented through a Trigger, Action, Response Plan (TARP), as part of the Extraction Plan BMP, to respond to impacts in the case that they do occur.

6.1.1.1 Future vegetation integrity scores

An incremental increase in remnant ponding is predicted to result in a partial loss of vegetation integrity. This prediction is informed by ongoing monitoring of previously undermined longwalls as part of Mandalong South Extension Project. For instance, more than negligible impacts to ground-water dependent ecosystems within the Extraction Area of LW22-24a (completed 2017-2018) have not yet been detected during annual monitoring within areas where increased ponding is predicted (RPS 2019 and 2020). Nevertheless, considering a conservative worst case scenario for vegetation integrity loss, condition input values for the future vegetation condition scores (i.e. composition, structure and function) assumed for this BDAR were halved from the current mean values (i.e. across replicate plots for each PCT). These future values are presented in **Table 6-2** below, with calculations provided in **Appendix B**.

Table 6-2 Current and future vegetation integrity scores

Zone	Current vegetation integrity score				Future vegetation integrity score				VI Loss
	Composition	Structure	Function	Integrity	Composition	Structure	Function	Integrity	
2: PCT1556 Moderate	84.8	58	97.4	78.2	45.4	30	54.6	42.1	-36.2
3: PCT 1568 Moderate	86.8	86	65.5	78.8	37.8	39.3	52.9	42.8	-36
4: PCT1573 Moderate	89.8	68	74.7	76.9	44.2	27.4	54.9	40.5	-36.4

6.1.2 Loss of species credit species habitat or individuals

A negligible increase in remnant ponding is predicted (see **Section 6.1.1**). It is assumed this ponding would lead to the following impacts on Candidate species (i.e. species credit species) that were either found as present or are assumed to be present (**Table 6-3**).

Table 6-3 Impacts to Species Credit Species

Species	Associated zone	Area (ha)[1]	Area rounded up to minimum BAM-C input (ha)
Callocephalon fimbriatum Gang-gang Cockatoo	2: PCT 1556_Moderate	0.000083	0.01
	3: PCT 1568_Moderate	0.000282	
	4: PCT 1573_Moderate	0.000078	
Cercartetus nanus Eastern Pygmy-possum	2: PCT 1556_Moderate	0.000083	0.01
	3: PCT 1568_Moderate	0.000313	
	4: PCT 1573_Moderate	0.000078	
Cryptostylis hunteriana Leafless Tongue Orchid	2: PCT 1556_Moderate	0.000083	0.01
	3: PCT 1568_Moderate	0.000313	
Haliaeetus leucogaster White-bellied Sea-Eagle	2: PCT 1556_Moderate	0.000083	0.01
	3: PCT 1568_Moderate	0.000313	
Hoplocephalus bitorquatus Pale-headed Snake	2: PCT 1556_Moderate	0.000083	0.01
	3: PCT 1568_Moderate	0.000313	
	4: PCT 1573_Moderate	0.000078	
Hoplocephalus stephensii Stephens' Banded Snake	2: PCT 1556_Moderate	0.000083	0.01
	3: PCT 1568_Moderate	0.000313	
	4: PCT 1573_Moderate	0.000078	
Litoria brevipalmata Green-thighed Frog	2: PCT 1556_Moderate	0.000083	0.01
	3: PCT 1568_Moderate	0.000313	
Litoria littlejohni Littlejohn's Tree Frog	3: PCT 1568_Moderate	0.000313	0.01
Lophoictinia isura Square-tailed Kite	2: PCT 1556_Moderate	0.000083	0.01
	3: PCT 1568_Moderate	0.000313	
Mixophyes balbus Stuttering Frog	2: PCT 1556_Moderate	0.000083	0.01
	3: PCT 1568_Moderate	0.000313	
	4: PCT 1573_Moderate	0.000078	
Mixophyes iteratus Giant Barred Frog	2: PCT 1556_Moderate	0.000083	0.01
	3: PCT 1568_Moderate	0.000313	
	4: PCT 1573_Moderate	0.000078	

Species	Associated zone	Area (ha)[1]	Area rounded up to minimum BAM-C input (ha)
Myotis macropus Southern Myotis	2: PCT 1556_Moderate	0.000083	0.01
	3: PCT 1568_Moderate	0.000313	
	4: PCT 1573_Moderate	0.000078	
Ninox connivens Barking Owl	2: PCT 1556_Moderate	0.000083	0.01
	3: PCT 1568_Moderate	0.000282	
Ninox strenua Powerful Owl	2: PCT 1556_Moderate	0.000083	0.01
	3: PCT 1568_Moderate	0.000282	
Petaurus norfolcensis Squirrel Glider	2: PCT 1556_Moderate	0.000083	0.01
	3: PCT 1568_Moderate	0.000313	
Phascogale tapoatafa Brush-tailed Phascogale	2: PCT 1556_Moderate	0.000083	0.01
	3: PCT 1568_Moderate	0.000313	
Pteropus poliocephalus Grey-headed Flying-fox	2: PCT 1556_Moderate	0.000083	0.01
	3: PCT 1568_Moderate	0.000313	
	4: PCT 1573_Moderate	0.000078	
Rhizanthella slateri Eastern Australian Underground Orchid	2: PCT 1556_Moderate	0.000083	0.01
	3: PCT 1568_Moderate	0.000313	
	4: PCT 1573_Moderate	0.000078	
Tetratheca juncea Black-eyed Susan	3: PCT 1568_Moderate	0.000313	0.01
Tyto novaehollandiae Masked Owl	2: PCT 1556_Moderate	0.000083	0.01
	3: PCT 1568_Moderate	0.000282	
Tyto tenebriocosa Sooty Owl	3: PCT 1568_Moderate	0.000282	0.01

1. The area to be impacted is ~<0.001 ha. As this value is too small for the BAM-C to recognise, it has been rounded up to the nearest accepted number (i.e. 0.01 ha).

Note that the area of impact (if to occur) is well below the BAM-C minimum input of 0.01 ha. This matter was raised with BCD on 9 August 2021 (see **Appendix E**), with no response received to date.

6.2 Indirect Impacts

It is not expected that the Project will contribute to the indirect impacts listed in Section 8.2 of BAM; however, hydrological changes are considered to be the most applicable.

Hydrological changes to Morans Creek and Buttonderry Creek due to subsidence from underground mining have potential to influence riparian-associated vegetation and habitat downstream. However, it is not expected that MOD 10 will materially change the watercourse stability impacts for Morans Creek and Buttonderry Creek from those identified for the approved SSD 5144 MOD 9 (Umwelt 2021). Moreover, the potential for change to remnant ponding and or storage of surface runoff is considered negligible for MOD 10 (i.e. a slight increase in remnant ponding; Umwelt 2021). Therefore, downstream ecological impacts due to MOD 10 are expected to be negligible.

6.3 Prescribed Impacts

The prescribed impacts identified as relevant to the Project are potential impacts to karst, caves, crevices, cliffs and other geological features, and impacts of development on water quality, water bodies and hydrological processes that sustain threatened species and threatened ecological communities. Other potential prescribed impacts (e.g. impacts of vehicle strikes on threatened species of animals or on animals that are part of a TEC) were minimised and or avoided (as per **Section 5.2**). The residual potential prescribed impacts are outlined further in **Sections 6.3.1** and **6.3.2**.

6.3.1 Karst, caves, crevices, cliffs and other geological features of significance

Underground mining has the potential to disturb microbats or cave-associated owls associated with structural changes to rock-habitat features resulting from subsidence. The Project specific risks of this impact and efforts to avoid and minimise these impacts are outlined in **Section 5.2.1**.

Bat roosts may be disturbed indirectly through noise/vibration associated with underground mining and/or through structural changes to cave/ cliff/ crevice habitat. As the Project involves extraction beneath sandstone formations may support threatened microbat or owl roosts, there is potential for this activity to impact these species if roosts are present.

Cave-associated species that may associate with sandstone structures within the Project Area, as associated with the PCTs within the Project Area, are:

- *Chalinolobus dwyeri* (Large-eared Pied Bat);
- *Miniopterus australis* (Little Bent-winged Bat);
- *Miniopterus orianae oceanensis* (Large Bent-winged Bat); and
- *Tyto tenebriocosa* (Sooty Owl).

The extent and nature of this potential impact is difficult to predict due to the potentially dispersed and temporal nature of maternity roosts of threatened cave-associated bats, and uncertainty about the location and extent of impacts to caves/ crevices and cliffs associated with the Project. As such, an Adaptive Management Strategy will be adopted to monitor for changes in bat occupancy/activity due to extraction, should roost sites for threatened microbats and or Sooty Owl be detected. This strategy is presented in **Section 6.4.1.1**.

6.3.2 Impacts of development on water quality, water bodies and hydrological processes that sustain threatened species and threatened ecological communities

Underground mining has the potential to disturb TEC's, and riparian-associated threatened flora through altering the ground water regime and remnant ponding extent. As detailed in **Section 5.2.1**, the Project is expected to have negligible impact on the hydrology of Morans and Buttonderry Creek within the Project Area. The only impact identified is the potential increase of <0.001 ha of remnant ponding within Buttonderry

Creek. Due to the ephemeral nature of this waterway, the translatable impact on threatened entities (i.e. TEC's and threatened frogs and plants) is expected to be negligible.

Nevertheless, as there is still some uncertainty of how impacts to ground and surface water associated with subsidence may express, an Adaptive Management Strategy will be adopted to monitor and respond to potential impacts to relevant plant communities and threatened flora is presented in **Section 6.4.1**.

6.4 Mitigation and Management of Impacts

6.4.1 Adaptive Management Strategy

6.4.1.1 Prescribed impact: karst, caves, crevices, cliffs and other geological features of significance

The Project is unlikely to have a measurable impact upon cave-associated bats (see **Section 6.3.1**). However, a monitoring program is recommended to evaluate the impacts of subsidence on cave structures for microbat roosting, if threatened microbats are found to be roosting in the Project Area.

If threatened microbats are found roosting in the Project Area [e.g. *Miniopterus australis* (Little Bent-winged Bat); *Chalinolobus dwyeri* (Large-eared Pied Bat)], monitoring is to incorporate an appropriate baseline period and is to end after the full effects of subsidence are realised. Impacts on caves may be associated with vibration (noise) and or physical disturbance.

If an impact may be attributed to MOD 10, it is expected that a decrease in microbat activity [e.g. *Miniopterus australis* (Little Bent-winged Bat); *Chalinolobus dwyeri* (Large-eared Pied Bat)], species richness and/or body condition (body condition index), or a shift in age structure (as indicated by Canine length) would be detected within the impact area, but not within roosts at control sites. This monitoring work would be undertaken as part of the Biodiversity Monitoring Program (BMP) for the LW34 Extraction Plan.

Surveys are also required to establish whether breeding activity of *Tyto tenebriocosa* (Sooty Owl) is associated with caves within the Project Area. Although no signs of breeding material consistent with this species were observed within caves surveyed, surveys are required to confirm this result during breeding season. If present activity is found associated with caves in the Project Area, monitoring should be incorporated over an appropriate baseline period and is to end after the full effects of subsidence are realised. This monitoring work would be undertaken as part of the BMP for the LW 34 Extraction Plan.

6.4.1.2 Prescribed impact: Impacts of development on water quality, water bodies and hydrological processes that sustain threatened species and threatened ecological communities

To ensure the potential impacts of the Project pertain to those identified by Umwelt (2021), where ponding may be increased by mine-related subsidence (see **Section 6.2**), a monitoring program will be undertaken to detect impacts associated with subsidence (if they occur).

A monitoring program as part of the Extraction Plan will be undertaken to determine if plant communities and or threatened flora are impacted by the Project and be based on the principles of a Before-After-Control-Impact (BACI) design. This BACI design will involve collecting data at monitoring sites where impacts are expected and corresponding control/reference sites before and after mining (*as per* Underwood 1991). If an impact may be attributed to the Project, it is expected that a positive or negative ecological response would be detected in plant communities and or threatened plants within the potential impact area, but not within relevant controls.

Baseline data for this monitoring program has been collected as part of this BDAR (i.e. BAM plots, locations of threatened plants and microbat activity levels). Moreover, existing controls have been established for other monitoring programs for Mandalong, including relevant PCTs. These control sites are in the Olney State Forest, unaffected by mining.

Given that the BAM Calculator has a minimum area of 0.01 ha for an impact, it is suggested here that the need to offset impacts is triggered when remnant ponding following extraction of LW34 exceeds 0.01 ha (i.e. the minimum area input within the BAM Calculator). In this case, ecosystem and species credits should be honoured, as calculated in this BDAR which applied this minimum BAM-C area value.

7 SERIOUS AND IRREVERSIBLE IMPACTS (SAII)

The only SAII species found was *Rhodamnia rubescens* (Scrub Turpentine). However, this species was located outside the predicted impact area (i.e. predicted increased ponding related to MOD 10).

Surveys have been sufficiently performed on the following SAII species and were not found:

- *Petrogale penicillata* (Brush-tailed Rock-wallaby);
- *Rhodomyrtus psidioides* (Native Guava).

Based on the PCTs suspected to be present in areas where ponding has been predicted, the following SAII species were considered as having potential to occur:

- *Chalinolobus dwyeri* (Large-eared Pied Bat);
- *Miniopterus australis* (Little Bent-winged Bat);
- *Miniopterus orianae oceanensis* (Large Bent-winged Bat);
- *Mixophyes balbus* (Stuttering Frog);
- *Rhizanthella slateri* (Eastern Australian Underground Orchid); and
- *Tyto tenebricosa* (Sooty Owl).

However, impacts of ponding pertain to sedimentary soils within the valley floor only. Hence, this minor extent of ponding is not likely to inundate rock structures, and so should not directly impact upon critical habitat of *C. dwyeri*; *M. australis*; *M. orianae oceanensis* or *Tyto tenebricosa*. These species associate with high relief, rocky areas. Moreover, a small increase in ponding is expected to modify habitat for *Mixophyes balbus* (Stuttering Frog), rather than remove it, so an SAII for this species is not expected.

The Project has potential to only impact the SAII species *R. slateri*. *R. slateri* was not surveyed for within the recommended survey period according to BioNet (DPIE 2021a), and hence presence was assumed.

Based on Section 9.1 of the BAM, the BDAR is to provide further information regarding the assessment of SAIIs. This assessment is provided below. The extent of threatened species at risk of an SAII, identified or assumed to occur within the Project Area, are shown in **Figure 7-1**.

a. The action and measures taken to avoid the direct and indirect impact on the potential entity for a SAII

The Project will avoid clearing-related impacts on *R. slateri* as it involves underground mining. However, there is potential to impact these species through ponding associated with mine subsidence. Nevertheless, the potential impacts of the Mandalong Southern Extension Project on flooding have been minimised by the iterative process Centennial Mandalong has undertaken over time to develop mine designs that minimise potential impacts on surface waters, including catchment areas, watercourse impacts, flood regimes, regional infrastructure and annual flows. As such, there is only a minor increase of ponding related to the Project of <0.001 ha that may impact habitat of this species.

b. The size of the local population directly and indirectly impacted by the development, clearing or biodiversity certification

The nearest record of *R. slateri* is near Wisemans Ferry (Latitude -33.4; Longitude 151.06; DPIE 2020b), approximately ~ 40 km to the southwest of the Project Area. As part of the extensive field surveys undertaken by RPS for Centennial Mandalong, this species has not been observed. Hence, given the minor (<0.001 ha) extent of ponding resulting from MOD 10, it is unlikely that this would impact *R. slateri*.

c. The extent to which the impact exceeds any threshold for the potential entity

Records of *R. slateri* are only known from fewer than 10 locations. As the nearest location this species has been recorded is over 40 km from the Project Area, it is considered that the minor extent of predicted ponding (i.e. <0.001 ha), is unlikely to exceed a threshold of impact for this entity.

d. The likely impact (including direct and indirect impacts) that the development, clearing or biodiversity certification will have on the habitat of the local population

1. An estimate of the change in habitat available to the local population as a result of the proposed development

The Project is expected to lead to no more than a negligible change in habitat for *R. slateri* (i.e. ponding of <0.001 ha of potential habitat), given the abundance of similar nature habitat available in the local area, including the Olney State Forest (i.e. 44,000 ha area of bushland, much of which is exempt from mining).

2. **The proposed loss, modification, destruction or isolation of the available habitat used by the local population**

   Based on the assumed presence of *R. slateri*, ponding associated with MOD 10 may lead to loss of <0.001 ha of habitat for these species. Given the dispersed distribution of this species and distance from known populations (i.e. 40 km from the Project Area), this potential loss of habitat is considered negligible.

3. **Modification of habitat required for the maintenance of processes important to the species' life cycle (such as in the case of a plant – pollination, seed set, seed dispersal, germination), genetic diversity and long-term evolutionary development.**

   The increased ponding (<0.001 ha) associated with the Project is not expected to modify habitat required to maintain processes important to *R. slateri* given the relatively minor extent of habitat to be impacted, when considering Given the dispersed distribution of this species and distance from known populations (i.e. 40 km from the Project Area; see sections **c.** and **g.**).

e. The likely impact on the ecology of the local population

R. slateri is known to only occur at fewer than 10 locations, over 40 km from the Project Area. Hence, it is highly unlikely that this species is to occur in the <0.001 ha of predicted ponding.

f. A description of the extent to which the local population will become fragmented or isolated as a result of the proposed development

Given the small nature of the potential impact (<0.001 ha), this is not expected to fragment or isolate a local population of *R. slateri*.

g. The relationship of the local population to other population/populations of the species

For *R. slateri*, no local population is known of, and hence it is not expected that the Project would impact a local population of this species (i.e. the nearest known population is over 40 km southwest of the Project Area; DPIE 2021a).

h. The extent to which the proposed development will lead to an increase in threats and indirect impacts, including impacts from invasive flora and fauna, that may in turn lead to a decrease in the viability of the local population

Except for the minor extent (i.e. <0.001 ha) of potential impact to habitat for *R. slateri*, it is not expected that the Project would enhance threats and indirect impacts to these species.

i. An estimate of the area, or number of populations and size of populations that is in the reserve system in NSW, the IBRA region and the IBRA subregion

The extent of *R. slateri* populations occur within reserves is unknown due to the rarity of this species (i.e. < 10 populations known).

j. The measure/s proposed to contribute to the recovery of the species in the IBRA subregion

Saving our Species programs have been established to assist with the recovery of *R. slateri*. The Project Area is not a priority management site for this species.

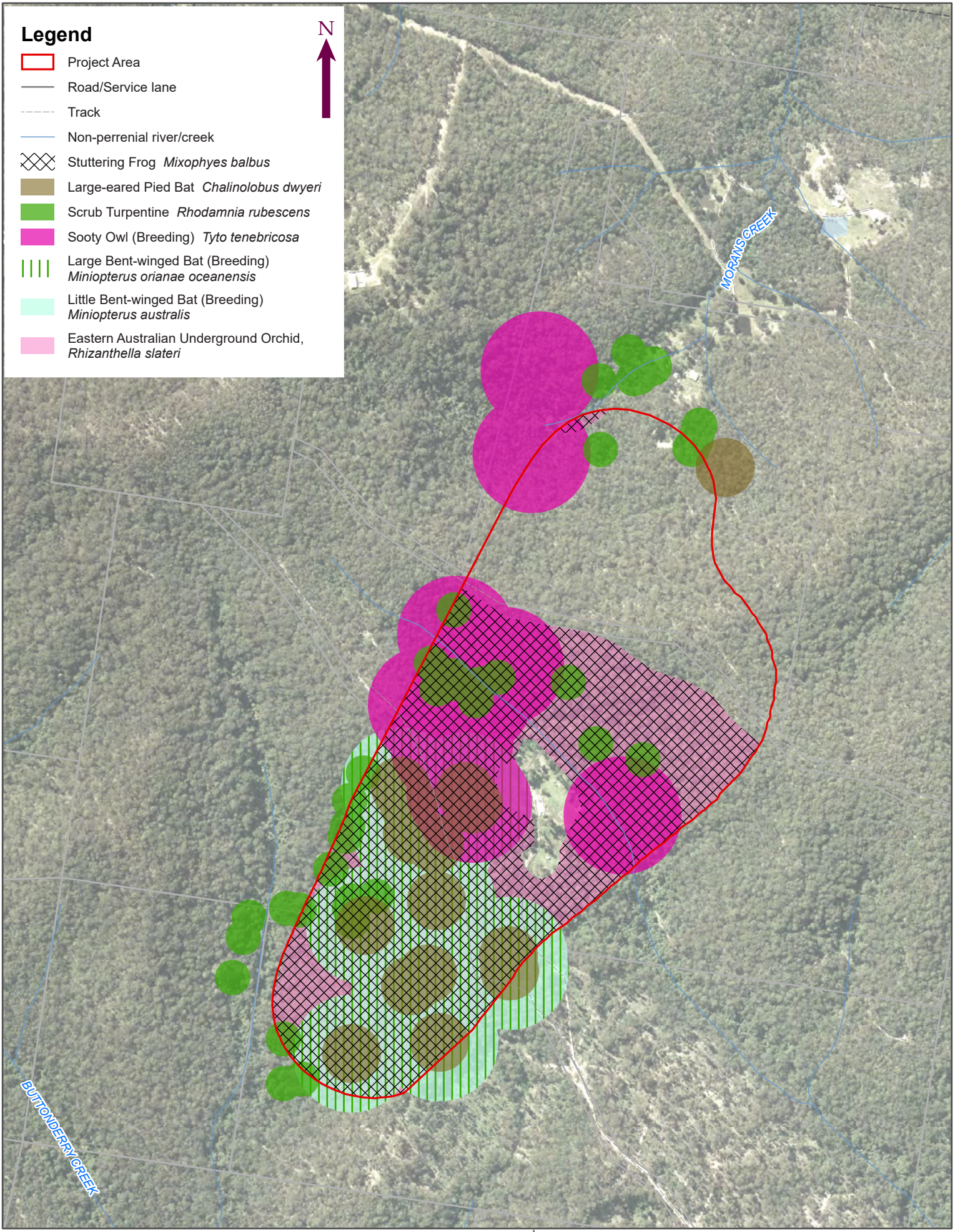


FIGURE 7-1
THREATENED SPECIES AT RISK OF AN SAII WITHIN THE PROJECT AREA

VERSION: **B**

DATE EXPORTED: **24/08/2021 8:47 AM**

TECHNICIAN: **Natalie.Wood**

LOCATION: **Mandalong**

DATA SOURCES
Centennial, RPS,

0 50 100 150 200 250 m

SCALE 1:8,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**

PROJECT: **149823**

PURPOSE: **BDAR**

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Project path: S:\Centennial\All Jobs\149823 Mandalong Revised MOD 10 BDAR\10 - Drafting\149823_Mandalong_MOD10_BDAR_figures_.aprx

8 REQUIREMENT TO OFFSET

The potential offset liability for the Project is presented below. As mentioned above, the potential impacts associated with MOD 10 on biodiversity values are considered unlikely and limited to a very small area (i.e. <10 m^2), which according to Umwelt (2021) is likely to be related to modelling artifacts (i.e. use of different LiDAR datasets between approved and proposed landforms). As such, it is proposed that BAM-C calculations here are considered within an Adaptive Management Framework, where credit liabilities are honoured only when an impact greater than negligible is detected. Noting that the minimum area is 0.01 ha (i.e. ten times the modelled remnant ponding increase), it is proposed that this area value is used as a threshold to trigger offsets (as outlined in **Section 6.4.1.2**).

The Biodiversity Credit Report is provided in **Appendix C**. Locations of impacts requiring offset and areas not requiring assessment are provided in **Figure 8-1** and **Figure 8-2**, respectively.

8.1 Impacts requiring an offset

8.1.1 Ecosystem credits

In the case that ponding-related impacts associated with MOD 10 materialise, ecosystem credits required to offset impacts related to ponding are presented in **Table 8-1**. Note that minimum value allowance for area within the BAM-C is 0.01 ha. As the area of impact is to be <0.001 ha (i.e. ten times less), it is considered that the offset liability presented here overestimates the potential impact, as the area of impact within each zone had to be rounded up to this minimum threshold of 0.01 ha (the minimum value in the BAM-C).

Based on the unexpected impact on vegetation communities, it is proposed that 0.01 ha increase in remnant ponding is used as a threshold to trigger offset requirements, which is to be included in the Extraction Plan BMP under an Adaptive Management Framework (as outlined in **Section 6.4.1.2**).

Table 8-1 Ecosystem credit liability

Zone	PCT	Vegetation integrity loss	Area (ha)	Species sensitivity to gain class (for BRW)	Biodiversity risk weighting	Potential SAII	No. ecosystem credits
2	PCT 1556 Tallowwood - Smooth-barked Apple - Blackbutt grass tall open forest of the Central and lower North Coast (Moderate)	36.2	0.01[1]	High Sensitivity to Potential Gain	1.5	No	1
3	PCT 1568 Blackbutt - Turpentine - Sydney Blue Gum mesic tall open forest on ranges of the Central Coast (Moderate)	36	0.01[1]	High Sensitivity to Potential Gain	1.5	No	1
4	PCT 1573 Sydney Blue Gum – Lilly Pilly mesic tall open forest of coastal ranges and tablelands escarpment (Moderate)	36.4	0.01[1]	High Sensitivity to Potential Gain	1.5	No	1

1. The area to be impacted is <0.001 ha. As this value is too small for the BAM-C to recognise, it has been rounded up to the lowest recognised number.

8.1.2 Areas not requiring assessment

An ~1.92 ha area of cleared/disturbed land does not require assessment (**Figure 8-2**). This area is mostly dominated by exotic species, with native vegetation cleared for a private property. ~0.00022 ha of ponding related impacts is predicted in this disturbed/cleared area.

8.2 Species credits

Species credits required to offset impacts related to ponding are presented in **Table 8-2**.

Table 8-2 Species credit liability

Species	Vegetation Zones	Area / Count	Biodiversity risk weighting	Potential SAII	No. species credits
Callocephalon fimbriatum Gang-gang Cockatoo	2: PCT 1556_Moderate 3: PCT 1568_Moderate 4: PCT 1573_Moderate	Area	2	No	1
Cercartetus nanus Eastern Pygmy-possum	2: PCT 1556_Moderate 3: PCT 1568_Moderate 4: PCT 1573_Moderate	Area	2	No	1
Cryptostylis hunteriana Leafless Tongue Orchid	2: PCT 1556_Moderate 3: PCT 1568_Moderate	Area	1.5	No	1
Haliaeetus leucogaster White-bellied Sea-Eagle	2: PCT 1556_Moderate 3: PCT 1568_Moderate	Area	2	No	1
Hoplocephalus bitorquatus Pale-headed Snake	2: PCT 1556_Moderate 3: PCT 1568_Moderate 4: PCT 1573_Moderate	Area	2	No	1
Hoplocephalus stephensii Stephens' Banded Snake	2: PCT 1556_Moderate 3: PCT 1568_Moderate 4: PCT 1573_Moderate	Area	2	No	1
Litoria brevipalmata Green-thighed Frog	2: PCT 1556_Moderate 3: PCT 1568_Moderate	Area	1.5	No	1
Litoria littlejohni Littlejohn's Tree Frog	3: PCT 1568_Moderate	Area	2	No	1
Lophoictinia isura Square-tailed Kite	2: PCT 1556_Moderate 3: PCT 1568_Moderate	Area	1.5	No	1
Mixophyes balbus Stuttering Frog	2: PCT 1556_Moderate 3: PCT 1568_Moderate 4: PCT 1573_Moderate	Area	3	Yes	1
Mixophyes iteratus Giant Barred Frog	2: PCT 1556_Moderate 3: PCT 1568_Moderate 4: PCT 1573_Moderate	Area	3	No	1
Myotis macropus Southern Myotis	2: PCT 1556_Moderate 3: PCT 1568_Moderate 4: PCT 1573_Moderate	Area	2	No	1
Ninox connivens Barking Owl	2: PCT 1556_Moderate 3: PCT 1568_Moderate	Area	3	No	1
Ninox strenua Powerful Owl	2: PCT 1556_Moderate 3: PCT 1568_Moderate	Area	2	No	1
Petaurus norfolcensis Squirrel Glider	2: PCT 1556_Moderate 3: PCT 1568_Moderate	Area	2	No	1
Phascogale tapoatafa Brush-tailed Phascogale	2: PCT 1556_Moderate 3: PCT 1568_Moderate	Area	2	No	1
Pteropus poliocephalus Grey-headed Flying-fox	2: PCT 1556_Moderate 3: PCT 1568_Moderate 4: PCT 1573_Moderate	Area	2	No	1

Species	Vegetation Zones	Area / Count	Biodiversity risk weighting	Potential SAII	No. species credits
Rhizanthella slateri Eastern Australian Underground Orchid	2: PCT 1556_Moderate 3: PCT 1568_Moderate 4: PCT 1573_Moderate	Area	3	Yes	1
Tetratheca juncea Black-eyed Susan	3: PCT 1568_Moderate	Area	2	No	1
Tyto novaehollandiae Masked Owl	2: PCT 1556_Moderate 3: PCT 1568_Moderate	Area	2	No	1
Tyto tenebricosa Sooty Owl	3: PCT 1568_Moderate	Area	2	No	1

Note that area values were rounded up to the minimum data entry value available in the BAM-C (i.e. total potential impact on a species polygon due to ponding is <0.001 yet BAM-C data entry is limited to two decimal places). As such, to allow a more accurate representation of this small impact in the BAM-C, only one value of 0.01 ha was added for species detected or assumed to be present.

Based on the unexpected impacts on these species credit species, it is proposed that a 0.01 ha increase in remnant ponding is to be used as a threshold to trigger offset requirements. This threshold for triggering an offset is to be included in the Extraction Plan BMP under an Adaptive Management Framework (as outlined in **Section 6.4.1.2**). This approach is considered pragmatic since assigning 0.01 ha for each relevant zone already grossly overestimates the predicted impact and its associated offset liability.

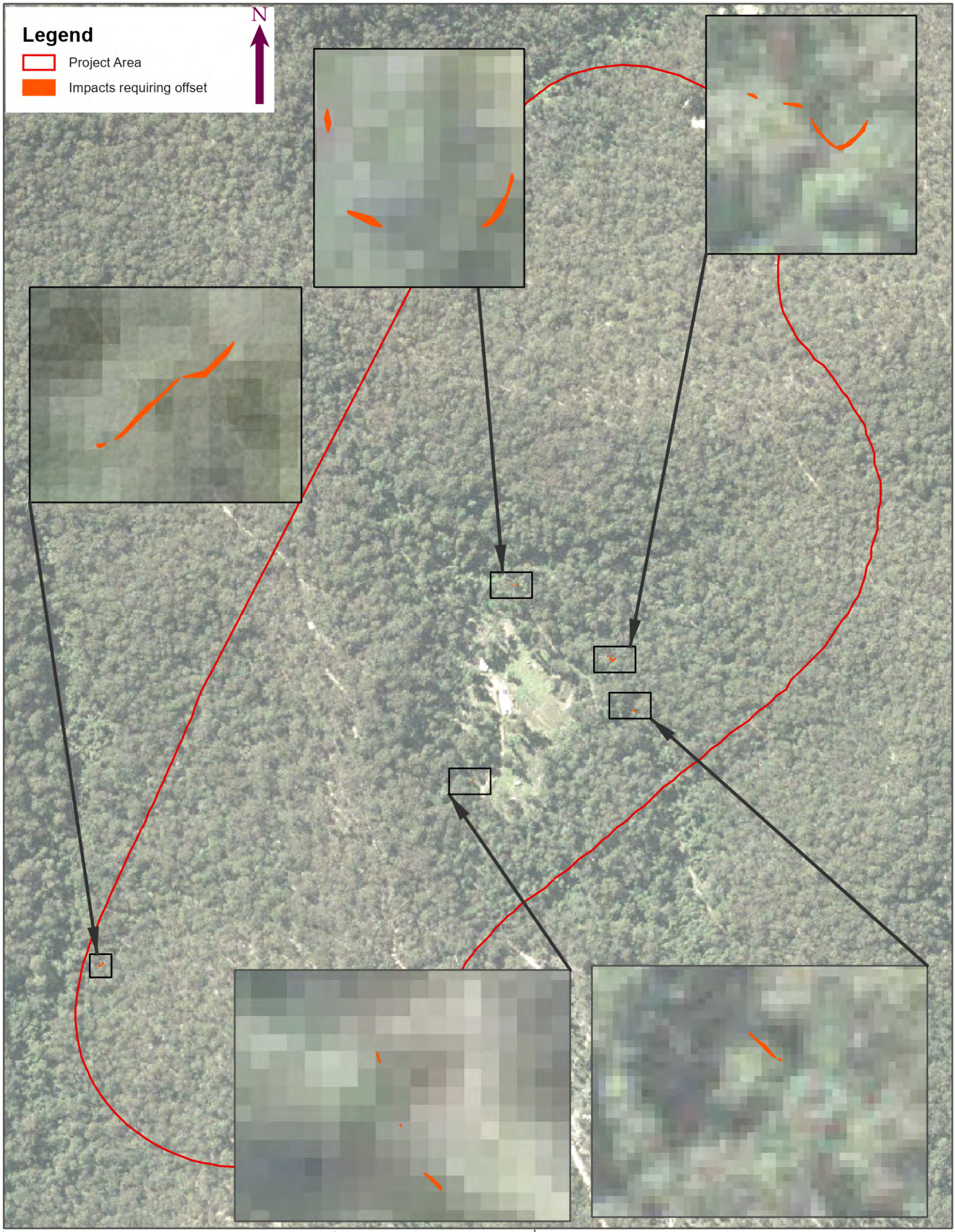


FIGURE 8-1
IMPACTS REQUIRING OFFSET

VERSION: **A**

DATE EXPORTED: **10/08/2021 2:35 PM**

TECHNICIAN: **Natalie.Wood**

LOCATION:
Mandalong

DATA SOURCES
Centennial, RPS,

0 50 100 150 m

SCALE 1:5,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**

PROJECT: **149823**

PURPOSE: **BDAR**

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FIGURE 8-2
AREAS NOT REQUIRING ASSESSMENT

VERSION: **A**

DATE EXPORTED: **10/08/2021 2:46 PM**

TECHNICIAN: **Natalie.Wood**

LOCATION:
Mandalong

DATA SOURCES
Centennial, RPS,

0 50 100 150 m

SCALE 1:4,959 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**

PROJECT: **149823**

PURPOSE: **BDAR**

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9 CONCLUSION

This BDAR addresses Stage 1 (Biodiversity Assessment) and Stage 2 (Impact Assessment) of the BAM. Maps have been provided in compliance with BAM, including the layout of the final project footprint in relation to biodiversity values, including impacts requiring/not requiring offsets.

In accordance with the objectives of the Biodiversity Offset Scheme (BOS), the mine layout for MOD 10 was designed to avoid and minimise impacts on biodiversity values. That is, impacts of the Mandalong Southern Extension Project on flooding have been minimised by the iterative process Centennial Mandalong has undertaken over time to develop mine designs that minimise potential impacts on surface waters, including catchment areas, watercourse impacts, flood regimes, regional infrastructure and annual flows. Specifically, the following steps were also undertaken to reduce impacts associated with MOD 10:

- LW33 (as part of MOD 9) will no longer be extracted. The potential impacts on biodiversity associated with this longwall would be avoided (and accordingly result in a reduction in approved impacts on biodiversity values);
- An original version of MOD 10 included the extension of LW30-33. By avoiding this extension, potential impacts to biodiversity in this area will be avoided; and
- The original version of MOD 10 and addition of LW34 initially extended into Lot 502 DP730395. This land parcel was inaccessible for survey. To avoid uncertain impacts on biodiversity values on that property, LW34 was shortened to avoid potential impacts on this property.

9.1 Need for Offsetting

MOD 10 is expected to lead to a negligible increase in remnant ponding (i.e. ponding that occurs after prolonged rainfall and/or flooding). Modelling undertaken by Umwelt (2021) suggests an increase of <10 m^2 of ponding, which is <1% change in ponding, which is to be confined to existing flow paths. They conclude that negligible change in remnant ponding is expected along Morans Creek and only minor increases expected along Buttonderry Creek. Moreover, Umwelt (2021) attribute much of this change in remnant ponding to modelling artifacts (i.e. use of different LiDAR datasets for approved and proposed mining landforms). As such, Umwelt conclude that MOD 10 proposed landform remnant ponding is essentially unchanged relative to the approved SSD-5144 MOD 9. Hence, the expression of ponding impacts associated with MOD 10 on biodiversity values are considered unlikely and calls for an Adaptive Management Approach to respond to impacts when (if) they occur.

Putting aside the basis for predicting impacts (i.e. reliance on modelling and associated assumptions), the question is posed here to the decision maker – is the BOS applicable in this case as the MOD is not likely to an increased impact on biodiversity values? It should be noted that by avoiding the extraction of the approved LW33 (combined with shortening of LW30, 31 and 34), MOD 10 as proposed is likely to lead to a net reduction in potential impacts relative to the approved Mandalong Southern Extension Project. Accordingly, measures to avoid impacts means that the MOD 10 is not likely to have a net increased impact on biodiversity values. The implementation of an Adaptive Management Approach through the Extraction Plan process is proposed to determine if and when offsetting is required (i.e. greater than negligible impact is identified).

9.2 Offsetting Measures

Given that the BAM Calculator has a minimum area of 0.01 ha for an impact, it is suggested here that the need to offset impacts is triggered when impacts associated with ponding following extraction of LW34 exceed 0.01 ha (i.e. the minimum area input within the BAM Calculator). In this case, ecosystem and species credits should be honoured, as calculated in this BDAR which applied this minimum BAM-C area value. Note that within this BDAR, a precautionary approach was applied to calculating the potential offset liability by reducing the vegetation integrity (worst-case scenario of halving of vegetation condition scores) for vegetation where ponding is predicted and assuming presence of Species Credit Species in these areas where surveys were not sufficient to rule out their presence.

In the case that impacts of MOD 10 are expressed, and the minimum area threshold within BAM-C of 0.01 ha impact threshold is met or exceeded, the Ecosystem Credits required for the Project are:

- 1 Ecosystem Credit for PCT 1556 Tallowwood - Smooth-barked Apple - Blackbutt grass tall open forest of the Central and lower North Coast;
- 1 Ecosystem Credit for PCT 1568 Blackbutt - Turpentine - Sydney Blue Gum mesic tall open forest on ranges of the Central Coast; and
- 1 Ecosystem Credit for PCT 1573 Sydney Blue Gum – Lilly Pilly mesic tall open forest of coastal ranges and tablelands escarpment.

In the same sense (i.e. offsetting in accordance with a detected impact 0.01 ha or greater), the Species Credits for threatened species required for the Project are:

- 1 *Callocephalon fimbriatum* (Gang-gang Cockatoo) Species Credit;
- 1 *Cercartetus nanus* (Eastern Pygmy-possum) Species Credits;
- 1 *Cryptostylis hunteriana* (Leafless Tongue Orchid) Species Credit;
- 1 *Haliaeetus leucogaster* (White-bellied Sea-Eagle) Species Credit;
- 1 *Hoplocephalus bitorquatus* (Pale-headed Snake) Species Credit;
- 1 *Hoplocephalus stephensii* (Stephens' Banded Snake) Species Credit;
- 1 *Litoria brevipalmata* (Green-thighed Frog) Species Credit;
- 1 *Litoria littlejohni* (Littlejohn's Tree Frog) Species Credit;
- 1 *Lophoictinia isura* (Square-tailed Kite) Species Credit;
- 1 *Mixophyes balbus* (Stuttering Frog) Species Credit;
- 1 *Mixophyes iteratus* (Giant Barred Frog) Species Credit;
- 1 *Myotis macropus* (Southern Myotis) Species Credit;
- 1 *Ninox connivens* (Barking Owl) Species Credit;
- 1 *Ninox strenua* (Powerful Owl) Species Credit;
- 1 *Petaurus norfolcensis* (Squirrel Glider) Species Credit;
- 1 *Phascogale tapoatafa* (Brush-tailed Phascogale) Species Credit;
- 1 *Pteropus poliocephalus* (Grey-headed Flying-fox) Species Credit;
- 1 *Rhizanthella slateri* (Eastern Australian Underground Orchid) Species Credit;
- 1 *Tetratheca juncea* (Black-eyed Susan) Species Credit;
- 1 *Tyto novaehollandiae* (Masked Owl) Species Credit; and
- 1 *Tyto tenebricosa* (Sooty Owl) Species Credit.

9.3 Offsetting Strategy

In the case that offsetting requirements are triggered, these credit requirements will need to be satisfied in accordance with the NSW BOS through retiring credits, based on like-for-like rules where possible. Payments into the Biodiversity Conservation Fund may be made where suitable credits are not available.

9.4 Adaptive Management for Uncertain Impacts

Mitigation measures proposed for the Project are presented in **Section 6.4**, which introduces adaptive management measures to allow for ongoing monitoring of potential prescribed impacts. Specifically, monitoring programs will be employed in an attempt to detect and respond to potential impacts arising from ponding of surface water (e.g. impacts to ground-water dependent ecosystems) and impacts to karst, caves, crevices, cliffs and other geological features of significance (e.g. impacts to cave-associated microbats). Regarding ponding-related impacts, this monitoring would be used to determine if ponding impacts meet or exceed the BAM-C minimum area threshold of 0.01 ha, and hence trigger the need to offset these impacts.

This monitoring program will be incorporated into the Biodiversity Management Plan prepared as part of the Extraction Plan to ensure impacts do not exceed those predicted to occur in this BDAR.

Threatened species which require further surveys and or monitoring to validate the assumption that cave structures will not be impacted are:

- *Miniopterus australis* (Little Bent-winged Bat);
- *Chalinolobus dwyeri* (Large-eared Pied Bat); and
- *Tyto tenebricosa* (Sooty Owl).

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Appendix A

Biodiversity Inventory Report

MANDALONG MOD 10: ADDITION OF LONGWALL 34

Biodiversity Inventory Report



149823
V1
26 August 2021

rpsgroup.com

REPORT

Document status

Version	Purpose of document	Authored by	Reviewed by	Approved by	Review date
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1	Final to client	Hayden Beck	Mark Aitkens	Mark Aitkens	26 August 2021

Approval for issue

Dr Hayden Beck  26 August 2021

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1 INTRODUCTION

RPS Australia East Pty Ltd (RPS) was engaged by Centennial Coal (the proponent) to prepare this Biodiversity Inventory Report (BIR) as supporting documentation for an application to modify State Significant Development (SSD) - 5144 (Modification 10 or MOD 10) by including the development of Longwall (LW) 34 (herein referred to as the 'Project').

This BIR documents the survey methods used to investigate the biodiversity values of the Project Area and the results associated with these investigations. This involves reporting results from relevant surveys, undertaken in adjacent, contiguous bushland that is connected to the Project Area, to inform on the biodiversity values relevant to the Project.

This BIR is a supporting document to the Biodiversity Development Assessment Report (BDAR); a mandatory assessment requirement for Major Projects prepared in accordance with relevant sections of the NSW *Biodiversity Conservation Act 2016* (BC Act). For this purpose, flora and fauna surveys performed within the Project Area were undertaken in a manner to comply with the Biodiversity Assessment Method (BAM; State of NSW 2020). The BIR also assesses matters not addressed in the BDAR, including the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and relevant State Environmental Planning Policies (SEPPs).

The following terms are used in this document:

- **Project** – Modification to Mandalong Mine SSD-5144 for the addition of LW34 (MOD 10);
- **Project Area** – Land within the angle-of-draw (i.e. angle between the goaf and the point on the ground surface to which subsidence is expected to occur; AOD);
- **Assessment Area** – Land within a 1500 m buffer from the outer extent of the Project Area; and
- **Local Area** or **Locality** – Land within 10 km of the Project Area.

1.1 The Project

Mandalong Mine (Mandalong) is an existing underground coal mine near Morisset, approximately 35 kilometres (km) south-west of Newcastle, predominantly in the Lake Macquarie local government area (LGA) (**Figure 1-1**). Mandalong is operated by Centennial Mandalong Pty Limited (Centennial Mandalong).

Centennial Mandalong has approval to extract run-of-mine (ROM) coal from the West Wallarah and Wallarah-Great Northern seams using a combination of longwall and continuous mining methods. Mandalong operates under State significant development (SSD) consent SSD-5144, which was granted on 12 October 2015 by the NSW Planning Assessment Commission under Part 4, Division 4.1 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act).

As identified in Mandalong's *Mining Operations Plan* (MOP) (Centennial Coal 2018), the progression of underground mining is regularly reviewed dependent on ongoing monitoring and geological conditions. Centennial Mandalong recently encountered poor geological conditions within the Mandalong Southern Extension Area, including a fault zone and igneous sill.

In response to these conditions and in order to maintain coal production, improve mining conditions and improve the financial viability of Mandalong, amendments to the approved mine plan were sought as part of a modification to SSD-5144 (herein referred to as MOD 9). As part of MOD 9, Centennial Mandalong sought approval to amend the approved mine plan, including the reorientation of LW30-LW33.

Since the approval of MOD 9 in April 2021, Centennial Mandalong has continued to review the progression of underground mining within the Mandalong Southern Extension Area. As a result of these investigations, the decision has been made to shorten LW30 and remove LW33 from the mine plan. The shortening of LW30 and removal of LW33 are estimated to result in the sterilisation of approximately 0.4 million tonnes (Mt) and 1.6 Mt of coal, respectively. Consequently, Centennial Mandalong has explored options to optimise the mine plan to access additional coal resources.

Centennial Mandalong is seeking to modify SSD-5144, pursuant to Section 4.55(2) of the EP&A Act, to change Mandalong's approved mine plan to include LW34 (herein referred to as MOD 10 or the proposed modification). The addition of LW34 will maximise resource extraction within the West Wallarah Seam and

Mandalong's development consent boundary and improve the continuity of coal extraction and employment at Mandalong. Two updates to Appendix 8 of SSD-5144 are also proposed.

1.2 Project Area Particulars

Locality:	Mandalong, NSW
LGA:	Lake Macquarie City Council (LMCC) and Central Coast Council (CCC)
Lot/DP:	Lot 114 DP755238; Lot 122 DP755238; Lot 502 DP730395; Lot 2 DP805044; Lot 145 DP755238; Lot 3 DP805044; and Lot 115 DP755238.
Project Area:	Footprint of the Project Area is approximately 52.17 ha. The location of the Project Area is shown in **Figure 1-1**.
Boundaries:	The Project Area is predominantly surrounded by vegetated lands in all directions on private land and State Forest.
Zoning:	Under the provisions of the LMCC and CCC Local Environment Plans (LEPs), the Project Area is zoned as E2 Environmental Conservation and E3 Environmental Management and RU3 Forestry. Other land uses within the Assessment Area are RU1 Primary Production, RE1 Public Recreation and RU2 Rural Landscape.
Current Land Use:	Bushland makes up most of the Project Area. Other land uses tributaries of Morans, Mannering and Buttonderry creeks; local roads (including Toepfers Road and Kiar Ridge Road); private dwellings, ancillary buildings, fences and driveways; and Aboriginal cultural and historic heritage sites.
Topography:	Project Area is dominated by undulating coastal hills ranging up to 210 m Above Sea Level (ASL) down to Buttonderry creek at approximately 50 m ASL. The land contains numerous watercourses, many of which are ephemeral, low order tributaries. The topography within the Project Area has been altered by local roads, earthworks associated with private properties and past state forestry activities.

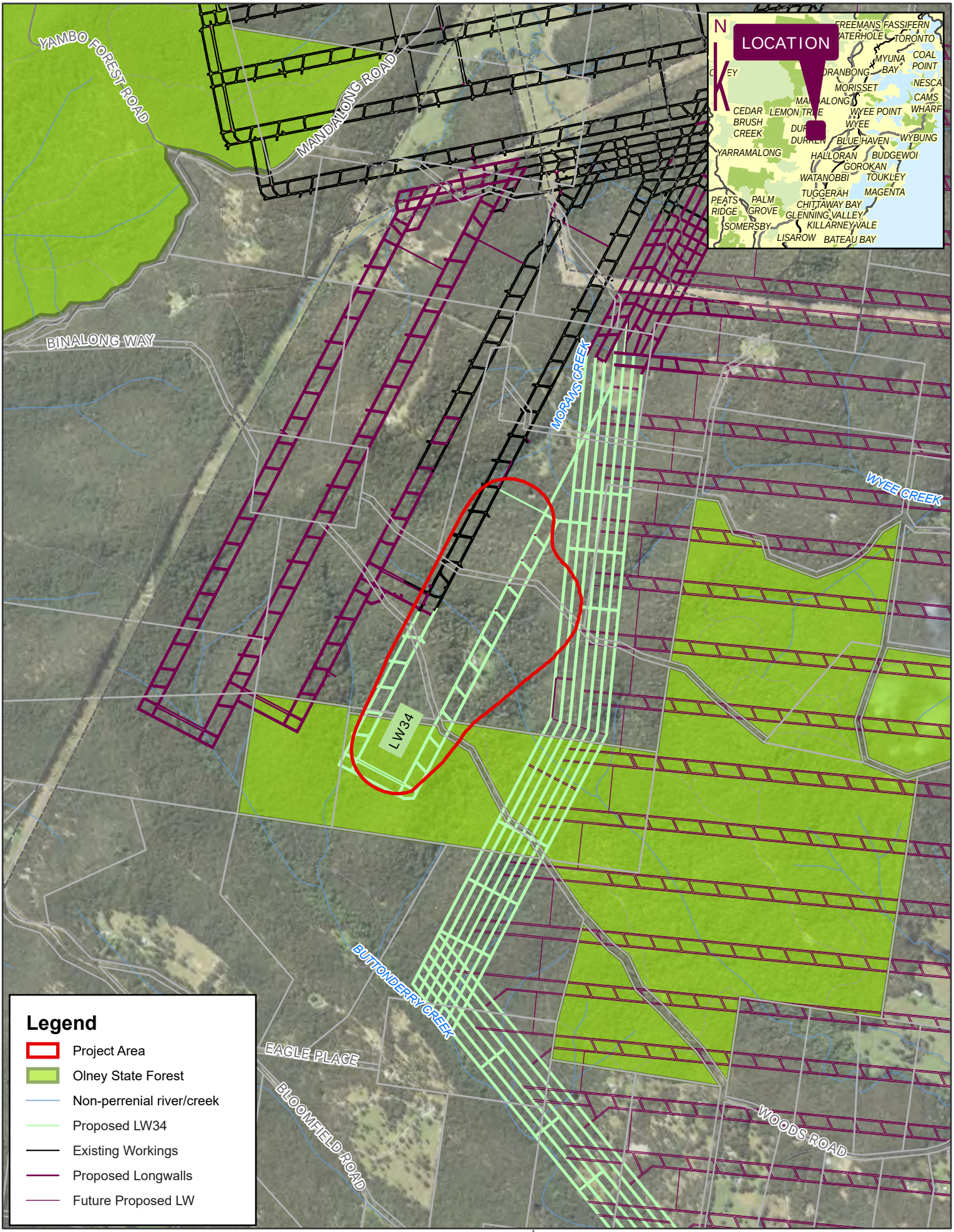


FIGURE 1-1
PROJECT AREA

VERSION:
A
DATE EXPORTED:
24/08/2021 2:37 PM
TECHNICIAN:
Robert.Suansri

LOCATION:
Mandalong

DATA SOURCES
Centennial, RPS, © Department of Finance, Services & Innovation 2018

0 100 200 300 400 500 600 m

SCALE 1:17,500 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**
PROJ: **149823**
PURPOSE: **BIR**

IMPORTANT NOTE
1. This plan was prepared for the sole purposes of the client for the specific purpose of producing a photographic overlay plan. This plan is strictly limited to the Purpose and does not apply directly or indirectly and will not be used for any other application, purpose, use or matter. The plan is presented without the assumption of a duty of care to any other person (other than the Client) ("Third Party") and may not be relied on by Third Party.
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g. the accuracy, reliability, suitability or completeness of any approximations or estimates made or referred to by RPS Australia East Pty Ltd in this plan.

Project path: S:\Centennial\All Jobs\149823 Mandalong Revised MOD 10 BDAR\10 - Drafting\149823_Mandalong_MOD10_BIR_figures.aprx

1.3 Purpose of this BIR

The purpose of this BIR is to describe the biodiversity values of the Project Area as a basis for assessing the impacts of the Project as per the requirement to do so under Section 1.7 of the EP&A Act. This BIR has focused on threatened biodiversity listed under the BC Act and EPBC Act to allow for the preparation of the following assessments:

- Biodiversity Development Assessment Report (BDAR) as required for proposed development that is likely to significantly affect threatened species (Section 7.7 of the BC Act); and
- *Significant Impact Guidelines 1.1 - Matters of National Environmental Significance* (DoE 2013), specifically for listings under Section 18 and 18A of the EPBC Act.

In relation to the above, the BIR is focused on evaluating the likelihood of occurrence and incidence of threatened biodiversity (i.e. threatened species, populations, ecological communities) listed under the BC Act and/or EPBC Act using methods and guidance specified in the BAM and Project brief. In addition, this BIR provides information that will support the assessment of impact to relevant Matters of National Environmental Significance (MNES) listed under the EPBC Act. MNES relevant to this report are those listed under Sections 178, 181, 183 and 209 (threatened species, ecological communities, threatening processes and migratory species), as amended on 14/12/2020.

The following documents and guidelines have been considered when preparing the BIR:

- Threatened Species Assessment Guidelines (DPIE);
- NSW State Groundwater Dependent Ecosystem Policy (NOW);
- Risk Assessment Guidelines for Groundwater Dependent Ecosystems (NOW);
- State Environmental Planning Policy (SEPP) Koala Habitat Protection 2021;
- State Environmental Planning Policy (Koala Habitat Protection) 2021;
- Coastal Management SEPP; and
- Significant Impact Guidelines 1.1 - Matters of National Environmental Significance (DoE 2013).

The BIR will also have regard for survey methodologies prescribed in various State and Commonwealth guidelines if deemed relevant to this stage of the Project.

1.4 Scope of Works

The scope of this BIR is to:

- Identify vascular plant species occurring within the Project Area, including any threatened species listed under the BC Act or EPBC Act;
- Identify and map the extent of vegetation communities and Plant Community Types (PCTs) within the Project Area, including any Threatened Ecological Communities (TECs) listed under the BC Act and/or EPBC Act;
- Identify any fauna species, including threatened and migratory species, and populations or their habitats, which occur within the Project Area and are known to occur in the wider locality;
- Report datasets necessary for performing computations in the online BAM Calculator (BAM-C);
- Assess the likely impact of the Project on threatened biodiversity listed under the EPBC Act that are relevant to the Project; and
- Consider relevance of local environmental legislation, including relevant SEPPs.

Information presented in this BIR is to be used to inform the preparation of the corresponding BDAR for the Project.

1.5 Regulatory Context

The Project is a modification under Section 4.55(2) of the EP&A Act to an existing SSD consent SSD-5144 for the Mandalong Mine granted on 12 October 2015. As the Project is a modification to an SSD, the BAM is mandatory. The regulatory context that defines the assessment framework for the Project is outlined in **Table 1-1**.

Table 1-1 Relevant Legislation, Policy and Guidelines

Legislation, Policy and Guidelines	Comment
State	
Biodiversity Assessment Method (BAM 2020)	The NSW Biodiversity Assessment Method (BAM) is part of the Biodiversity Offsets Scheme (BOS). The BAM outlines how to assess changes in native vegetation, threatened species and their habitats. BAM provides the number and class of biodiversity credits that need to be offset to achieve 'no net loss' of biodiversity.
Biodiversity Conservation Act 2016	Provides lists of species, populations and ecological communities with a legal threatened status in NSW. Introduces the Biodiversity Offsets Scheme (BOS) and *Biodiversity Assessment Method Order* 2017 (BAM). Threatened species, ecological communities and their habitats impacted by Projects determined under Part 5 of the EP&A Act are assessed in accordance with the 'Test of Significance' as prescribed in Section 7.3 of the BC Act.
Biosecurity Act 2015	Prescribes the statutory requirements for managing pests, diseases, weeds and contaminants in NSW. Applies to construction activities and occupation of the Project Area.
Environmental Planning and Assessment Act 1979	The Project is being assessed under Part 4 of the EP&A Act. Section 1.7 of the EP&A Act requires consideration of Part 7 of the BC Act.
State Environmental Planning Policy (Koala Habitat Protection) 2020	State Environmental Planning Policy (Koala Habitat Protection) 2020 applies to the LMCC portion of the Project Area. SEPP (Koala Protection) 2020 repeals and replaces the State Environmental Planning Policy (SEPP) (Koala Habitat Protection) 2019.The Koala Habitat Protection SEPP is closely aligned with the previous SEPP 44 – Koala Habitat Protection (SEPP 44). with similar definitions of 'potential' and 'core' koala habitat. SEPP (Koala Habitat Protection) 2021 applies to the CCC portion of the Project Area. Note that this SEPP does not apply to SSDs and so has not been addressed here.
State Environmental Planning Policy Koala Habitat Protection 2021	The Koala SEPP 2021 reinstates the policy framework of SEPP Koala Habitat Protection 2019 to 83 Local Government Areas (LGA) in NSW, which includes CCC. For CCC, Koala SEPP 2021 applies to all zones. Note that this SEPP does not apply to SSDs and so has not been addressed here.
Coastal Management SEPP (2018)	The Coastal Management SEPP sets the land use planning framework for coastal management and ensures implementation of the planning objectives of the Coastal Management Act 2016. This policy repeals and consolidates SEPP 14 (Coastal Wetlands), SEPP 26 (Littoral Rainforests) and SEPP 71 (Coastal Protection).
National Parks and Wildlife Act 1974	The intent of the *National Parks and Wildlife Act* 1974 is to conserve NSW's natural and cultural heritage; fostering public appreciation, understanding and enjoyment of the State's natural and cultural heritage; and managing any lands reserved for the purposes of conserving and fostering public appreciation and enjoyment of the State's natural and/or cultural heritage. Under this act, any impacts on the conservation reserve network, including National Parks, state conservation areas, karst conservation reserves, nature reserves and regional parks, need to be considered.
Fisheries Management Act 1994	Provides lists of species, populations and ecological communities with a legal threatened status in NSW. One of the objectives of this act is to 'conserve key fish habitats'.

Legislation, Policy and Guidelines	Comment
Commonwealth	
Environment Protection and Biodiversity Conservation Act 1999	Provides lists of MNES such as threatened species, ecological communities, threatening processes and migratory species (Sections 178, 181, 183 and 209 respectively). Outlines circumstances where a Proponent is required to refer a proposed action for assessment under the EPBC Act (i.e. Section 68).
Significant Impact Guidelines 1.1 – Matters of National Environmental Significance	These significant impact guidelines aid in determining if a proposed action is likely to have a significant impact on a MNES. Consideration of survey methods for specific MNES required where potential impacts are identified.

2 STAFF QUALIFICATIONS AND INVOLVEMENT

2.1 Staff involvement

The preparation of this BIR and associated BDAR was managed and issued for approval by Dr Hayden Beck (Accredited BAM Assessor – BAAS19000). The report was reviewed by Mark Aitkens (Accredited BAM Assessor BAAS17034).

Fieldwork was undertaken by Dan Creevey, Hayden Beck, Rhys Corrigan, Tara Boreham and John Hembra.

2.2 Qualifications

Academic qualifications and professional experience of key RPS staff involved in the documentation are provided in **Appendix A**.

3 METHODOLOGY

Investigation methods, including desktop information sources and survey methods, are detailed in the following sections.

3.1 Desktop Assessment

3.1.1 Databases

Relevant information was reviewed to gain an understanding of the biodiversity values occurring or potentially occurring within the Project Area. Information sources reviewed within 10 km of the Project Area (i.e. locality) were:

- BAM-C candidate species output (BAM-C; accessed June 2021);
- Flora and Fauna records contained in NSW BioNet Atlas (DPIE 2021a; accessed June 2021); and
- Flora and Fauna records contained in the EPBC Act Protected Matters Search tool (DAWE 2021a; accessed June 2021; **Appendix B**).

A preliminary LoO was produced from this information to provide a framework for determining investigation methods necessary for performing adequate site investigations.

3.1.2 Spatial Datasets

Desktop analysis of vegetation cover including a review of the resources listed below:

- Lake Macquarie Native Vegetation Community Mapping (Bell and Driscoll 2016a; Bell and Driscoll 2016b; Bell 2016c);
- Natural Vegetation of the Wyong Local Government Area (Bell 2002);
- Mitchell Landscapes (NPWS 2003a);
- IBRA Region and subregion mapping (IBRA7); and
- Recent aerial imagery of the Project Area.

3.1.3 Literature

Previous reports that considered the occurrence of threatened species or ecological communities within the Project Area and or Locality were reviewed. These information sources included:

- RPS (2013) Mandalong Southern Extension Project;
- RPS (2016) Mandalong Transmission Line TL24 Relocation Project;
- RPS (2018a) Mandalong 33kv Transmission Easement BDAR and BIR;
- RPS (2019a) Mandalong Mine Substation BDAR and BIR;
- RPS (2018b, 2019b and 2020a) Mandalong LW22-29 annual ecological monitoring;
- RPS (2019c and 2020b) Mandalong LW30-33 Baseline data collection; and
- RPS (2020c) Mandalong MOD 10 Version 1 Ecological Surveys.

Commercially available aerial imagery, regional mapping and literature was also explored to identify areas of potential biodiversity value in the Project Area. Information sources included:

- Aerial Photograph Interpretation (API) to prepare preliminary vegetation mapping for the Project Area;
- Bell S.A. (2002) The natural vegetation of the Wyong Local Government Area, Central Coast, New South Wales: Technical Report. Unpublished Final Report to Wyong Shire Council, August 2002. East Coast Flora Survey;

- Bell S. A. (2016) Conversion Lake Macquarie Native Vegetation Community Map Units to Plant Community Types (PCTs) March 2016. Accessed October2020 https://lakemac.com.au/page.aspx?pid=109&vid=25&fid=138&ftype=FGrp
- Bell S. A. and Driscoll C (2016a) Volume 1: Vegetation Mapping Report, Lake Macquarie Local Government Area Stages 1 – 6. Unpublished report prepared by East Coast Flora Survey for Lake Macquarie City Council https://www.lakemac.com.au/files/assets/public/development/native-vegetation-community-map-report.pdf
- Bell S. A. and Driscoll C (2016b) Volume 2: Vegetation Community Profiles, Lake Macquarie Local Government Area. Unpublished report prepared by East Coast Flora Survey for Lake Macquarie City Council https://www.lakemac.com.au/files/assets/public/development/native-vegetation-community-profiles.pdf
- Department of Land and Water Conservation (2002) NSW State Groundwater Dependent Ecosystem Policy;
- Eamus D. (2009) Identifying groundwater dependent ecosystems, A guide for land and water managers. Australian Government – Land and Water Australia;
- LMCC (2015) Lake Macquarie Native Vegetation and Corridors Map;
- NPWS (2003b) Lower Hunter and Central Coast Regional Environment Management Strategy Vegetation Survey, Classification and Mapping; Lower Hunter and Central Coast Region (LHCCREMS);
- A review of Geographic Information System (GIS) data including (but not limited to) aerial photography, topographic maps, SEPP 14 Wetland Mapping, Soil Landscapes and Acid Sulphate Soil Potential; and
- Collective knowledge gained within the RPS team from extensive fieldwork throughout the Mandalong South Extension Area.

3.1.4 Likelihood of Occurrence

A list of threatened species, populations and ecological communities (collectively referred to as 'threatened biodiversity') identified as potentially occurring in the Project Area was compiled through a Likelihood of Occurrence Analysis (LoO; **Appendix C**). Criteria the LoO was assessed is provided in **Table 3-1**.

Table 3-1 Likelihood of Occurrence criteria

Likelihood	Description
None	Species specific habitat types (i.e. important habitat features) and known vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are absent from the Study Area. The Study Area is also likely located outside the species known 'area of occurrence' and may also occur outside the species 'extent of occurrence' [i.e. standard grid size of 2x2 km (IUCN 2017)]. Species incidence is not expected and, if detected, would likely represent atypical occurrence (e.g. incidence linked with transient activity). Presence unlikely associated with habitat occupancy involving important lifecycle processes.
Low	Vegetation classification-based habitat surrogates (i.e. PCT and/ or vegetation formations) are present; however, species specific habitat types (i.e. important habitat features) are either absent, in low abundance and/ or in a disturbed state. The Study Area is likely to be located outside the species known 'area of occurrence' but may be within the known 'extent of occurrence' [i.e. standard grid size of 2x2 km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are likely to be negatively influencing the likelihood of habitat occupancy. If detected, species activity is most likely low and associated with landscape scale habitat use such as movement between areas of higher value habitat, the use of supplementary habitat or reflect the negative effects of active/ uncontrolled KTPs.
Moderate	Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Study Area. The Study Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy.
High	Habitat values within the Study Area are generally consistent with descriptions provided in the BCD TSPD. Habitat is likely to be located within the known 'extent of occurrence' and 'area of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are unlikely to adversely influence the capacity of the species to occupy the habitat. Pre-

Likelihood	Description
	existing and active KTPs are unlikely to be substantially influencing species incidence and/ or habitat occupancy.
Known	Species observed and habitat values within the Study Area are generally consistent with descriptions provided in the BCD TSPD. Habitat is located within known 'extent of occurrence' and 'area of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Habitat occupancy is likely to be associated with important life cycle processes; however, the reliance on this habitat would depend on additional factors (e.g. size and extent of local population, effect of KTPs).

A preliminary LoO was performed prior to field surveys to guide investigation methods and effort. This was subsequently refined following the completion of field surveys.

As per BAM 2020, it was considered that a Candidate Species may only be dismissed from requiring survey when:

- presence is assumed;
- an expert report is prepared; or
- more appropriate local data is gained.

3.2 Flora Surveys

Flora surveys were conducted in accordance with the BAM, with the aim to identify the vegetation communities and quantify their integrity within the Project Area.

3.2.1 Vegetation Mapping

The Lake Macquarie Vegetation Community Mapping (Bell and Driscoll 2016a) and the Natural Vegetation of the Wyong Local Government Area Vegetation Community Mapping (Bell 2002) were consulted to construct a preliminary map of vegetation communities within the Project Area. Bell and Driscoll (2016a and b) and Bell (2002) were then used to update this vegetation map, following revision of the latest aerial photography (e.g. Google Earth™ 2020) prior to field surveys. Plant Community Types (PCTs) were assigned using the conversion table (i.e. prescribing PCTs to previously classified Mapping Units) by Bell (2016). Updates also included the assigning of notional condition classes, based on observed areas of differing vegetation condition within aerial photographs. Following field surveys, which ground-truthed the vegetation types and condition zones using Rapid Data Points (RDPs).

Data collected at each RDP used to map various important habitat features included:

- Tree and dominant understory species within a 10 m radius of the RDP including OEH (2017) diameter at breast height (DBH) classes; and
- Weed cover (measured as projected foliage cover).

Following the refinement of the vegetation map following this initial fieldwork, the PCT extents were calculated using Geographic Information System (GIS; ArcGIS™) to inform the minimum number of BAM plots required.

3.2.2 BAM Plots

Seventeen BAM plots were performed within the Project Area, measuring the composition, structure and functional components of the vegetation cover. The BAM plots were placed locations that best represented the vegetation zone being assessed. The locations of BAM plots in context to the revised vegetation mapping is provided in **Section 4.2**.

Data recorded in each plot included:

- One standard 20 x 20 m plot, to assess the composition and structure attributes, including trees, shrubs, grasses, forbs, ferns and other growth forms;
- One standard 20 x 50 m plot (1000 m^2) to assess the function attributes: number of large trees [i.e. > 50 cm Diameter at breast height (DBH)], stem size class, tree regeneration, length of fallen logs, high threat exotic vegetation cover and hollow-bearing trees; and

- Five 1 m^2 sub-plots to assess average litter cover for the plots.

The methods for collecting data from within a BAM plot are described in State of NSW (2020).

Note: due to design changes for MOD 10, there were changes in the extent of the Project Area, and so some plots undertaken fall outside the finalised Project Area. Nevertheless, these plots were considered representative of their respective Vegetation Zones within the Project Area, as they were consistent PCTs and condition states, whilst belonged to the same tract of contiguous vegetation.

3.2.3 Quality Control

To ensure the floristic data collected were reliable, all BAM plots were undertaken by teams of two ecologists, with an in-depth understanding of native vegetation within the Central Coast region. Where there was uncertainty identifying a species, a specimen (i.e. leaves, buds, fruit and or flowers) were collected and later identified using relevant guides and keys (including PlantNET; National Herbarium of NSW 2021). In cases where further resolution was required, samples were sent to the National Herbarium of NSW for identification.

When estimating vegetation cover and abundance, these variables were independently assessed by the two observers. If a disparity occurred, the observers discussed the value in question until an agreement was reached to control for observer bias.

As a further quality control measure, RPS senior staff conducted training sessions and routinely checked floristic, cover and abundance data collected within BAM plots for accuracy. All data electronically entered are also subject to internal quality control audits.

3.2.4 Targeted Flora Surveys

Direct impacts from the Project on biodiversity were considered those potentially associated with increased ponding due to predicted subsidence from longwall mining; as modelled by Umwelt (2021). In the case that subsidence increases ponding within the Project Area, habitats may be altered by expanding areas of inundation or water logging. This has potential to impact threatened species by inundating their habitat in areas within low-lying depressions, often nearby areas currently subject to pooled water during periods of prolonged rainfall. Hence, surveys focused primarily on riparian areas due to the potential for ponding-related impacts associated with subsidence resulting from the Project.

Targeted flora searches were conducted with the aim of locating threatened flora species identified as Candidate Species (Species credits; BC Act) or those having moderate or greater likelihood of occurrence within the targeted survey area of the Project Area. Specific emphasis was given to those threatened plants that may occur in riparian areas, due to their potential to be impacted by ponding. Targeted searches were conducted by teams of two Ecologists, using parallel transects. Surveys were performed with reference to the methods, timing and effort provided by DPIE (2020a). The locations and timing of the targeted flora searches are shown on **Figure 3-1**.

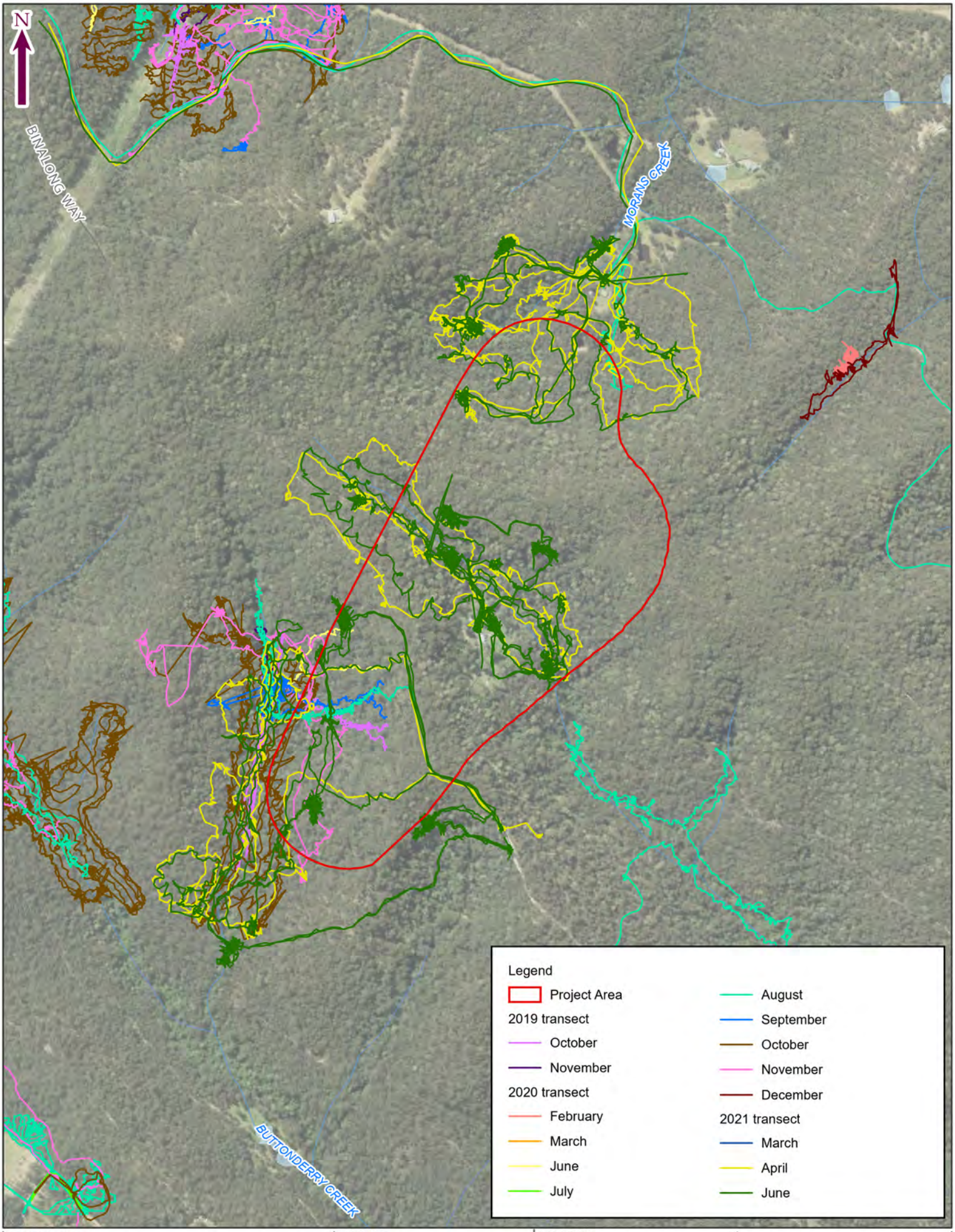


FIGURE 3-1
TARGETED FLORA SEARCHES

VERSION:
A
DATE EXPORTED:
13/07/2021 4:52 PM
TECHNICIAN:
Robert.Suansri

LOCATION:
Mandalong

DATA SOURCES
Centennial, RPS, © Department of Customer Service 2020

0 100 200 300 m

SCALE 1:10,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**
PROJ: **149823**
PURPOSE: **BIR**

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Project path: S:\Centennial\All Jobs\149823 Mandalong Revised MOD 10 BDAR\10 - Drafting\149823_Mandalong_MOD10_BIR_figures.aprx

3.3 Fauna Surveys

As the Project Area is connected to contiguous bushland (and associated habitat for threatened species), previous survey efforts undertaken by RPS within five years of this report, across the Assessment and considered relevant to the Project are reported here. Nevertheless, for the purpose of this assessment, survey results pertaining to areas that may be subjected to ponding (i.e. direct impacts) were given emphasis due to implications for offsetting requirements as part of the BDAR, as per the rationale outlined in **Section 3.2.4**.

Field survey methods, timing and effort used in this investigation were guided by results from the desktop assessment (i.e. identification of threatened fauna species listed under the BC Act and/or EPBC Act that may occur within the refined survey Project Area) and initial BAM-C output.

Survey techniques performed in this investigation are outlined below and included spotlighting and a herpetofauna census. These locations are shown in **Figure 3-2**. Adequacy of the survey effort, in terms of spatial and temporal representativeness against DPIE guidelines, is assessed in **Section 4.1.5**.

3.3.1 Anabat surveys

Candidate Species Targeted: Large-eared Pied Bat (*Chalinolobus dwyeri*); Little Bent-wing bat (*Miniopterus australis*); Large Bent-wing bat (*Miniopterus schreibersii oceanensis*), Southern Myotis (*Myotis macropus*) and *Vespadelus troughtoni* (Eastern Cave Bat)

Microbat echolocation calls were recorded using Anabat Express Detector units set to remotely record for the entire night inclusive of civil twilight hours (recording period based on GPS location and time of year). Units were set-up at the entrance of caves found to offer potential maternity roost habitat, as determined through cave surveys (see **Section 3.3.8.2**). In total, Anabat units were set-up for two days at six locations for two nights at each.

Bat call analysis was undertaken by Fly-by-night Bat Surveys. Each call sequence ('pass') was assigned to one of two categories, according to the confidence with which identification could be made, being:

- Pass identified to species level and could not be confused with another species; or
- Probable - Pass identified to species level and there is a low chance of confusion with another species.

Two units were established within the Project Area, with an additional four positioned nearby, in bushland adjoining the Project Area. Each unit was set for two nights.

3.3.2 Camera trap surveys

Candidate Species Targeted: *Petaurus norfolcensis* (Squirrel Glider), *Cercartetus nanus* (Eastern Pygmy-possum); *Phascogale tapoatafa* (Brush-tailed Phascogale); *Planigale maculata* (Common Planigale); and *Macropus parma* (Parma Wallaby)

Terrestrial camera traps were located at ground level to sample for ground-dwelling mammals, including small-medium mammals, such as wallabies, dasyurids (e.g. Antechinus and Dunnarts), rodents (e.g. rats and mice) and bandicoots. Feral animals were also captured using this method (e.g. wild dogs, foxes and cats). These camera traps were baited with a rolled oats mixture.

Two units were established within the Project Area, with an additional four positioned nearby, in bushland adjoining the Project Area. Each unit was set for four nights.

3.3.3 Elliot trap surveys

Candidate Species Targeted: *Petaurus norfolcensis* (Squirrel Glider), *Cercartetus nanus* (Eastern Pygmy-possum); *Phascogale tapoatafa* (Brush-tailed Phascogale)

Arboreal trapping was undertaken using tree mounted Elliott A size traps. Traps were mounted on brackets set at approximately 3 m in height on trees with a diameter at breast height (DBH) greater than 30 cm. Traps were baited with rolled oats, peanut butter and honey mixture, and the tree trunks were sprayed liberally with a brown sugar and water mix each day in the late afternoon. Traps were checked early the following morning. One transect, consisting of six arboreal Elliott A traps, was established adjacent to the Project Area

as part of baseline surveys for LW25-29). These traps were set for four nights; totalling 24 arboreal Elliott A trap nights. All Elliott traps were all positioned in bushland adjoining the Project Area.

3.3.4 Spotlighting

Candidate Species Targeted: *Cercartetus nanus* (Eastern Pygmy-possum); *Hoplocephalus bitorquatus* (Pale-headed Snake); *Hoplocephalus stephensii* (Stephens' Banded Snake); *Macropus parma* (Parma Wallaby); *Petaurus norfolcensis* (Squirrel Glider); *Phascolarctos cinereus* (Koala); *Planigale maculata* (Common Planigale); *Potorous tridactylus* (Long-nosed Potoroo); *Pteropus poliocephalus* (Grey-headed Flying-fox); and *Turnix maculosus* (Red-backed Button-quail)

Spotlighting was undertaken using a 75-watt hand-held spotlight and head torch whilst walking across the Project Area, targeting areas of appropriate habitat. Eight evenings of spotlighting were undertaken; four that extended both within and adjacent to the Project Area, and four evenings surveys adjacent to the Project Area only. Each survey effort was undertaken over 2 to 4 hours.

3.3.5 Identification of diurnal bird nest trees/ Grey-headed Flying-fox roosts

Candidate Species Targeted: Square Tailed Kite; White-bellied Sea Eagle and Grey-headed Flying-fox

Coinciding with threatened flora survey transects (**Section 3.2.4**) and habitat tree surveys (**Section 3.3.8.1**), surveys were undertaken to detect nesting/ roosting of threatened diurnal birds and selected mammal species. During this survey effort, any nests and or utilised hollows were observed from ground-level on foot to identify nesting/ roosting activity.

3.3.6 Herpetofauna Census

Candidate Species Targeted: *Litoria littlejohni* (Littlejohn's Tree Frog), *Pseudophryne australis* (Red-crowned Toadlet), *Crinia tinnula* (Wallum Froglet), *Litoria aurea* (Green and Golden Bell Frog), *Litoria brevipalmata* (Green-thighed Frog), *Mixophyes iteratus* (Giant Barred Frog) and *Uperoleia mahonyi* (Mahony's Toadlet)

Herpetofauna (frog and reptile) searches undertaken targeting areas of appropriate habitat and focusing on areas of predicted impact (i.e. riparian areas).

Note that for the Green-Thighed Frog (*Litoria brevipalmata*), surveys are required following heavy rainfall, which is required to generate the pooling of water to instigate breeding (DECC 2009). DPIE (2020b) notes that this occurs typically when rainfall is >50 mm in 24 hrs. This criterion was met prior to surveys which were conducted on 26th October 2020, with pooling within and nearby the Project Area shown in **Plate 3-1**. **Table 3-2** shows the rainfall over the survey period.



Plate 3-1 Pooling of water during frog survey on 26 October 2020

Table 3-2 Rainfall during amphibian surveys

Date	Rainfall in 24hrs (mm)	Cumulative rainfall in 72hrs (mm)	Survey inside Project Area	Survey adjacent Project Area
21 January 2020	1.2	1.4	Yes	Yes
22 January 2020	3.4	4.6	-	Yes
25 March 2020	0	2.0	Yes	Yes
26 October 2020[1]	62.8	101.2	-	Yes
2 November 2020	3.6	3.6	-	Yes
4 November 2020	0	3.6	Yes	Yes

1. Rainfall was sufficient to allow for a representative survey for *L. brevipalmata* (Green Thighed Frog).

3.3.7 Secondary Indications and Incidental Observations

Opportunistic sightings of secondary indications (scratches, scats, diggings, tracks etc.) of resident fauna were noted. Such indicators included:

- Distinctive scats left by mammals;
- Scratch marks made by various types of arboreal animals;
- Nests made by various guilds of birds;
- Feeding scars on Eucalyptus trees made by Gliders;
- Whitewash, regurgitation pellets and prey remains from Owls;
- Aural recognition of bird and frog calls;
- Skeletal material of vertebrate fauna; and
- Chewed *Allocasuarina* spp. cones - indicative of feeding by Glossy Black-cockatoo (*Calyptorhynchus lathami*).

3.3.8 Habitat Survey

Habitat surveys were undertaken to assess the condition and value of habitat across the Project Area. Significant fauna habitat features, including hollow-bearing trees (HBT), hollow logs and termite nests, were identified and noted. The assessment also considered the potential value of the Project Area (and surrounds) for all major guilds of native flora and fauna.

Habitat assessments for threatened species, known to occur or likely to occur in the locality, were undertaken to identify any specific habitat requirements for threatened fauna species within the Project Area. Habitat parameters taken into consideration included: home range, feeding, roosting, breeding, movement patterns and corridor requirements. Factors considered include topography, soil, light and hydrology.

3.3.8.1 Habitat tree survey

Targeted HBT surveys were undertaken to identify the presence of potential habitat for hollow-associated threatened fauna habitat within or nearby areas predicted to be impacted by subsidence-related ponding. That is, all hollow-bearing trees within 100 m of creeklines (i.e. identified as predicted to have ponding related impacts) were marked by GPS. To allow identification of the potential habitat provided to threatened fauna, the characteristics of the hollows were also noted, including the number and size of the hollows.

3.3.8.2 Cave survey

To identify the potential for breeding roosts for threatened microbats, suitable cave structures were surveyed across the Project Area. Focus was given to marking up of caves located toward riparian areas, where ponding related impacts associated with mining are proposed. A desktop assessment was firstly undertaken to identify areas with potential caves; focusing on areas with steep topography and or areas marked up

during an archaeological survey for potential shelter locations using by the First Nations People. These areas were then traversed on foot, with each suitable cave structure marked on GPS. The following attributes were also recorded for each cave:

- Cliff height/ slope;
- Fissures (maximum width; maximum depth; length);
- Cave/ overhang (maximum width; maximum height; length);
- Area of honeycombing;
- Presence of bat scats;
- Bat species/ numbers; and
- Signs of other species use.

3.4 Survey Dates and Weather Conditions

Weather conditions and timing of tasks undertaken during flora and fauna surveys relevant to the Project Area are provided in **Table 3-3**. Weather information was accessed from Cooranbong (station numbers 61412) at Latitude 33.09° S, Longitude 151.46° E, and 10 m ASL elevation. Data was also supplemented with a nearby station (061014) (BOM 2021a). The weather station is approximately 11 km to the northeast of the Project Area.

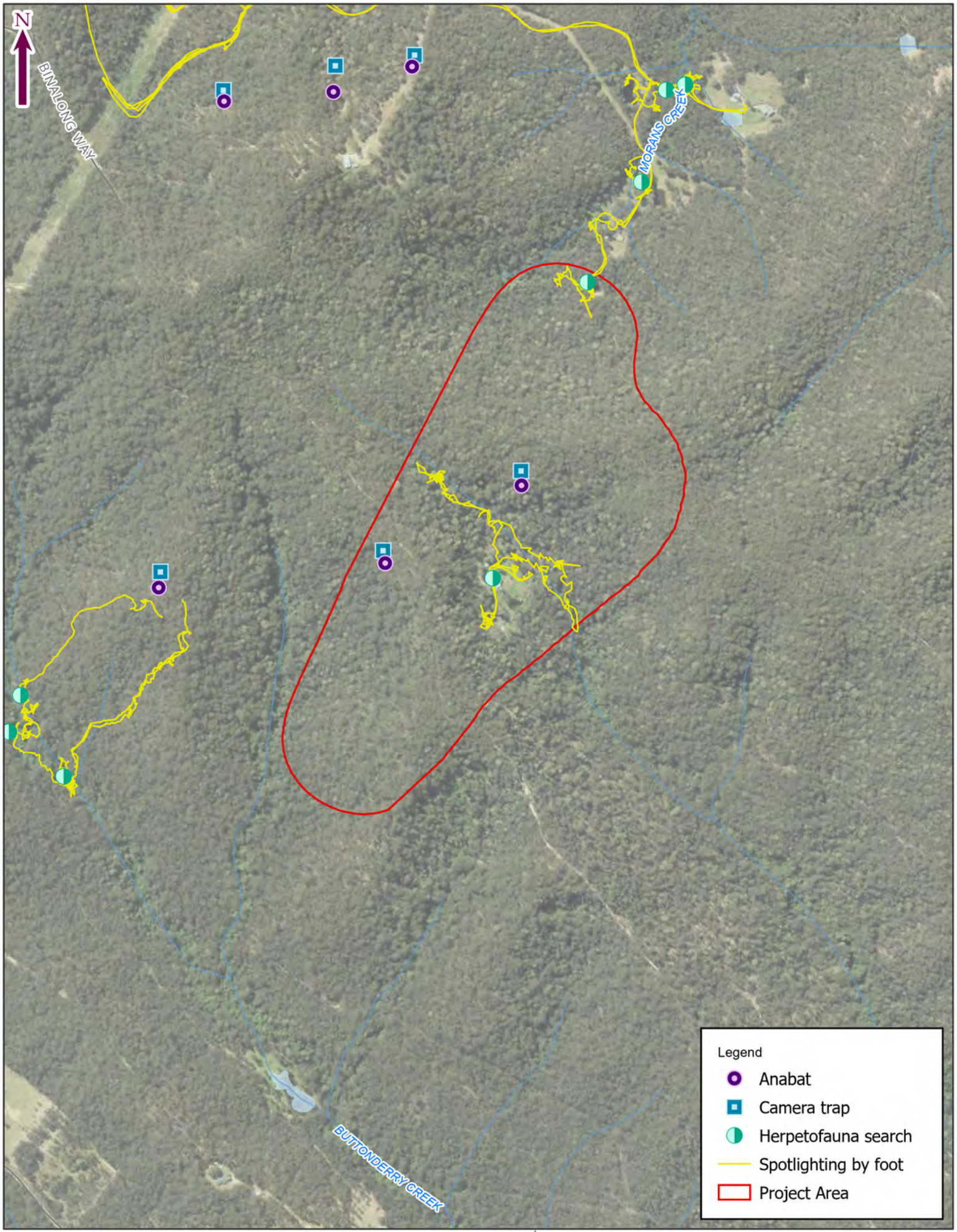


FIGURE 3-2
FAUNA SURVEY EFFORT

VERSION:
A
DATE EXPORTED:
13/07/2021 4:51 PM
TECHNICIAN:
Robert.Suansri

LOCATION:
Mandalong

DATA SOURCES
Centennial, RPS, © Department of Customer Service 2020

0 100 200 300 m

SCALE 1:10,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**
PROJ: **149823**
PURPOSE: **BIR**

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Table 3-3 Weather conditions during survey period

Date	Min Temp (°C)	Max Temp (°C)	Rainfall (mm)	Max wind speed and direction	Task	Survey inside Project Area	Survey adjacent Project Area
21 Jan 2019	NA	NA	NA	NA	Elliott trapping/ bird survey	-	Yes
22 Jan 2019	NA	NA	NA	NA	Elliott trapping/ bird survey	-	Yes
23 Jan 2019	NA	NA	NA	NA	Elliott trapping/ bird survey	-	Yes
24 Jan 2019	NA	NA	NA	NA	Elliott trapping/ bird survey	-	Yes
24 Sep 2019	NA	NA	NA	NA	BAM Plot Surveys	Yes	Yes
23 Oct 2019	11.1	24.7	0	ESE @ 28km/hr	BAM Plot Surveys	-	Yes
24 Oct 2019	NA	NA	NA	NA	BAM Plot Surveys	Yes	Yes
25 Oct 2019	12.3	34.9	0.2	N @ 41km/hr	BAM Plot Surveys	-	Yes
21 Jan 2020	16.0	34.5	0.6	W @ 35 km/hr	Aural/visual Frog survey/ Spotlight	Yes	Yes
22 Jan 2020	18.7	32.9	0	ESE @ 33 km/hr	Aural/visual Frog survey/ Spotlight	-	Yes
24 Mar 2020	NA	NA	NA	NA	Aural/visual Frog survey/ BAM Plot Surveys	-	Yes
25 Mar 2020	13.7	24.5	0	WNW @ 28 km/hr	Aural/visual Frog survey/ Spotlight	Yes	Yes
19 May 2020	NA	NA	NA	NA	BAM Plot Surveys/ Threatened Flora survey	Yes	Yes
16 Jun 2020	4.1	21.0	0	NNW @ 19km/hr	BAM Plot Surveys/ RDPs/ Threatened Flora survey	-	Yes
17 Jun 2020	4.0	19.4	0.2	SSE @ 24km/hr	BAM Plot Surveys/ RDPs/ Threatened Flora survey	-	Yes
19 Jun 2020	7.2	19.7	0.2	N @ 17 km/hr	BAM Plot Surveys/ RDPs/ Threatened Flora survey	-	Yes
6 Aug 2020	3.5	16.3	0	WNW @ 28km/hr	BAM Plot Surveys/ RDPs/ Threatened Flora survey	Yes	Yes
12 Aug 2020	7.3	17.5	0.2	ESE @ 19km/hr	BAM Plot Surveys	-	Yes
3 Sep 2020	8.0	28.1	0	NNW @ 44km/hr	BAM Plot Surveys/ RDPs	Yes	Yes
4 Sep 2020	18.9	25.4	0	NW @ 31 km/hr	BAM Plot Surveys	-	Yes
11 Sep 2020	7.8	19.6	1.2	ESE @ 28 km/hr	BAM Plot Surveys	-	Yes
6 Oct 2020	14.6	21.0	0	S @ 30 km/hr	Threatened Flora survey	-	Yes
7 Oct 2020	16.8	22.9	0	E @ 17 km/hr	Threatened Flora survey	Yes	Yes
8 Oct 2020	15.0	31.1	0.4	WNW @ 44 km/hr	Threatened Flora survey	Yes	Yes
25 Oct 2020	14.4	16.6	14.6	S @ 22 km/hr	Threatened Flora survey	Yes	Yes
26 Oct 2020	13.1	15.7	62.8	SSE @ 43 km/hr	Aural/visual Frog survey/ Spotlight	-	Yes
27 Oct 2020	13.1	20.3	23.8	SSW @ 24 km/hr	Threatened Flora survey	-	Yes

Date	Min Temp (°C)	Max Temp (°C)	Rainfall (mm)	Max wind speed and direction	Task	Survey inside Project Area	Survey adjacent Project Area
2 Nov 2020	15.2	22.6	3.6	S @ 31 km/hr	Aural/visual Frog survey/ Spotlight	-	Yes
3 Nov 2020	9.9	22.1	0	ESE @ 26 km/hr	Cave survey/ Spotlight/ BAM Plot survey/ Threatened Flora survey	Yes	Yes
4 Nov 2020	8.7	25.5	0	E @ 24 km/hr	Cave survey/ Threatened Flora survey/ Spotlight/ Aural/visual Frog survey	Yes	Yes
5 Nov 2020	14.3	20.6	0	WSW @ 30 km/hr	Cave survey	Yes	Yes
6 Nov 2020	13.1	21.1	21.6	SW @ 37 km/hr	Cave survey	Yes	Yes
11 Jan 2021	13.5	26.7	0	E @ 31 km/hr	Anabat and camera trap surveys	Yes	Yes
12 Jan 2021	13.5	28.7	0	ESE @ 26 km/hr	Anabat and camera trap surveys	Yes	Yes
13 Jan 2021	15.4	27.9	0	E @ 37 km/hr	Anabat and camera trap surveys	Yes	Yes
14 Jan 2021	16.5	35.4	0	N @ 24 km/hr	Anabat and camera trap surveys	Yes	Yes
2 Mar 2021	20.2	32.3	0	N @ 19 km/hr	BAM Plot and Threatened Flora survey	Yes	Yes
15 June 2021	4.5	20.0	0	ESE @ 15 km/hr	Threatened Flora survey	Yes	-
16 June 2021	2.3	20.4	0	N @ 24 km/hr	Threatened Flora survey	Yes	-
17 June 2021	4.8	17.8	0.4	W @ 44 km/hr	Threatened Flora survey	Yes	-
18 June 2021	8.3	19.2	0	W @ 37 km/hr	Threatened Flora survey	Yes	-
21 June 2021	8.0	18.4	2.0	SW @ 22 km/hr	BAM plots	Yes	-
22 June 2021	8.2	17.0	0.2	SE @ 11 km/hr	BAM plots	Yes	-
23 June 2021	5.8	19.6	2.2	NNE @ 13 km/hr	BAM plots	Yes	-
24 June 2021	10.6	22.1	0.2	NNE @ 29 km/hr	BAM plots	Yes	-

3.5 Limitations

Limitations associated with this assessment are presented in the following sections. The limitations have been considered specifically in relation to threatened species assessments, results and conclusions.

3.5.1 Seasonality

Some plant species that occur in the local area, such as cryptic species, are annuals and are present only in the seed bank for much of the year. Other plant species are perennial but are inconspicuous or difficult to identify unless flowering.

Similarly, some fauna species have potential to occur on a seasonal, vagrant or migratory basis and may be absent from the locality for much for the year. Fauna species that are easily disturbed or cryptic may not have been detected. Hence, it is possible that several flora and fauna species occurring in the Project Area were not detected in the current survey due to the above factors.

These potential limitations have been minimised by literature research, through identification of potential habitats for flora and fauna species. Assessment of the potential for targeted species to occur on the Project Area based on:

- Results for field surveys undertaken in adjacent, contiguous bushland;
- The type and condition of habitats present;
- The land use throughout the Project Area and surrounds; and
- The landscape context.

The precautionary principle (assumed presence) was applied where suitable habitat was identified and survey was not performed adequately to discount presence or species were predicted to use habitat components (i.e. food, shelter and or living space) at some stage during their life cycle.

3.5.2 Data Availability and Accuracy

The collated threatened flora and fauna species records provided by NSW BioNet Atlas for the region are known to vary in accuracy and reliability. Traditionally, this is due to the reliability of information provided to the NSW BioNet Atlas (DPIE 2021a) for collation and/or the need to protect specific threatened species locations. For the purposes of this report, threatened species records were considered to have an accuracy of ± 1 km, up to 2 km for more sensitive records.

Threatened flora and fauna records within the region were predominantly sourced from the NSW BioNet Atlas (DPIE 2021a) and an EPBC Act Protected Matters Search Tool (DAWE 2021a). Similar limitations are known to exist with regards to these data sources and their accuracy.

A Trimble Differential GPS unit was used by RPS to record data in field survey. This unit is capable of sub-metre accuracy following post processing, however accuracy of <5 m is more typically achieved.

4 RESULTS

4.1 Desktop Assessment

4.1.1 Database Interrogation

Database search results (DPIE 2021a; DAWE 2021a) identified 33 threatened flora and 68 threatened or migratory fauna species with the potential to occur within the locality. A comprehensive list of threatened species, including their habitat types, is provided in **Appendix C**.

A summary of the threatened or migratory species with a moderate or greater likelihood of occurrence based on DPIE database search, literature review, EPBC Protected Matters Search Tool and BAM-C output is provided in **Table 4-1**. Note that this threatened species list was refined to consider the potential to occur within riparian areas, due to the ponding-related impacts that may occur with the Project (note that this rationale is detailed further in **Section 3.2.4**).

Table 4-1 Threatened Species with 'moderate' or greater likelihood of occurrence

Scientific Name	Common Name	BC Act	EPBC Act	Sensitive to ponding-related impact
Fauna				
Anthochaera phrygia	Regent Honeyeater	CE	CE	No
Callocephalon fimbriatum	Gang-gang Cockatoo	V	-	No
Litoria brevipalmata	Green-thighed Frog	V	-	Yes
Flora				
Asperula aesthenes	Trailing Woodruff	V	V	Yes
Corybas dowlingii	Red Helmet Orchid	E	-	Yes
Cryptostylis hunteriana	Leafless Tongue-orchid	V	V	Yes
Cynanchum elegans	White-flowered Wax Plant	E	E	Yes
Maundia triglochinoides	-	V	-	Yes
Melaleuca biconvexa	Biconvex Paperbark	V	V	Yes
Persicaria elatior	Tall Knotweed	V	V	Yes
Rhodamnia rubescens	Scrub Turpentine	CE	CE	Yes
Rhodomyrtus psidioides	Native Guava	CE	CE	Yes
Syzygium paniculatum	Magenta Lilly Pilly	E	V	Yes
Tetratheca juncea	Black-eyed Susan	V	V	Yes

Key: V: Vulnerable; E: Endangered; CE: Critically Endangered

4.1.2 Literature Review

Threatened species listed in **Table 4-2** have previously been detected in or near the Project Area.

Table 4-2 Previously detected threatened species

Scientific Name	Common Name	BC Act	EPBC Act	Source
Fauna				
Calyptorhynchus lathami	Glossy Black-Cockatoo	V	-	RPS (2013), RPS (2018)
Callocephalon fimbriatum	Gang-gang Cockatoo	V	-	RPS (2013)
Climacteris picumnus victoriae	Brown Treecreeper	V	-	RPS (2016)
Daphoenositta chrysoptera	Varied Sittella	V	-	RPS (2013)
Glossopsitta pusilla	Little Lorikeet	V	-	RPS (2013)
Litoria brevipalmata	Green-thighed Frog	V	-	RPS (2018)
Daphoenositta chrysoptera	Varied Sittella	V	-	RPS (2013)
Miniopterus australis	Little Bentwing-bat	V	-	RPS (2016), RPS (2018)
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	V	-	RPS (2018)
Mormopterus norfolkensis.	Eastern Freetail-bat	V	-	RPS (2016)
Ninox strenua	Powerful Owl	V	-	RPS (2013), RPS (2018)
Petaurus australis	Yellow-bellied Glider	V	-	RPS (2013)
Phoniscus papuensis.	Golden-tipped Bat	V	-	RPS (2013)
Pteropus poliocephalus;	Grey-headed Flying-fox	V	V	RPS (2013)
Flora				
Asperula aesthens	Trailing Woodruff	V	V	RPS (2020)
Corybas dowlingii	Red-helmet Orchid	V	-	RPS (2019)
Genoplesium insigne	Variable Midge Orchid	CE	CE	RPS (2020c)
Grevillea parviflora subsp. parviflora	Small-flowered Grevillea	V	V	RPS (2013), RPS (2018)
Maundia triglochinoides	-	V	-	RPS (2018)
Melaleuca biconvexa	Biconvex Paperbark	V	V	RPS (2013); RPS (2018)
Rhodamnia rubescens	Scrub Turpentine	CE	-	RPS (2019)
Tetratheca juncea	Black-eyed Susan	V	V	RPS (2013), RPS (2018)

4.1.3 Spatial Datasets

The Project Area is located within the Sydney Basin IBRA region and Wyong subregion (SYB06) and Gosford – Cooranbong Coastal Slopes Mitchell Landscape (NPWS 2003a). This is described as:

"Coastal fall of the Sydney Basin, rolling hills and sandstone plateau outliers of Triassic Narrabeen sandstones, extensive rock outcrop and low cliffs along ridge margins, general elevation 0 to 75 m. Texture-contrast soils on lithic sandstones and shales. Loamy sand alluvium along creeks. Organic sand and mud in lagoons and swamps. Open forest and woodland of smooth-barked apple (Angophora costata), red bloodwood (Corymbia gummifera), brown stringybark (Eucalyptus capitellata), Sydney peppermint (Eucalyptus piperita), spotted gum (Corymbia maculata), bastard mahogany (Eucalyptus carnea), northern grey ironbark (Eucalyptus siderophloia) and grey gum (Eucalyptus punctata) on hills and slopes. Small areas of closed forest with; turpentine (Syncarpia glomulifera), lilly pilly (Acmena smithii), mountain cedar wattle (Acacia elata), coachwood (Ceratopetalum apetalum), sassafras (Doryphora sassafras) and water gum (Tristaniopsis laurina) in gullies under high escarpments. Prickly-leaved tea-tree (Melaleuca stypheliodes) and other shrubs with swamp mahogany (Eucalyptus robusta), swamp oak (Casuarina glauca), sedges and common reed (Phragmites australis) on swampy creek flats. Coastal heath subject to salt spray on headlands" (NPWS 2003a).

Vegetation mapping and inspection of recent aerial photography indicates a limited amount of vegetation clearing within the locality resulting in a very large and generally continuous tract of native vegetation that extends to the Olney State Forest and further into the Great Dividing Range.

The Project Area is connected to surrounding vegetation with partial interruptions evident by way of unsealed tracks, fencing and cleared areas associated with the rural properties. Apart from some fenced boundaries and cleared areas associated with these rural areas, it is considered that movement of most fauna species through the Project Area should be largely unconstrained. Note that steep rises associated with the valley ridges may present some challenges to dispersal for some ground-dwelling species.

4.1.4 Candidate Species Survey Matrix – BAM Calculator

A refined candidate species list was used to focus survey efforts on threatened flora and fauna that may use habitat within the Project Area. This was constructed through entering the sub-bioregion, landscape and PCTs present into the BAM-C. A matrix indicating the required timing of surveys was then produced to inform survey requirements. Species and appropriate survey periods (i.e. grey shading) are provided in **Table 4-3**, with the timing of survey efforts indicated by a cross (i.e. ☒).

Table 4-3 Candidate species list and survey timing for PCT 1528, 1556, 1568 and 1573

Species Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Method (effort)	Survey adequacy
Callocephalon fimbriatum Gang-gang Cockatoo	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	NA	No
Calyptorhynchus lathami Glossy Black-Cockatoo	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	BC	Yes
Cercartetus nanus Eastern Pygmy-possum	☐	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	SL; CT	No
Chalinolobus dwyeri Large-eared Pied Bat	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	AB; HS	No
Corybas dowlingii Red Helmet Orchid	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	TFS	Yes
Cryptostylis hunteriana Leafless Tongue Orchid	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	NA	No
Cynanchum elegans White-flower Wax Plant	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	TFS	Yes
Haliaeetus leucogaster White-bellied Sea-Eagle	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	NA	No
Hoplocephalus bitorquatus Pale-headed Snake	☒	☐	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	SL	No
Hoplocephalus stephensii Stephens' Banded Snake	☒	☐	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	SL	No
Litoria aurea Green and Gold Bell Frog	☒	☐	☒	☐	☐	☐	☐	☐	☐	☐	☒	☐	FS	No
Litoria brevipalmata Green-thighed Frog	☒	☐	☒	☐	☐	☐	☐	☐	☐	☐	☒	☐	FS	No
Litoria littlejohni Littlejohn's Tree Frog	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	FS	No
Lophoictinia isura Square-tailed Kite	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	NA	No
Macropus parma Parma Wallaby	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	SL; CT	Yes
Melaleuca biconvexa Biconvex Paperbark	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	TFS	Yes

Species Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Method (effort)	Survey adequacy
Melaleuca groveana Grove's Paperbark	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	TFS	Yes
Miniopterus australis Little Bent-winged Bat	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	AS; HS	No
Miniopterus orianae oceanensis Large Bent-winged Bat	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	AS; HS	No
Mixophyes balbus Stuttering Frog	☒	☐	☒	☐	☐	☐	☐	☐	☐	☐	☒	☐	FS	No
Mixophyes iteratus Giant Barred Frog	☒	☐	☒	☐	☐	☐	☐	☐	☐	☐	☒	☐	FS	No
Myotis macropus Southern Myotis	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	AS; HS	No
Ninox connivens Barking Owl	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	HS	No
Ninox strenua Powerful Owl	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	HS	No
Petaurus norfolcensis Squirrel Glider	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	SL; CT	No
Petrogale penicillata Brush-tailed Rock-wallaby	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	SL; CT	Yes
Phascogale tapoatafa Brush-tailed Phascogale	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	SL; CT	No
Phascolarctos cinereus Koala	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	SL; CT	Yes
Planigale maculata Common Planigale	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	SL; CT	Yes
Potorous tridactylus Long-nosed Potoroo	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	SL; CT	Yes
Pteropus poliocephalus Grey-headed Flying-fox	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	SL	No
Rhizanthella slateri Eastern Australian Underground Orchid	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	NA	No
Rhodamnia rubescens Scrub Turpentine	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	TFS	Yes
Rhodomyrtus psidioides Native Guava	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	TFS	Yes
Tetratheca juncea Black-eyed Susan	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	NA	No
Turnix maculosus Red-backed Button-quail	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	SL; CT	Yes
Tyto novaehollandiae Masked Owl	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	HS	No
Tyto tenebricosa Sooty Owl	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	HS	No

Note: x indicates timing of survey effort. Methodology codes: AS = Anabat survey; BC = Bird Census; CT = Camera Trap; FS = Aural/visual Frog survey; SL = Spotlight; TFS = Threatened Flora Survey; NA = no targeted survey.

4.1.5 Survey adequacy

Targeted threatened species surveys were undertaken with an emphasis on species that were likely to be impacted by predicted ponding associated with the Project, as per the rational provided in **Section 3.2.4**.

Over the course of the Project, the AOD boundary was modified such that some survey efforts (e.g. Anabat and camera traps) were outside the final Project Area. However, it is considered that this survey effort was representative for the mobile target species with large home ranges, with suitable and belonging to a contiguous tract of vegetation that also includes the Project Area. Specifically, it was considered that the camera trap and spotlighting survey effort applied in adjacent bushland was representative of the following species with large home ranges: *Macropus parma* (Parma Wallaby); *Petrogale penicillata* (Brush-tailed Rock-wallaby); *Phascolarctos cinereus* (Koala); *Planigale maculata* (Common Planigale); and *Potorous tridactylus* (Long-nosed Potoroo). Additionally, survey effort was also considered representative of the following Candidate species:

- *Calyptorhynchus lathami* (Glossy Black-Cockatoo);
- *Corybas dowlingii* (Red Helmet Orchid);
- *Cynanchum elegans* (White-flower Wax Plant);
- *Melaleuca biconvexa* (Biconvex Paperbark);
- *Melaleuca groveana* (Grove's Paperbark);
- *Rhodamnia rubescens* (Scrub Turpentine); and
- *Rhodomyrtus psidioides* (Native Guava).

Survey effort was not considered to be representative of the following Candidate species, given the timing or spatiotemporal representation of sampling effort:

- *Callocephalon fimbriatum* (Gang-gang Cockatoo);
- *Cercartetus nanus* (Eastern Pygmy-possum);
- *Chalinolobus dwyeri* (Large-eared Pied Bat);
- *Cryptostylis hunteriana* (Leafless Tongue Orchid);
- *Haliaeetus leucogaster* (White-bellied Sea-Eagle);
- *Hoplocephalus bitorquatus* (Pale-headed Snake);
- *Hoplocephalus stephensii* (Stephens' Banded Snake);
- *Litoria brevipalmata* (Green-thighed Frog);
- *Litoria littlejohni* (Littlejohn's Tree Frog);
- *Lophoictinia isura* (Square-tailed Kite);
- *Miniopterus australis* (Little Bent-winged Bat);
- *Miniopterus orianae oceanensis* (Large Bent-winged Bat);
- *Mixophyes balbus* (Stuttering Frog);
- *Mixophyes iteratus* (Giant Barred Frog);
- *Myotis macropus* (Southern Myotis);
- *Ninox connivens* (Barking Owl);
- *Ninox strenua* (Powerful Owl);
- *Petaurus norfolcensis* (Squirrel Glider);
- *Phascogale tapoatafa* (Brush-tailed Phascogale);
- *Pteropus poliocephalus* (Grey-headed Flying-fox);
- *Rhizanthella slateri* (Eastern Australian Underground Orchid);

- *Tetratheca juncea* (Black-eyed Susan);
- *Tyto novaehollandiae* (Masked Owl); and
- *Tyto tenebricosa* (Sooty Owl).

To better inform the allocation of species polygons for the above species, habitat constraints (i.e. those species with DPIE recognised habitat niche requirements) were recorded for relevant species. These attributes were namely habitat trees (offering hollows of appropriate dimensions) and caves, with this approach detailed further in **Section 3.3.8**. Specifically, habitat constraints were recorded for:

- *Callocephalon fimbriatum* (Gang-gang Cockatoo; Habitat Tree Survey);
- *Chalinolobus dwyeri* (Large-eared Pied Bat; Cave Survey);
- *Miniopterus australis* (Little Bent-winged Bat; Cave Survey);
- *Miniopterus orianae oceanensis* (Large Bent-winged Bat; Cave Survey);
- *Myotis macropus* (Southern Myotis; Waterbodies >3 m in width; as informed by remnant ponding GIS data provided by Umwelt 2021);
- *Ninox connivens* (Barking Owl; Habitat Tree Survey);
- *Ninox strenua* (Powerful Owl; Habitat Tree Survey);
- *Tyto novaehollandiae* (Masked Owl; Habitat Tree Survey); and
- *Tyto tenebricosa* (Sooty Owl; Habitat Tree and Cave Survey).

4.2 Vegetation Cover

4.2.1 Plant Community Types (PCTs)

Five PCTs were located within the Project Area. These PCTs are listed in **Table 4-4** and are displayed in **Figure 4-1**.

Table 4-4 PCTs and condition classes within the Project Area

Zone	PCT	Condition	Project Area (ha)[1]	No. BAM plots undertaken	No. BAM plots required
1	1528 - Jackwood - Lilly Pilly - Sassafras riparian warm temperate rainforest of the Central Coast	Moderate/ Good	0.04	1	1
2	1556 - Tallowwood - Smooth-barked Apple - Blackbutt grass tall open forest of the Central and lower North Coast	Moderate	25.10	5	4
3	1568 - Blackbutt - Turpentine - Sydney Blue Gum mesic tall open forest on ranges of the Central Coast	Moderate	7.20	4	3
4	1573 - Sydney Blue Gum - Lilly Pilly mesic tall open forest of coastal ranges and tablelands escarpment	Moderate/ Good	2.48	2	2
5	1588 - Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast	Moderate	15.44	3	3
6	Cleared / Disturbed	Not native	1.92	2	1

1. Misalignment of listed Project Area size reported elsewhere and total areas in this table is due to rounding.

A description of this vegetation type is provided in **Sections 4.2.1.1** to **4.2.1.5**. BAM plot photographs and data are provided in **Appendix D** and **E**.

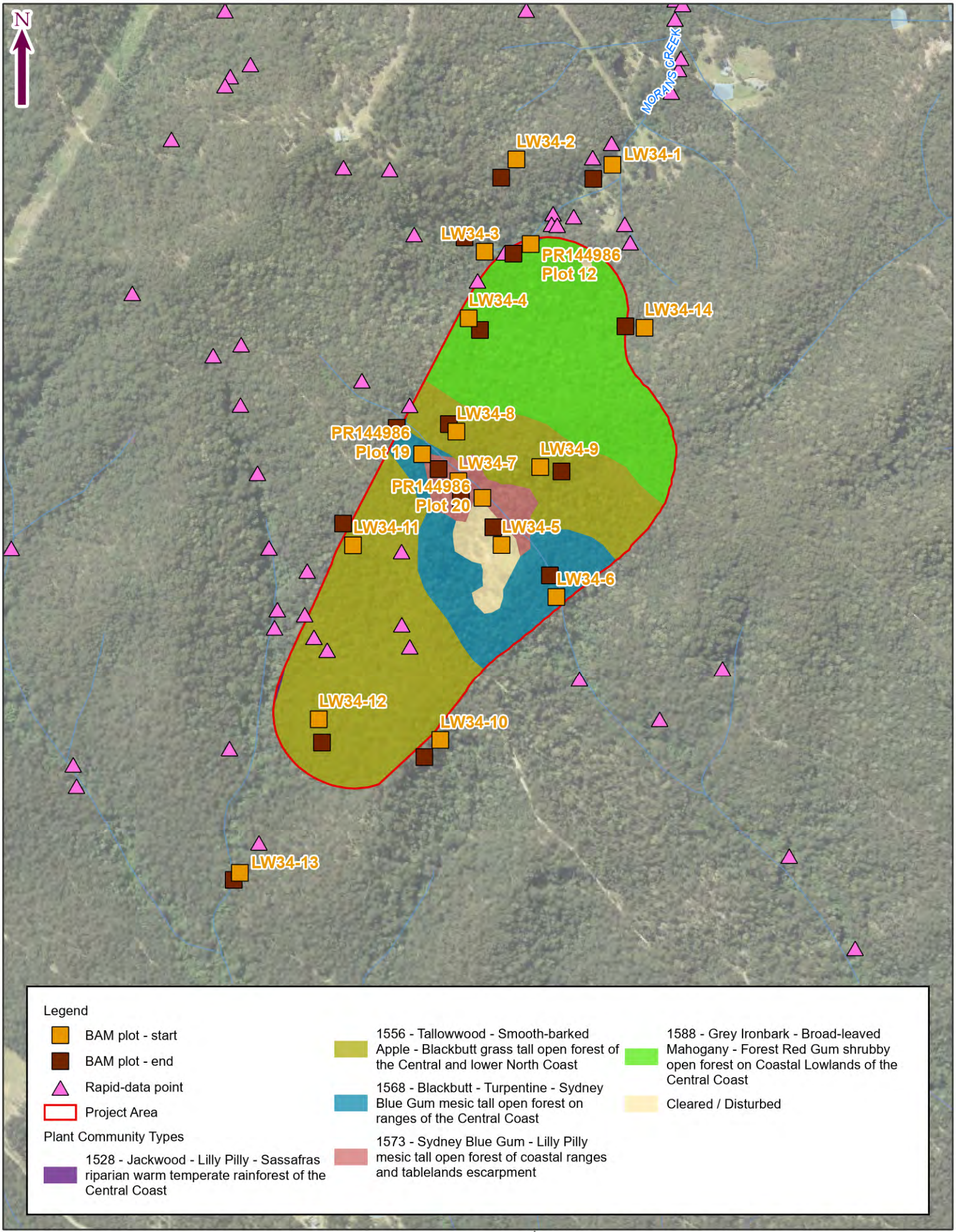


FIGURE 4-1
PLOT LOCATIONS AND VEGETATION COMMUNITIES

VERSION:
A
DATE EXPORTED:
13/08/2021 1:29 PM
TECHNICIAN:
Natalie.Wood

LOCATION:
Mandalong

0 100 200 300 m

DATA SOURCES
Centennial, RPS, © Department of Finance, Services & Innovation 2018

SCALE 1:10,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**
PROJ: **149823**
PURPOSE: **BIR**

IMPORTANT NOTE
1. This plan was prepared for the sole purposes of the client for the specific purpose of producing a photographic overlay plan. This plan is strictly limited to the Purpose and does not apply directly or indirectly and will not be used for any other application, purpose, use or matter. The plan is presented without the assumption of a duty of care to any other person (other than the Client) ("Third Party") and may not be relied on by Third Party.
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g. the accuracy, reliability, suitability or completeness of any approximations or estimates made or referred to by RPS Australia East Pty Ltd in this plan.

Project path: S:\Centennial\All Jobs\149823 Mandalong Revised MOD 10 BDAR\10 - Drafting\149823_Mandalong_MOD10_BIR_figures.aprx

4.2.1.1 1528 - Jackwood - Lilly Pilly - Sassafras riparian warm temperate rainforest of the Central Coast

Description:	Closed forests with a diverse canopy characterised by *Acmena smithii; Cryptocarya glaucescens* and *Doryphora sassafras.*
BAM Plot Number:	LW 34-3
Diagnostic upper stratum species:	*Acmena smithii, Cryptocarya glaucescens, Doryphora sassafras, Ceratopetalum apetalum, Ficus coronata, Planchonella australis, Alphitonia excelsa, Archontophoenix cunninghamiana* and *Eucalyptus saligna*
Diagnostics middle stratum species:	*Alectryon subcinereus, Neolitsea dealbata, Syzygium oleosum, Guioa semiglauca, Wilkiea huegeliana, Pittosporum multiflorum, Morinda jasminoides, Trophis scandens* and *Cissus antarctica*
Diagnostic ground stratum species:	*Lastreopsis microsora, Hypolepis muelleri, Gymnostachys anceps* and *Oplismenus imbecillis*
Classification:	This PCT corresponds with BC Act-listed Lowland Rainforest in the NSW North Coast and Sydney Basin Bioregions TEC. This PCT can correspond to Lowland Rainforest of Subtropical Australia (DAWE 2020b), but this vegetation is located too south to be classified as this EEC.
Condition:	This PCT occurs in one condition state (moderate) as indicated in **Plate 4-1**.



Plate 4-1 Jackwood - Lilly Pilly - Sassafras riparian warm temperate rainforest of the Central Coast

4.2.1.2 1556 - Tallowwood - Smooth-barked Apple - Blackbutt grass tall open forest of the Central and lower North Coast

Description: Open forests with a canopy dominated by *Eucalyptus microcorys.* The mid- storey consists of an open shrub layer and the ground layer is a dominated by grasses with various ferns; and forbs.

BAM Plot Number:	LW34-8; LW34-9; LW34-10; LW34-11; LW34-12
Diagnostic upper stratum species:	*Eucalyptus microcorys, Angophora costata* and *Eucalyptus pilularis*
Diagnostics middle stratum species:	*Allocasuarina torulosa, Polyscias sambucifolia, Persoonia linearis, Glochidion ferdinandi, Breynia oblongifolia* and *Dodonaea triquetra*
Diagnostic ground stratum species:	*Imperata cylindrica, Entolasia stricta, Themeda triandra, Dianella caerulea, Lomandra longifolia, Lepidosperma laterale, Pratia purpurascens, Glycine clandestine* and *Vernonia cinerea*
Classification:	Although this PCT can correspond with BC Act listed River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions TEC, vegetation within the Project Area was inconsistent with this TEC since it was not positioned on a river flat of the coastal floodplain. That is, river flats are typically level landforms that occur below 20 m ASL (DECC 2007b), whilst the lowest point of the Project Area is approximately 50 m ASL with typically steep terrain. This PCT does not correspond to any EPBC Act listed TEC.
Condition:	This PCT occurs in one condition state (moderate) as indicated in **Plate 4-2**.



Plate 4-2 Tallowwood - Smooth-barked Apple - Blackbutt grass tall open forest of the Central and lower North Coast

4.2.1.3 1568 - Blackbutt - Turpentine - Sydney Blue Gum mesic tall open forest on ranges of the Central Coast

Description:	All open forests to open forests with a canopy dominated by *Syncarpia glomulifera* and *Eucalyptus pilularis*. The mid-storey is semi-mesic and includes diverse small trees and shrubs along with climbers. The ground layer is dominated by ferns.
BAM Plot Number:	LW 34-6; LW 34-13; PR144986 Plot 12; PR144986 Plot 19
Diagnostic upper stratum species:	*Eucalyptus pilularis, Syncarpia glomulifera; Eucalyptus saligna* and *Eucalyptus acmenoides*
Diagnostics middle stratum species:	*Cryptocarya microneura, Synoum glandulosum, Wilkiea huegeliana, Acmena smithii, Pittosporum revolutum, Glochidion ferdinandi, Livistona australis, Guioa semiglauca, Rhodamnia rubescens, Notelaea longifolia, Dioscorea transversa* and *Pandorea pandorana*
Diagnostic ground stratum species:	*Blechnum cartilagineum, Doodia aspera, Calochlaena dubia, Gymnostachys anceps* and *Dianella caerulea*
Classification:	This PCT does not correspond to any BC Act or EPBC Act listed TEC.
Condition:	This PCT occurs in one condition state (moderate) as indicated in **Plate 4-3**.



Plate 4-3 Blackbutt - Turpentine - Sydney Blue Gum mesic tall open forest on ranges of the Central Coast (Moderate condition)

4.2.1.4 1573 – Sydney Blue Gum – Lilly Pilly mesic tall open forest of coastal ranges and tablelands escarpment

Description:	Open forests to tall open forests consisting of a eucalypt canopy over a small tree layer of mesic species. The lower mid-storey consists mainly of vines; with sparse shrubs. The under-storey is ferny; with only sparse grasses and forbs. Occurs on steep near coastal ranges of the lower North coast and Northern Tablelands escarpment between 150 and 900 m elevation; predominately on mid to lower slopes.
BAM Plot Number:	LW34-7; PR144986 Plot 20
Diagnostic upper stratum species:	*Eucalyptus saligna*
Diagnostics middle stratum species:	*Acmena smithii*, *Synoum glandulosum*, *Schizomeria ovata*, *Crytocarya glaucescens*, *Guioa semiglauca*, *Cissus antarctica*, *Cissus hypoglauca*, *Eupomatia laurina*, *Tasmannia insipida*
Diagnostic ground stratum species:	*Adiantum formosum*, *Lastreopsis decomposita*, *Lastreopsis microsora*, *Blechnum cartilagineum*, *Oplismenus imbecillis*
Classification:	This PCT does not correspond to any BC Act or EPBC Act listed TEC.
Condition:	This PCT occurs in one condition state (moderate) as indicated in **Plate 4-4**.



Plate 4-4 Sydney Blue Gum – Lilly Pilly mesic tall open forest of coastal ranges and tablelands escarpment (Moderate condition)

4.2.1.5 1588 - Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast

Description:	Open forests characterised by *Eucalyptus paniculata*. The understorey is typically shrubby with sparse climbers. The ground layer is characteristically grassy with various graminoids and forbs.
BAM Plot Number:	LW 34-2; LW 34-4; LW 34-14
Diagnostic upper stratum species:	*Eucalyptus paniculata*, *Eucalyptus umbra* and *Eucalyptus tereticornis*
Diagnostics middle stratum species:	*Macrozamia communis, Notelaea longifolia, Breynia oblongifolia, Dodonaea triquetra, Acrotriche divaricata, Eustrephus latifolius* and *Pandorea pandorana*
Diagnostic ground stratum species:	*Themeda australis*, *Imperata cylindrica*, *Entolasia stricta*, *Dianella caerulea*, *Lomandra longifolia*, *Pratia purpurascens* and *Glycine clandestina*
Classification:	This PCT can correspond with BC Act listed Subtropical Coastal Floodplain Forest of the New South Wales North Coast Bioregion TEC where it is on the floodplain and in the North Coast bioregion. Accordingly, at this location, this vegetation is not classified as this TEC. This PCT does not correspond to any EPBC Act listed TEC.
Condition:	This PCT occurs in one condition state (moderate) as indicated in **Plate 4-5**.



Plate 4-5 Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast

4.2.1.6 Cleared/ Disturbed Land

Description:	Cleared land for rural property development and associated activities.
BAM Plot Number:	LW34-1; LW 34-5
Diagnostic upper stratum species:	None
Diagnostics middle stratum species:	None
Diagnostic ground stratum species:	None
Classification:	This vegetation does not correspond to any EPBC Act listed TEC.
Condition:	This vegetation is classified as non-native, as indicated in **Plate 4-6**.



Plate 4-6 Cleared/ Disturbed Land

4.3 Flora Surveys

In total, 263 flora species were detected within the BAM plots; 233 native and 30 exotic species. **Appendix F** lists the full list of species recorded with BAM plots and RDPs.

4.3.1 Threatened Flora

One threatened flora species, *Rhodamnia rubescens* (Scrub Turpentine; BC Act: Critically Endangered; EPBC Act: Critically Endangered), was detected within the Project Area during surveys. In total, 89 individual *R. rubescens* were found. The location of this threatened species is shown in **Figure 4-2**.

4.3.2 Weeds

All weeds detected during surveys are provided in **Table 4-5** in consideration of NSW WeedWise (DPI 2021). Weeds were also classified as BAM 'High Threat Weeds' (HTW) and Weeds of National Significance (WoNS) where relevant. The Project Area is subject to the Greater Sydney Regional Strategic Weed Management Plan 2017-2022.

Table 4-5 Weeds detected within the Project Area and their management requirements

Scientific Name	Common Name	BAM HTW	WoNS	Duty under *Biosecurity Act* 2015
Ageratina adenophora	Crofton Weed	☒	☐	**General Biosecurity Duty** All plants are regulated with a general biosecurity duty to prevent, eliminate or minimise any biosecurity risk they may pose. Any person who deals with any plant, who knows (or ought to know) of any biosecurity risk, has a duty to ensure the risk is prevented, eliminated or minimised, so far as is reasonably practicable.
Alternanthera philoxeroides	Alligator Weed	☒	☐	**General Biosecurity Duty** All plants are regulated with a general biosecurity duty to prevent, eliminate or minimise any biosecurity risk they may pose. Any person who deals with any plant, who knows (or ought to know) of any biosecurity risk, has a duty to ensure the risk is prevented, eliminated or minimised, so far as is reasonably practicable.
Bidens pilosa	Cobbler's Peg	☒	☐	**General Biosecurity Duty** All plants are regulated with a general biosecurity duty to prevent, eliminate or minimise any biosecurity risk they may pose. Any person who deals with any plant, who knows (or ought to know) of any biosecurity risk, has a duty to ensure the risk is prevented, eliminated or minimised, so far as is reasonably practicable.
Cyperus eragrostis	Umbrella Sedge	☒	☐	**General Biosecurity Duty** All plants are regulated with a general biosecurity duty to prevent, eliminate or minimise any biosecurity risk they may pose. Any person who deals with any plant, who knows (or ought to know) of any biosecurity risk, has a duty to ensure the risk is prevented, eliminated or minimised, so far as is reasonably practicable.
Paspalum dilatatum		☒	☐	**General Biosecurity Duty** All plants are regulated with a general biosecurity duty to prevent, eliminate or minimise any biosecurity risk they may pose. Any person who deals with any plant, who knows (or ought to know) of any biosecurity risk, has a duty to ensure the risk is prevented, eliminated or minimised, so far as is reasonably practicable.
Lantana camara	Lantana	☐	☒	**General Biosecurity Duty** All plants are regulated with a general biosecurity duty to prevent, eliminate or minimise any biosecurity risk they may pose. Any person who deals with any plant, who knows (or ought to know) of any biosecurity risk, has a duty to ensure the risk is prevented, eliminated or minimised, so far as is reasonably practicable.

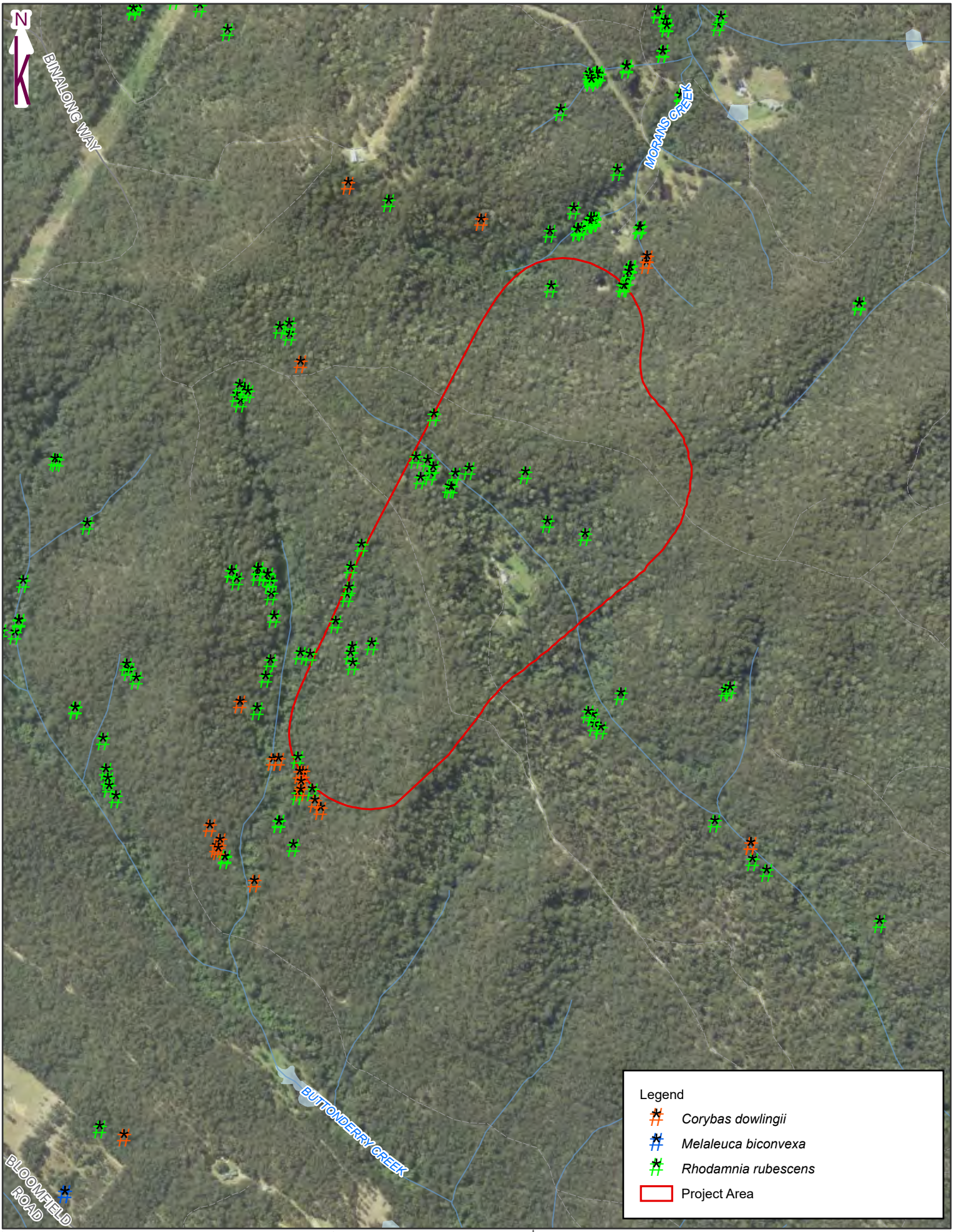


FIGURE 4-2
THREATENED FLORA RECORDED

VERSION:
A
DATE EXPORTED:
24/08/2021 2:08 PM
TECHNICIAN:
Robert.Suansri

LOCATION:
Mandalong

0 100 200 300 m

DATA SOURCES
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SCALE 1:10,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**
PROJ: **149823**
PURPOSE: **BIR**

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4.4 Fauna Surveys

Threatened fauna detected during field surveys (either opportunistic or during targeted surveys) within or nearby the Project Area are detailed in **Table 4-6**.

Table 4-6 Threatened fauna detected

Scientific Name Common Name	BC Act	EPBC Act	Detected inside Project Area	Detected outside Project Area
Chalinolobus dwyeri Large-eared Pied Bat	Vulnerable	Vulnerable	No	Yes
Miniopterus australis Little Bent-winged Bat	Vulnerable	Not Listed	No	Yes
Calyptorhynchus lathami Glossy Black Cockatoo	Vulnerable	Not Listed	Yes	Yes
Climacteris picumnus Brown Treecreeper (eastern subspecies)	Vulnerable	Not Listed	No	Yes
Pteropus poliocephalus Grey-headed Flying Fox	Vulnerable	Vulnerable	No	Yes
Petaurus australis Yellow-bellied Glider	Vulnerable	Not Listed	No	Yes
Petauroides volans Greater Glider	Not Listed	Vulnerable	No	Yes
Haliaeetus leucogaster White-breasted Sea Eagle	Vulnerable	Not Listed	No	Yes
Tyto novaehollandiae Masked Owl	Vulnerable	Not Listed	Yes	No
Tyto tenebricosa Sooty Owl	Vulnerable	Not Listed	No	Yes

Table Note

A small glider observed northwest and outside of the Project Area was identified as either a Squirrel Glider (*Petaurus norfolcensis*; BC Act = Vulnerable; EPBC Act = Not Listed) or Sugar Glider (*Petaurus breviceps*; BC Act = Not Listed; EPBC Act = Not Listed). In the absence of scientific certainty, the precautionary approach was adopted with the individual identified as a Squirrel Glider.

Fauna detected during surveys are provided in **Appendix G**. The Anabat echolocation call analysis for microbats is provided in **Appendix H**.

4.4.1 Targeted Herpetofauna Census

No threatened herpetofauna were detected within the Project Area during diurnal or nocturnal surveys. Common amphibian species recorded within the Project Area are identified in **Appendix G**.

4.4.2 Habitat Values

Habitat values identified within the Project Area for fauna included: HBTs; caves; sandstone boulders and rocks; ephemeral creeks; and termite mounds. These habitat features provide potential foraging and / or breeding habitat for a range of bird, reptile, amphibian and mammal species. **Sections 4.4.2.1** and **4.4.2.2** present results from targeted habitat surveys that focused on habitat constraints for Candidate Species: cave- and tree hollow-associated fauna. These habitat attributes were used to inform the development of Species Polygons for relevant threatened fauna within the BDAR.

4.4.2.1 Hollow bearing trees

Twenty hollow-bearing trees were located within the vicinity of the predicted ponding areas (i.e. within approximately 100 m of creek lines). The attributes of these trees are summarised in **Table 4-7** and displayed in **Figure 4-4**.

Table 4-7 Hollow-bearing trees recorded within 100 m of predicted ponding areas

HBT ID	Species	DBH (cm)	Hollow Class		
			C1 (>20cm)	C2 (11-20cm)	C3 (<10cm)
5	Dead stag	51 - 60	1	-	-
12	*Corymbia maculata*	61 - 70	-	2	-
13	*Eucalyptus pilularis*	81 - 90	1	1	-
14	*Eucalyptus microcorys*	81 - 90	1	-	-
15	*Eucalyptus microcorys*	71 - 80	1	-	-
16	*Eucalyptus pilularis*	>100	1	-	-
17	*Eucalyptus pilularis*	>100	-	2	-
18	*Eucalyptus microcorys*	71 - 80	-	1	-
19	Dead stag	51 - 60	1	-	-
20	*Eucalyptus propinqua*	71 - 80	-	2	-
33	*Eucalyptus acmenoides*	71 - 80	-	1	-
34	*Eucalyptus pilularis*	>100	1	2	-
35	*Corymbia maculata*	>100	2	-	-
63	Dead stag	>100	-	2	2
64	*Eucalyptus siderophloia*	81 - 90	1	3	-
65	*Corymbia maculata*	>100	3	-	-
66	*Angophora floribunda*	51 - 60	-	2	-
68	*Eucalyptus microcorys*	41 - 50	-	1	-
153	*Eucalyptus propinqua*	81 - 90	-	1	1
264	*Eucalyptus pilularis*	>100	1	4	-

4.4.2.2 Caves

Nineteen caves were recorded inside or near the Project Area as potential bat habitat during the current study. Of these, bat scat was detected in three caves. An additional eight caves were marked up as shelter sites for First Nations People (two with art), which may also provide microbat roosting habitat. The locations of these caves, including those with scats present, is shown in **Figure 4-5**. Details regarding the attributes of these caves summarised in **Table 4-8** and photographs are provided in **Appendix I**.

The potential for these caves to constitute habitat for cave-associated threatened bats was informed by Mr Glenn Hoye (Fly By Night Bat Surveys; 25 years' experience researching microbats).

Table 4-8 Caves recorded within 100 m of predicted ponding areas

CAVE ID	Overhang max width (m)	Overhang max depth (m)	Overhang max length (m)	Bat scat present	Bats present
C32	2.66	1.83	1.83	-	-
C33	2.6	1.99	1.99	-	-
C34	5.27	2.97	2.97	-	-
C35	4.24	2.94	2.94	-	-
C36	4.07	4.64	4.64	-	-

CAVE ID	Overhang max width (m)	Overhang max depth (m)	Overhang max length (m)	Bat scat present	Bats present
C37	4.44	7.22	7.22	-	-
C38	4.43	4.3	4.3	-	-
C39	5.05	4.56	4.56	-	-
C40	2.98	4.85	4.85	-	-
C41	2.61	2.76	2.76	-	-
C42	3.23	2.68	2.68	-	-
C43	3.61	2.73	2.73	-	-
C44	3.25	3.64	3.64	-	-
C45	2.31	2.97	2.97	Yes	-
C46	2.27	1.95	1.95	-	-
C47	4.15	3.79	3.79	-	-
C56	7.1	1.35	4.69	Yes	-
NA	NA	NA	NA	Yes	-
NA	NA	NA	NA	-	-

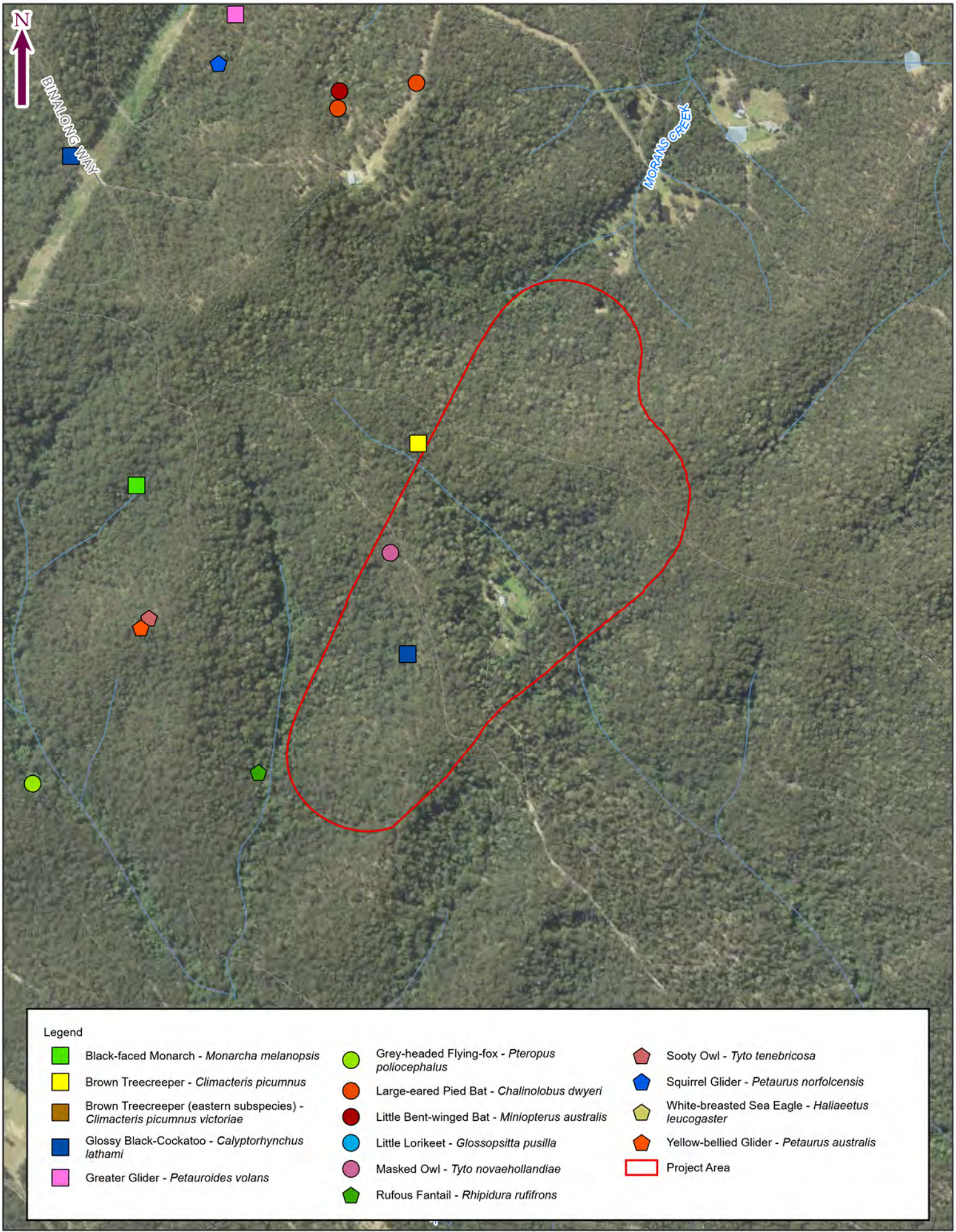


FIGURE 4-3
THREATENED/MIGRATORY FAUNA RECORDED

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DATE EXPORTED:
13/07/2021 4:25 PM
TECHNICIAN:
Robert.Suansri

LOCATION:
Mandalong

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0 100 200 300 m

SCALE 1:10,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

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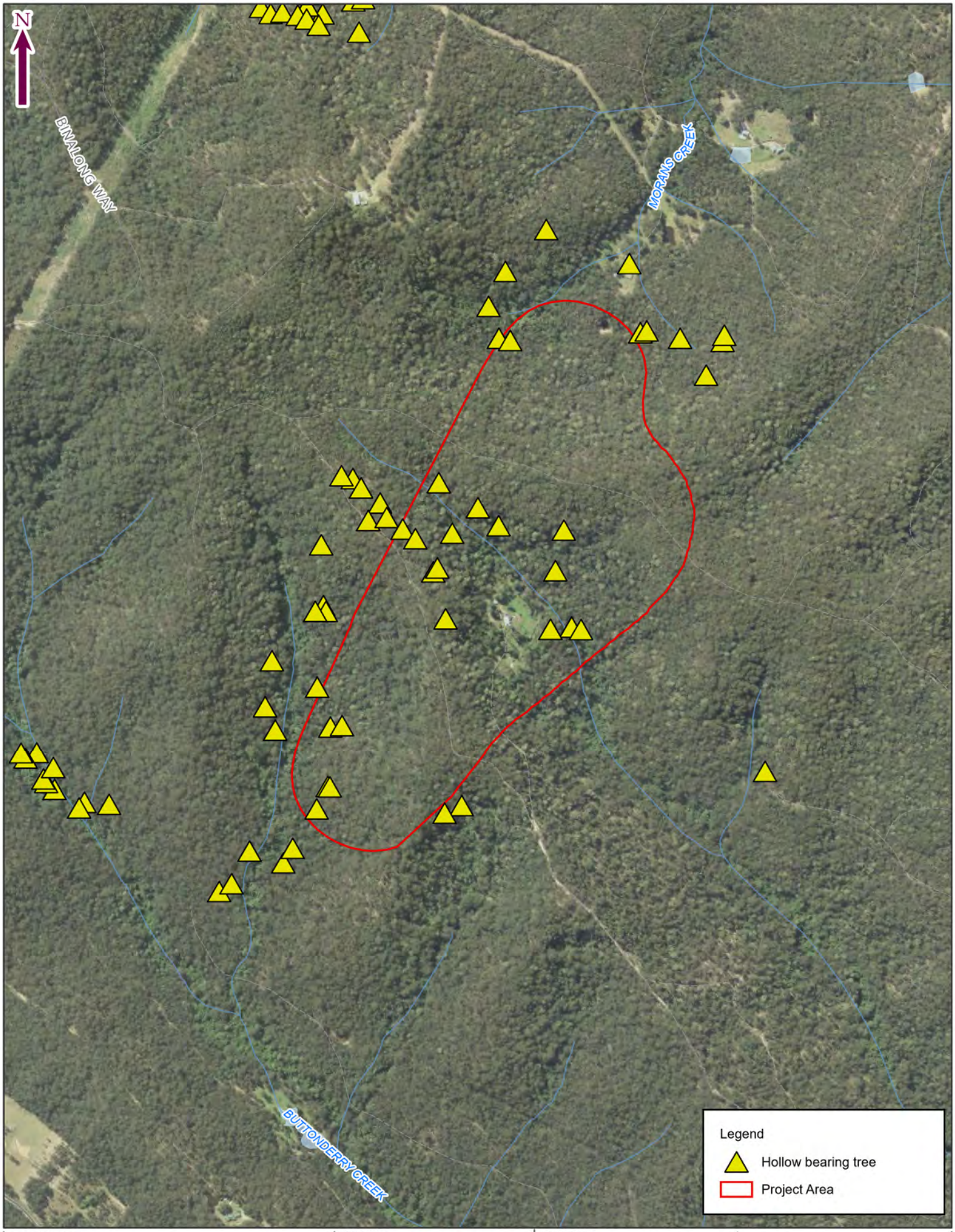


FIGURE 4-4
HABITAT TREES RECORDED

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13/07/2021 4:50 PM
TECHNICIAN:
Robert.Suansri

LOCATION:
Mandalong

0 100 200 300 m

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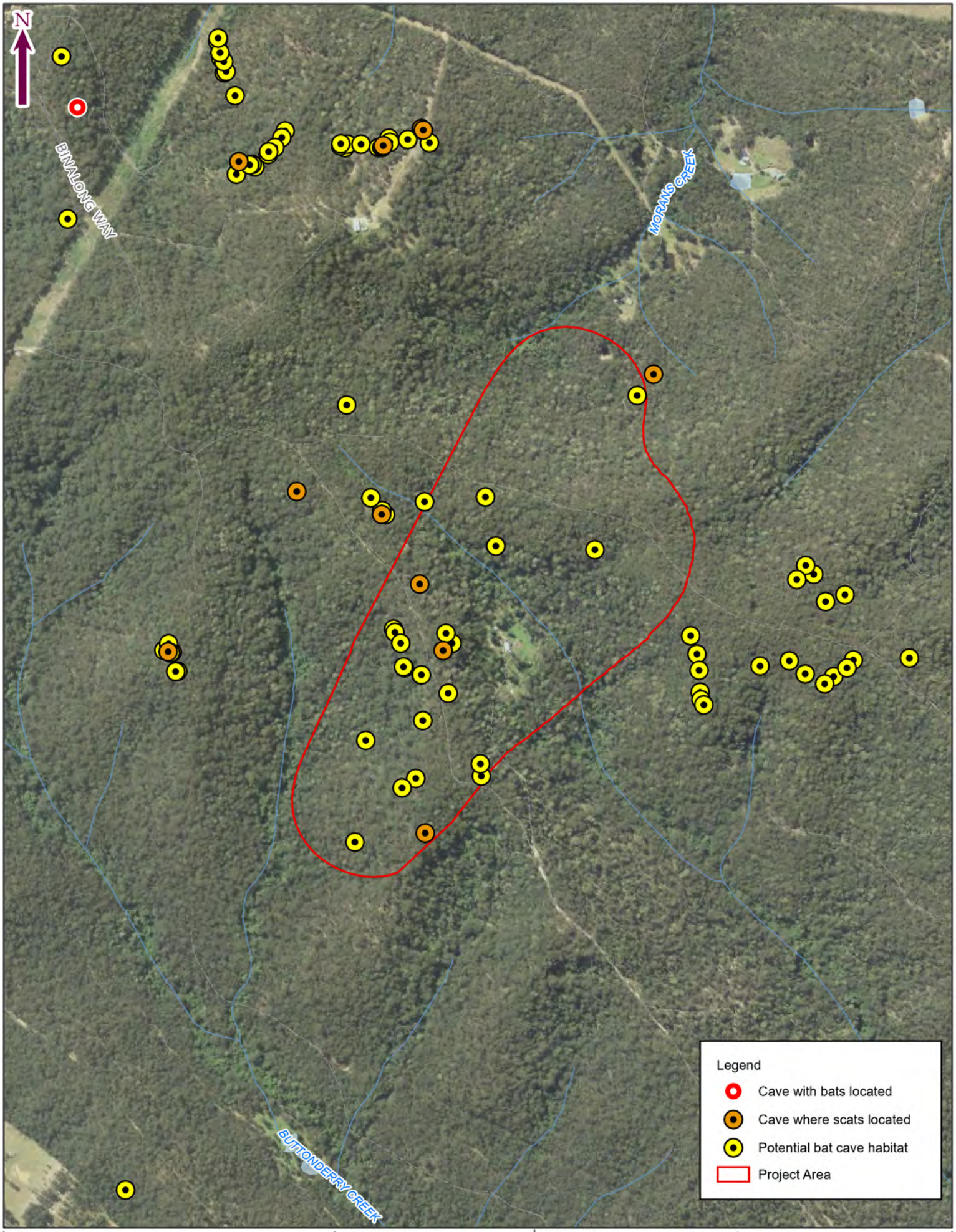


FIGURE 4-5
CAVES RECORDED

VERSION:
A
DATE EXPORTED:
13/07/2021 5:05 PM
TECHNICIAN:
Robert.Suansri

LOCATION:
Mandalong

DATA SOURCES
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0 100 200 300 m

SCALE 1:10,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**
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5 IMPACT ASSESSMENT

5.1 NSW State Groundwater Dependant Ecosystems

The potential for Groundwater Dependent Ecosystems was explored using the Groundwater Dependent Ecosystems Atlas (GDE Atlas). The GDE Atlas was developed as a national dataset of Australian GDEs to inform groundwater planning and management (BOM 2021b). According to the GDE Atlas, potential GDEs within the Project Area are displayed in **Figure 5-1**.

The primary source of groundwater in the region, owing to the underlying sandstone, is likely to be a sedimentary rock groundwater system.

The PCTs on the Project Area that have a moderate or greater potential to be a GDE include:

- 1528 - Jackwood - Lilly Pilly - Sassafras riparian warm temperate rainforest of the Central Coast;
- 1556 - Tallowwood - Smooth-barked Apple - Blackbutt grass tall open forest of the Central and lower North Coast;
- 1568 - Blackbutt - Turpentine - Sydney Blue Gum mesic tall open forest on ranges of the Central Coast; and
- 1573 - Sydney Blue Gum - Lilly Pilly mesic tall open forest of coastal ranges and tablelands escarpment.

Based on the nature of the Project, impacts on groundwater are expected to be negligible. That is, a minor increase in groundwater influence within areas predicted for ponding (i.e. <1 ha) are not expected to lead to a significant shift in vegetation communities (composition or integrity) given the strong association of PCTs with groundwater where ponding is predicted. Nevertheless, ongoing annual monitoring will be undertaken as part of the Extraction Plan Biodiversity Management Plan (BMP) to detect and respond to any community shifts that may arise from mining-related subsidence in the unexpected case that they do occur.

Note that, to date, ongoing annual monitoring of predicted ponding-related impacts associated with other sets of longwalls has yet to detect a more than negligible impact upon GDE's (including PCTs 1568 and 1573).

5.2 Coastal Management State Environmental Planning Policy 2018

The Project Area is outside of any planning considerations under the Coastal Management SEPP, including Coastal Wetlands, Littoral Rainforest, Coastal Vulnerability Area, Coastal Environment Area and Coastal Use Area (DPE 2021).

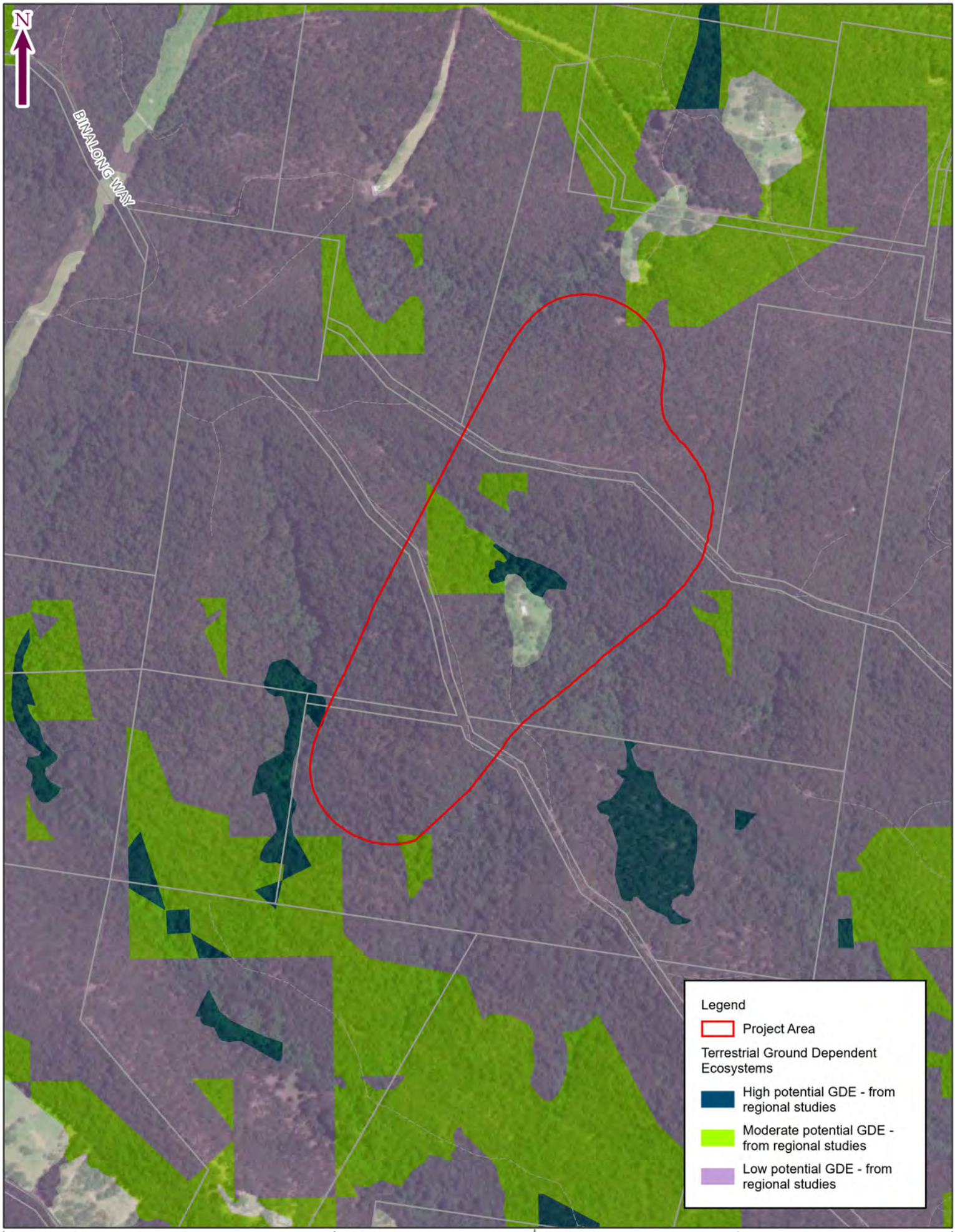


FIGURE 5-1
GROUND DEPENDENT ECOSYSTEMS (BOM 2021B)

VERSION:
A
DATE EXPORTED:
13/07/2021 4:49 PM
TECHNICIAN:
Robert.Suansri

LOCATION:
Mandalong

DATA SOURCES
Centennial, RPS, Maxar

0 100 200 300 m

SCALE 1:10,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**
PROJ: **149823**
PURPOSE: **BIR**

IMPORTANT NOTE
1. This plan was prepared for the sole purposes of the client for the specific purpose of producing a photographic overlay plan. This plan is strictly limited to the Purpose and does not apply directly or indirectly and will not be used for any other application, purpose, use or matter. The plan is presented without the assumption of a duty of care to any other person (other than the Client) ("Third Party") and may not be relied on by Third Party.
2. RPS Australia East Pty Ltd will not be liable (in negligence or otherwise) for any direct or indirect loss, damage, liability or claim arising out of or incidental to:
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b. RPS Australia East Pty Ltd relying on information provided to it by the Client or a Third Party where the information is incorrect, incomplete, inaccurate, out-of-date or unreasonable;
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f. judgement of this plan with any final authority against the recommendation of RPS Australia East Pty Ltd;
g. the accuracy, reliability, suitability or completeness of any approximations or estimates made or referred to by RPS Australia East Pty Ltd in this plan.

Project path: S:\Centennial\All Jobs\149823 Mandalong Revised MOD 10 BDAR\10 - Drafting\149823_Mandalong_MOD10_BIR_figures.aprx

5.3 Environmental Protection and Biodiversity Conservation Act 1999

5.3.1 Listed Migratory Species

Seventeen nationally listed migratory terrestrial and wetland species were recorded on the DAWE online database or are considered to have potential habitat available within the locality (**Table 5-1**).

Table 5-1 Migratory birds listed under EPBC Act

Scientific Name	Common Name
Migratory Terrestrial Species	
Cuculus optatus	Oriental Cuckoo, Horsfield's Cuckoo
Hirundapus caudacutus	White-throated Needletail
Monarcha melanopsis	Black-faced Monarch
Monarcha trivirgatus	Spectacled Monarch
Motacilla flava	Yellow Wagtail
Myiagra cyanoleuca	Satin Flycatcher
Rhipidura rufifrons	Rufous Fantail
Migratory Wetland Species	
Actitis hypoleucos	Common Sandpiper
Calidris acuminata	Sharp-tailed Sandpiper
Calidris canutus	Red Knot
Calidris ferruginea	Curlew Sandpiper
Calidris melanotos	Pectoral Sandpiper
Gallinago hardwickii	Latham's Snipe
Limosa lapponica	Bar-tailed Godwit
Numenius madagascariensis	Eastern Curlew
Pandion haliaetus	Osprey
Tringa nebularia	Common Greenshank

Of these species Rufous Fantail (*Rhipidura rufifrons*) and Black-faced Monarch (*Monarcha melanopsis*) were recorded nearby the Project Area (**Figure 4-3**).

Due to the minor extent of impact on habitat for these above listed migratory birds, as a result of the predicted increase in ponding relating to subsidence (i.e. <1 ha), the Project is unlikely to impact on any area considered to be 'important habitat' for these migratory species or impact a significant proportion of a migratory population.

5.3.2 Listed Threatened Species

Forty-five nationally threatened species have been recorded or may occur within the locality. Through the LoO, 13 EPBC Act listed species were deemed as having a moderate or greater likelihood of occurring within the Project Area and have potential to be impacted by ponding (**Appendix C**). EPBC Act Listed threatened species with a moderate or greater likelihood of occurring (and impacted by ponding) are:

- *Angophora inopina* (Charmhaven Apple; EPBC Act: Vulnerable);
- *Cryptostylis hunteriana* (Leafless Tongue-orchid; EPBC Act: Vulnerable);
- *Cynanchum elegans* (White-flowered Wax Plant; EPBC Act: Endangered);
- *Diuris praecox* (Rough Doubletail; EPBC Act: Vulnerable);
- *Mixophyes iteratus* (Giant Barred Frog; EPBC Act: Endangered);

- *Heleioporus australiacus* (Giant Burrowing Frog; EPBC Act: Vulnerable);
- *Litoria aurea* (Green and Golden Bell Frog; EPBC Act: Vulnerable);
- *Petauroides volans* (Greater Glider; EPBC Act: Vulnerable);
- *Pteropus poliocephalus* (Grey-headed Flying Fox; EPBC Act: Vulnerable);
- *Litoria littlejohni* (Littlejohn's Tree Frog; EPBC Act: Vulnerable);
- *Melaleuca biconvexa* (Biconvex Paperbark; EPBC Act: Vulnerable);
- *Persicaria elatior* (Tall Knotweed; EPBC Act: Vulnerable);
- *Rhodamnia rubescens* (Scrub Turpentine; EPBC Act: Critically Endangered);
- *Rhodomyrtus psidioides* (Native Guava; EPBC Act: Critically Endangered);
- *Mixophyes balbus* (Stuttering Frog; EPBC Act: Vulnerable);
- *Syzygium paniculatum* (Magenta Lilly Pilly; EPBC Act: Vulnerable); and
- *Tetratheca juncea* (Black-eyed Susan; EPBC Act: Vulnerable).

Out of the above species the following EPBC Act listed species were detected within or nearby the Project Area:

- *Pteropus poliocephalus* (Grey-headed Flying-fox);
- *Petauroides volans* (Greater Glider);
- *Chalinolobus dwyeri* (Large-eared Pied Bat); and
- *Rhodamnia rubescens* (Scrub Turpentine; EPBC Act: Critically Endangered).

One individual Grey-headed Flying Fox was detected to the west of the Project Area (foraging only). Moreover, one Greater Glider (*Petauroides volans*) was detected in contiguous vegetation, nearby the Project Area. As the Project is expected to modify only a small extent of vegetation (i.e. < 1 ha) by ponding, it is not expected to have a significant impact on EPBC Act listed fauna, which typically have large foraging ranges.

Large-eared Pied Bat (*Chalinobolus dwyeri*) were found outside the Project Area at monitoring sites 3 and 4 (see **Figure 3-2** and **Appendix H**). Note that this species was not detected within the two monitoring sites within the Project Area.

Of the above species, the greatest potential impact on the above MNES entities was considered to be for the Critically Endangered *R. rubescens*, as it occurs within the Project Area. Although this species can be locally abundant, they have recently been listed due to impacts by Myrtle Rust (*Puccinia psidii*) (DAWE 2020b). Nevertheless, all *R. rubescens* individuals were found outside the predicted ponding areas. An assessment of significance is provided for this species is provided in **Appendix J**, concluding that there is unlikely to be a significant impact on this species.

5.3.3 Threatened Ecological Communities

No TEC listed under the EPBC Act were detected within the Project Area. As such, no assessment for EPBC Act Listed TECs is provided in this report.

6 CONCLUSIONS AND RECOMMENDATIONS

This BIR provides ecological survey results required to inform the preparation of a BDAR for impacts on biodiversity values arising from the addition of Longwall (LW) 34 as part of Modification 10 to SSD-5144. This report also assesses matters not addressed in the BDAR, such as assessments required under the EPBC Act and relevant SEPPs. Conclusions and recommendations are provided in the following sections.

6.1 State Requirements (BC Act)

Five PCTs were located within the Project Area. These PCTs were:

- 1528 - Jackwood - Lilly Pilly - Sassafras riparian warm temperate rainforest of the Central Coast Moderate condition);
- 1556 - Tallowwood - Smooth-barked Apple - Blackbutt grass tall open forest of the Central and lower North Coast (Moderate condition);
- 1568 - Blackbutt - Turpentine - Sydney Blue Gum mesic tall open forest on ranges of the Central Coast (Moderate condition);
- 1573 - Sydney Blue Gum - Lilly Pilly mesic tall open forest of coastal ranges and tablelands escarpment (Moderate condition); and
- 1588 - Grey Ironbark - Broad-leaved Mahogany - Forest Red Gum shrubby open forest on Coastal Lowlands of the Central Coast (Moderate condition).

Of these PCTs, subsidence related impacts associated with ponding may occur to PCT 1556 (Zone 2), 1568 (Zone 3) and 1573 (Zone 4).

Of the BC Act listed threatened flora, only *Rhodamnia rubescens* (Scrub Turpentine; BC Act = Critically Endangered; EPBC Act = Critically Endangered) was detected.

The following fauna species listed under the BC Act (or signs thereof) were found within or nearby the Project Area:

- Brown Treecreeper (eastern subspecies) (*Climacteris picumnus*; BC Act = Vulnerable; EPBC Act = Not Listed);
- Glossy Black Cockatoo (*Calyptorhynchus lathami* (Glossy Black-Cockatoo; BC Act = Vulnerable; EPBC Act = Not Listed);
- Grey-headed Flying Fox (*Pteropus poliocephalus*; BC Act = Vulnerable; EPBC Act = Vulnerable);
- Large-eared Pied Bat (*Chalinolobus dwyeri*; BC Act = Vulnerable; EPBC Act = Vulnerable);
- Little Bent-winged Bat (*Miniopterus australis*; BC Act = Vulnerable; EPBC Act = Not Listed);
- Masked Owl (*Tyto novaehollandiae*; BC Act = Vulnerable; EPBC Act = Not Listed); and
- Sooty Owl (*Tyto tenebricosa*; BC Act = Vulnerable; EPBC Act = Not Listed).
- Squirrel Glider (*Petaurus norfolcensis*; BC Act = Vulnerable; EPBC Act = Not Listed)'
- White-breasted Sea Eagle (*Haliaeetus leucogaster*; BC Act = Vulnerable; EPBC Act = Not Listed); and
- Yellow-bellied Glider (*Petaurus australis*; BC Act = Vulnerable; EPBC Act = Not Listed).

Impacts to the above listed PCT and Species Credit Species are addressed in the BDAR.

6.2 Commonwealth Requirements (EPBC Act)

No TECs listed under the EPBC Act were detected within the Project Area. As such, no assessment for EPBC Act listed TECs is required. Moreover, due to the minor increase in ponding expected, it is considered unlikely that the Project would result in a significant impact to any EPBC Act listed threatened species.

Of the potential EPBC Act listed fauna with potential to occur, Large-eared Pied Bat (*Chalinolobus dwyeri*), Grey-headed Flying Fox (*Pteropus poliocephalus*) and Greater Glider (*Petauroides volans*; EPBC Act =

Vulnerable) were found within or nearby the Project Area. It was considered unlikely that the Project would have a significant impact on these mobile species, with large home ranges, due to the scale and nature of the impacts associated with the Project.

Eighty-nine *Rhodamnia rubescens* (Scrub Turpentine) individuals were detected in the Project Area. An Assessment of Significance was undertaken in **Appendix J** due to potential impacts on Critically Endangered *Rhodamnia rubescens* (Scrub Turpentine) due to potential impacts on this sensitive receiver, as it can be associated with riparian areas that could be subject to mining-related ponding.

Based on the self-assessment (AoS), it is considered that the Project is unlikely to have a significant impact on *R. rubescens*. As such, we believe the action does not constitute a controlled action (i.e. not a significant impact on this species). Nevertheless, Centennial may consider referring the Project to the Minister for the Minister's decision under Section 68 (2) of the EPBC Act for the purposes of regulatory certainty. Alternatively, it is recommended that Centennial retain this assessment as evidence of a proper self-assessment being undertaken for this species.

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Appendix A

Staff Qualifications



Hayden Beck

Senior Ecologist

Role at RPS
Senior Ecologist

Location
Newcastle, NSW, Australia

Qualifications
BSc (Mar Sc); BEnvSc (Hons); MSc (Res); PhD

BAM Accredited Assessor (BAAS19000)

AUSRIVAS Macroinvertebrate Bioassessment Training

Contaminated Site Assessment, Remediation and Management (CSARM) short course, UTS4X4 driving Certificate

White Card

Rail Industry Safety Induction – RISI

Memberships
Ecological Consultants Association of NSW (Practicing Member)

Why Hayden for this role

Hayden specialises in terrestrial, aquatic and marine ecology. As an Ecologist at RPS, Hayden undertakes fieldwork and prepares reports for diverse projects, including the mining and housing sectors.

Being a Biodiversity Assessment Method (BAM) Accredited Assessor, Hayden has considerable experience preparing Biodiversity Assessment Reports under the NSW *Biodiversity Conservation Act 2016*.

Relevant projects

Woolooga Solar Farm, Lightsource BP, 2020 - 2021

Hayden prepared Preliminary Documentation to assist with Commonwealth assessment for a proposed solar farm in Woolooga, QLD. Preparation of this report involved collating several specialist reports to assess impacts on biodiversity values. As part of this project, Hayden also prepared a Biodiversity Management Plan (BMP) and Offset Management Plan (OMP).

Fernleigh Track Extension REF and EIS, Lake Macquarie City Council, 2020

RPS was engaged for a Review of Environmental Factors (REF) and Environmental Impact Statement (EIS) for the Fernleigh Awabakal Shared Track (FAST) Extension from Belmont to Blacksmiths. Hayden provided ecological advice including Fauna trapping and aquatic ecology.

33kV Power Easement for Mandalong Coal Mine, Centennial Coal, 2019

Hayden prepared a Biodiversity Development Assessment Report (BDAR) to determine the offset liability for this State Significant Development (SSD). This project extended 7.6km easement will extent through multiple Plant Communities. Preparation of this report involved collating multiple years of field data and specialist reports to assess impacts on biodiversity values. As part of this project, Hayden supported the lodgement an EPBC Act referral due to uncertain impacts on threatened flora.

LW22-24a and LW 25-31 Mandalong Coal Mine, Centennial Coal, 2019 - 2021

Hayden organises annual monitoring of sensitive ecological communities, as well as frogs, to detect impacts of longwall mining. As a project manager, he coordinates teams of up to six ecologists to undertake surveys across a vast area.

Jemalong Solar Farm, Genex Power Pty Ltd, 2019

Hayden prepared an EPBC Act referral document for a proposed Solar Farm (SSD) in Jemalong, NSW. This Project involved assessing impacts of removing hollow-bearing trees on Swift Parrot and Corben's Long-eared Bat.

Relevant projects

Basalt Quarry, Boral, 2019

Hayden undertook a feasibility assessment for a proposed basalt mine at North Star, NSW. This project involved undertaking flora surveys across Semi-evergreen Vine Thicket EEC to determine the offset liability to develop the site. Three extraction options were assessed. Involvement included fieldwork, preparation of a report and presentation to the client.

NBN tower Installation, Vision Stream, 2019

Hayden prepared a BDAR to determine the offset liability for an infrastructure Project at Tallong, NSW. Impacts to ecosystems and threatened species were assessed for the installation of an access track, NBN tower and associated facilities.

Newcastle Light Rail (NLR) Project, Downer, 2019

Hayden prepared the ecological sections of an Infrastructure sustainability rating (ISCA) application for the 'As Built' stage of the NLR Project

Tikitere Quarry, SMK Consultants, 2017

Hayden assisted the ecological assessment of a basalt quarry at North Star, NSW. Tasks included fieldwork and assistance with reporting.

Concrete Batch Plant at Bushells Ridge, Advision, 2017

Hayden prepared a Flora and Fauna impact assessment for the proposed establishment of a concrete batch plant. This facility is currently being used to facilitate widening of the M1. This project involved several survey efforts targeting multiple threatened flora and fauna species, including a critically endangered orchid that was found on site.

Roads and Maritime Services, Road Upgrade Projects, 2016 to 2018

Hayden undertook Biodiversity Assessments for 15 road projects. Examples include:

- Widening of Golden Highway, Castlereagh Junction to Dunedoo;
- Shoulder Widening, Golden Highway (Segments 240 to 260), Denman;
- Culvert rehabilitation (23 sites): Old Pacific Highway, Kariong to Mooney;
- Manns Road Upgrade, West Gosford; and
- Drainage Upgrades to M1, Mt Pleasant, Roads and Maritime Services.

Dungog Council, Road Upgrade Projects, 2016

Hayden undertook Biodiversity Assessments and preclearance surveys for two road projects in Dungog Shire Council LGA.

Climate change impacts on tropical fishes, University of Technology Sydney, 2012-2015

This project was aimed at understanding factors mediating the geographic response of marine reef fishes to climate change. This project involved extensive, multi-year underwater surveys of temperate and tropical marine ecosystems in eastern Australia and western Japan. Various aquarium experiments were undertaken to study how predator-prey interactions may structure recruitment success of tropical fishes when colonising a new range. A new method was devised to survey rare reef fish species, which uses a towed GPS to delineate survey effort.

Impacts of soil pollution on reef fish recruitment, Kochi University, 2014

Studied impacts of red soil pollution on reef fish recruitment within Japan, which stems from water pollution arising from agricultural runoff. This project included coral and reef fish surveys, as well as laboratory experiments.

Characterisation of Stormwater pollution in Sydney Harbour, Marrickville, City of Sydney and Leichhardt Councils, 2010-2012

Measured and analysed water pollution within Sydney Harbour catchments, including metals, nutrients and suspended solids. This project involved generating water pollution budgets for different flow conditions, then devising a water treatment strategy.

Research Assistant, Macquarie University, 2007-2010

Organised and conducted fieldwork and laboratory experiments for several aquatic ecology-focused projects, including a sea urchin aquaculture venture and collaborations with James Cook University and NSW DPI. In this role, Hayden surveyed marine fishes and invertebrates throughout NSW.

Water Quality Officer, NSW Department of Environment, 2009

Undertook monitoring of water quality through Sydney's Waterways and Beaches. Role involved operating a small vessel to collect water samples from remote locations.

Connectivity of sea urchin populations between southern and eastern Australian Coastlines, Deakin University, 2007

Undertook hierarchically nested surveys of the sea urchin *Heliocidaris erythrogramma* along the coastline from Sydney to Adelaide. This study demonstrated potential breaks in connectivity between populations on the Southern and Eastern coastlines of Australia. Breeding experiments were undertaken to explore a genetic cause for patterns in colour variation of this sea urchin.



Mark Aitkens

Principal Ecologist

Role at RPS
Principal Ecologist

Location
Newcastle, NSW, Australia

Qualifications
Bachelor of Science (Environmental Biology), University of Technology Sydney (UTS)

Accredited Biodiversity Assessment Method Assessor under Section 6.10 of the *Biodiversity Conservation Act* 2016

Rail Industry Safety Induction - RISI

Memberships
Ecological Society of Australia

Why Mark for this role

Mark is a Principal Ecologist with 25 years' experience in the delivery of terrestrial and aquatic ecology services to the private and public sectors. Mark is accredited to perform assessments in accordance with the Biodiversity Assessment Methodology (BAM) and has conducted a range of BBAM and BAM assessments for State Significant Infrastructure and State Significant Developments. He is also experienced in the application of the EPBC Act preparation of EPBC Act offset calculations.

Mark is experienced in all aspects of project delivery including design and implementation of seasonally based flora and fauna surveys, identification of terrestrial and aquatic species and ecological communities, impact assessments, and design and implementation of monitoring programs.

Relevant projects

Fernleigh Awabakal Track Extension REF and EIS, Lake Macquarie City Council, 2020 - present

RPS was engaged for a Review of Environmental Factors (REF) and Environmental Impact Statement (EIS) for the Fernleigh Awabakal Shared Track (FAST) Extension from Belmont to Blacksmiths. Mark oversaw ecological field work requirements and preparation of biodiversity assessment documentation for the project including the preparation of a Biodiversity Development Assessment Report. This report informed an overarching Review of Environmental Factors, which aimed to avoid, minimise and mitigate impacts upon local biodiversity in the Lake Macquarie Local Government Area.

Medlow Bath upgrade, Transport for NSW (TfNSW), 2020 – 2021

As part of the Great Western Highway Upgrade Program, the Medlow Bath section will be upgraded to allow dual lanes and safety improvements. Mark prepared a biodiversity assessment report as part of the REF for the Medlow Bath upgrade project.

The Horsley Drive, Transport for NSW (TfNSW), 2021 – present

Mark is the project ecologist engaged for the preparation of an addendum biodiversity assessment to support an REF for the Horsley Drive upgrade between the M7 Motorway and Cowpasture Road to a four-lane divided road. Mark is actively working with the project team to identify impact avoidance, minimisation and mitigation measures suitable for the management of impacts on locally occurring threatened ecological communities including Cumberland Plain Woodland and River-flat Eucalypt Forest.

Relevant projects

NSW Telco Authority (Visionstream), 2018-2021

Preparation of biodiversity assessments for multiple existing and proposed telecommunication sites scattered throughout NSW involving a range of impacts including green field development (e.g. installation of lattice towers) to brownfield works (e.g. bush fire mitigation works). Assessments were performed in accordance with Part 5 of the EP&A Act (i.e. preparation of Test of Significance under Section 7.3 of the BC Act) to determine if the works are likely to have a significant impact on threatened species and ecological communities. Important measures for avoiding and minimising impacts on affected threatened species and ecological communities are provided to manage impacts.

Garfield Road West Upgrade, TfNSW, 2019 -2020

Mark prepared a specialist biodiversity assessment report prepared under Part 5 of the EP&A Act for inclusion in a REF for the reconstruction of Garfield West Road, Riverstone along a new alignment. Challenges successfully encountered included the management of roadside impacts on critically endangered ecological communities, threatened species habitat and key fish habitat (Eastern Creek).

TAP3 Project, TfNSW, 2017 - 2020

Mark is the project ecologist involved in the preparation of biodiversity assessment documentation for rail station upgrade for inclusion in the REF. Assessments have included the identification and assessment of threatened species and ecological communities found within the rail corridor for multiple rail stations located within the greater Sydney metropolitan area.

Kings Hill Concept Plan, Kings Hill Developments, 2015 - present

Mark prepared a Species Impact Statement for a 500 ha development site located within the Newcastle drinking water supply (Grahamstown Dam). Key affected species included the Koala, Brush-tailed Phascogale, woodland birds and threatened orchids. Impacts on coastal wetlands and swamp sclerophyll forest situated in mapped coastal wetlands were also prepared. Assessments were based on comprehensive seasonal surveys involving the project management of eight ecologists. Mark utilised innovative techniques to assess the projects impacts on the Koala (i.e. use of detection dogs and foliage nutrient analysis). Other commissions included the preparation of Biodiversity Management Plan for a dedicated Conservation Area, Vegetation Management Plan and Aquatic Impact Assessment.

Woolooga Solar Farm, lightsourceBP, 2020 - 2021

Mark provided high level support to the RPS environment team assisting with Commonwealth assessment for a proposed solar farm in Woolooga, QLD. He also reviewed the RPS Biodiversity Management Plan (BMP) and Offset Management Plan (OMP) for this project.

Chaffey Dam, WaterNSW, 2020

Mark was involved in the reconfiguration of the approved Biodiversity Offset Strategy for the endangered Booroolong Frog. Involvement includes the reconsideration of offset mechanisms and locations in light of implementation challenges associated with land tenure, impacts of drought and broader conservation needs for the species. Mark is working with a team of specialists to achieve an improved offsetting outcome for the species.

Holsworthy Base Training Facility Project, 2020

A new training facility proposed on Commonwealth land within the Holsworthy Military Base required detailed biodiversity investigations and assessment against the Significant impact guidelines 1.2 - Actions on, or impacting upon, Commonwealth land and Actions by Commonwealth Agencies. Matters of National Environmental Significance identified (i.e. threatened species and ecological communities) were mapped and used to identify an impact footprint with the least impact on these matters (i.e. avoid, minimise). Assessments were performed for the Koala, a range of threatened flora and two critically endangered ecological communities. Mitigation measures were recommended.

Bulga to Broke Water Pipeline, Singleton Council, 2019

Biodiversity assessment for the installation of a water pipeline to supply potable water from Broke to Bulga. Works initially involved a routes selection process to determine the option with the least environmental impact. Detailed assessments were then performed for the preferred pipeline option, which included the mapping of site scale habitat to vegetation mapping including condition classes for critically endangered vegetation. Impact avoidance, minimisation and mitigation measures were provided within a Review of Environmental Factors assessment framework. State and Commonwealth assessments were performed for affected threatened species and ecological communities.

NBN Build, Visionstream, 2018 - 2019

Preparation of biodiversity assessments for multiple greenfield NBN Towers from Mullumbimby to Tallong (five sites). Biodiversity constraints were identified and managed within tight assessment timeframes to meet NBN delivery objectives.

NBN Build, Tata Consulting, 2016 - 2018

Preparation of biodiversity assessments for multiple greenfield NBN cabling installations from Tweed Heads to Merimbula and west to Braidwood (27 sites). Biodiversity constraints were identified and

managed within tight assessment timeframes to meet NBN delivery objectives.

Waterloo Road Upgrade, RMS, 2017

Mark prepared a specialist biodiversity assessment report as part of a Review of Environmental Factors for the Upgrade of Waterloo Road, North Ryde. Challenges successfully encountered included the management of roadside impacts on critically endangered ecological communities and threatened species habitat.

Wyong Hospital Enabling Works, Health Infrastructure NSW, 2016

Mark prepared a Flora and Fauna Assessment for the Wyong Hospital Enabling Works to inform a Review of Environmental Factors (REF). The approach adopted for field surveys for the Flora and Fauna Assessment was in accordance with the BioBanking Methodology (OEH 2014), enabling the surveys and results of the assessment to be transferrable to any BioBanking Assessments that may be required if the project became considered a Major Project (i.e. State Significant Infrastructure (SSI) or a State Significant Development (SSD)).

Bells Line of Road Upgrade, RMS, 2016 - 2017

Mark prepared a specialist biodiversity assessment report as part of a Review of Environmental Factors for the Upgrade of Bells Line of Road from Lithgow to Bell. Challenges successfully encountered included the management of roadside impacts on endangered ecological communities and threatened species habitat. Investigations included assessments for terrestrial and aquatic matters.

Finley Solar Farm EIS, ESCO, 2017

Mark was involved in RPS' preparation of an Environmental Impact Statement (EIS) for the Finley Solar Farm Project. The Finley Solar Farm would produce 170MW over 500 hectares of land. Numerous RPS service lines worked together to prepare the document. To date RPS have successfully liaised with the NSW Department of Planning and Environment, as well as the client, to progress the project smoothly in line with the desired outcomes.

Western Region Biodiversity Offset Strategy, Centennial Coal, 2018

Preparation of a biodiversity offset strategy for multiple approved coal mining operations in the NSW 'Western Coal Fields' near Lithgow. Involved a post hoc assessment of Project impacts and comparable offsets using the repealed Framework for Biodiversity Offsets (Major Projects) and Part 7A of the *Threatened Species Conservation Act* 1995. Demonstrated a suitable offset strategy for approved projects by gaining approval through the NSW Department of Planning and Environment and Office of Environment and Heritage.

Springvale Coal, Centennial Coal, 2018

Preparation and implementation of Biodiversity Management Plans (BMP) and Swamp Monitoring Programs (SMP) as subplans of Longwall Extractions Plans for the Springvale Coal Extension Project. BMPs and SMPs are reviewed by the Independent Monitoring Panel and State/ Commonwealth regulators prior to the approval of secondary coal extraction. Works involved the synthesis of a growing knowledge base on best practice monitoring and management of endangered upland peat swamps listed on State and Commonwealth legislation.

Albion Park, Tower Holdings, 2015 - 2016

Prepared Biodiversity Management Plans for the protection of State and Commonwealth listed endangered and critically endangered plant species (*Zieria granulata* and *Cynanchum elegans*) and ecological communities (Illawarra and South Coast Lowland Forest and Woodland). Management prescriptions centred on weed and fire management, with the latter linked to asset protection zones for the adjoining approved residential subdivision.

Rosewood Estate Tamworth, 2014 - 2015

Project managed and prepared Preliminary Documentation for a 'controlled action' declared under the EPBC Act. Assessment involved a detailed consideration of White Box Yellow Box Blakely's Redgum Grassy Woodland and Derived Native Grasslands, a critically endangered ecological community.

Mary's Mount Blue Metal Quarry, Gunnedah Quarry Products, 2013 - 2014

Project managed and prepared Preliminary Documentation for a 'controlled action' declared under the EPBC Act for a quarry project linked to the delivery of ballast needed for the inland rail project. Assessment involved the consideration of MNES impacted by the quarry including, but not restricted to Semi-evergreen Vine Thicket EEC and the Koala. Calculated and report biodiversity offset requirements in accordance with Commonwealth Offsets Policy and incorporated into a Biodiversity Offset Strategy.

Pacific Highway Upgrade: Oxley Highway to Kempsey, RMS, 2012 - 2014

Assisted in the procurement of approvals under State and Commonwealth legislation including participation in risk assessments, field surveys, reporting, project design and impact assessments (i.e. EPBC Act Preliminary Documentation). Performed monitoring surveys for the State listed *Maundia triglochinoides* and the State and Commonwealth listed Giant Barred Frog (*Mixophyes iteratus*) in accordance with a Before Impact Control After monitoring design. Analysed results and

reported findings including an evaluation of Project impacts and performance of mitigation measures.

Water Quality Monitoring Program, Orchard Hills Defence Facility, 2012

Prepared a Water Quality Monitoring Program for a defence facility in western Sydney. Monitoring works included measures of abiotic and biotic indicators for a catchment containing defence activities imbedded within a highly sensitive natural setting containing the critically endangered Cumberland Plan Woodland and nationally listed threatened species. The program included the monitoring of groundwater dependant ecosystems.

Midal Cabling Project, Midal Cabling, 2011 - 2012

The approved Midal aluminium cabling plant is a heavy industrial development located adjacent to the Tomago aluminium smelter. Mark's role in the approvals process involved the preparation of State and Commonwealth assessments for impacts on lands adjacent to the Tomago sands beds (Newcastle water supply). Considered impacts on the threatened New Holland Mouse and Ramsar Wetlands. The EPBC Act Referral adequately demonstrated that Project was not a controlled action.

Maitland to Minimbah Third Track Project, 2011 - 2012

As part of the Hunter8 Alliance, Mark performed integral part of the approvals, post approvals and biodiversity offsetting components of a 30 km section of new rail track constructed adjacent to the existing rail corridor between Maitland and Minimbah, NSW. Prepared and, implemented management plans for microbat exclusion from culverts, pre-clearance surveys and reporting, vegetation clearing audits, biodiversity offset site identification, evaluation and assessment.

Reconstruction of the Limbri to Weabonga Road, Tamworth Regional Council, 2011

Performed biodiversity surveys and assessment for the reconstruction of the Limbri to Weabonga Road following flood damage from the adjacent Swamp Oak Creek. The endangered Booroolong Tree Frog (*Litoria booroolongensis*) and Eel-tailed Catfish (*Tandanus tandanus*) were detected adjacent to the construction area. Impact minimisation involving the establishment of exclusion zones and frog hygiene (Chytrid control) was successfully used to avoid a significant impact on the species. Works could proceed in accordance with an EPBC Act 'Particular Manner' decision notice.

ELF Stage 2 Construction Biodiversity Assessment, Singleton Military Area, 2010

Prepared a Biodiversity Assessments for multiple defence training installations associated with the ELF program located within the Singleton Military Area. Included the assessment of development and operational impacts such as 'ballistic pruning' on threatened flora and fauna species including the Slaty Redgum (*Eucalyptus glaucina*) and habitat occupied by threatened woodland birds. Assessments adopted the 'good neighbour policy' (i.e. consideration of impacts on State listed threatened species and ecological communities).



Dan Creevey

Field Ecologist

Role at RPS
Field Ecologist

Location
Newcastle, NSW, Australia

Qualifications
Bachelor of Science

Why Dan Creevey for this role

At RPS, Dan is a Field Ecologist with experience in flora survey and monitoring techniques.

Dan Creevey is an adaptable, hardworking team member with a particular interest in botany. His exposure to several survey methods and ability to lead field and coordinate fieldwork suits him to this project.

Relevant projects

Kings Hill Development – Threatened Species and Vegetation Surveys & Mapping, 2018-2019

Assisted the RPS Ecology team in undertaking Targeted Threatened Species Searches and extensive Vegetation Mapping surveys.

LW22-24a and LW 25-31 Mandalong Coal Mine, Centennial Coal, 2019

Dan undertakes annual monitoring of sensitive ecological communities, as well as frogs, to detect impacts of longwall mining. Here, Dan works within a large team to undertake floristic plots and monitor threatened plants across a vast area.

Swamp Monitoring Project, Centennial Coal, 2019

Employing a variety of survey techniques to gather floristic data within Threatened Highland Peat Swamps on Sandstone (THPSS) vegetation community. Survey techniques include; monitoring ground control points, carrying out threatened species surveys and annual transect monitoring. Data was then analysed and reported to the client as part of ongoing monitoring programs.

Newstan Extension Ecology Assessment, Centennial Coal, 2019

Carrying out flora and fauna surveys for threatened species located above a proposed mine extension. These surveys involved walking wandering transects to locate threatened species, installing nest boxes and carrying out bird surveys. Data was then analysed and reported to the client.

Mandalong Annual Monitoring, Centennial Coal, 2019

Assisted in carrying out BAM plots in a variety of vegetation types. Data was then analysed and reported to the client as part of an ongoing monitoring program.

Threatened Flora Monitoring: *Astrotricha crassifolia* and *Prostanthera junonis*, Newcastle University, 2016-2017

Conducted fieldwork to assess the population dynamics of locate then monitor remanent populations.

Relevant projects

Springvale Blue Mountains Water Skink (*Eulamprus leurensis*) monitoring, Centennial Coal, 2019

Field monitoring to assess the population dynamics of Blue Mountains Water Skink within swamps of the Newnes Plateau.



Rhys Corrigan

Field Ecologist

Role at RPS
Field Ecologist

Location
Newcastle, NSW, Australia

Qualifications
Bachelor of Biotechnology (Hons), University of Newcastle, 2016

First Aid Certificate

White Card

4WD Ticket

Memberships
Member - Animal Care and Rescue Native Animal Trust Fund (Hunter Wildlife Rescue), 2016 - present

Why Rhys for this role

Rhys has over 5 years' field experience conducting various wildlife, vegetation and habitat assessments. He has a sound understanding of State and Commonwealth legislation, along with substantial experience in wildlife research, rehabilitation, and monitoring for the purpose of conservation.

His expertise lies in flora and fauna surveys and monitoring efforts; regularly preparing documentation and reports for clients in relation to monitoring programs and their outcomes.

Relevant projects

Newnes Plateau Shrub Swamp EEC, Centennial Coal Springvale, 2018 – present

Rhys was engaged on this large-scale, long term monitoring project of Endangered Ecological Communities (EEC) across the Newnes Plateau; adjacent to Springvale Colliery. Tasks included flora monitoring, due diligence, fauna and ecological community monitoring and biodiversity management planning. Rhys also provided data management, baseline, seasonal and annual reporting for the project.

Airly Coal Mine Flora and Fauna Surveys and Assessment, Centennial Coal, 2018 – present

Rhys undertook a range of flora and fauna surveys to inform the Annual Airly Coal Mine Flora and Fauna Report. Project tasks included diurnal bird surveys, assessment of fauna habitat quality and value to threatened species, identification of project impacts and measures to avoid or mitigate potential impacts.

Kings Hill Concept Plan, Kings Hill Developments, 2018 – present

Rhys assisted in the preparation of a Species Impact Statement for a 500 ha development site with focal species being the Koala, Brush-tailed Phascogale, woodland birds and threatened orchids. Documentation was based on comprehensive seasonal surveys; utilising innovative techniques to assess the projects impacts on the Koala.

Temperate Highland Peat Swamp (THPSS) Monitoring, Centennial Coal, 2019

Rhys is engaged for a complex seasonal and annual monitoring program for this State and Commonwealth listed threatened ecological community. Monitoring includes flora based repeated measures sampling within a BACI monitoring design and Soil Adjusted Normalised Vegetation Index (SANDVI) analysis of remotely sensed imagery (7cm resolution RGBI imagery) on a quarterly basis.

Relevant projects

Newstan Extension Ecology Assessment, Centennial Coal, 2019

Rhys undertook flora and fauna surveys for threatened species located above a proposed mine extension. These surveys involved walking wandering transects to locate threatened species, installing nest boxes and carrying out bird surveys. Data was then analysed and reported to the client.

Boronia Deanei Monitoring, Springvale Colliery, 2018 – 2019

Rhys assisted in the development of an innovative method to detect Boronia deanei from the spatial analysis of areal imagery in combination with field-based surveys. This resulted in the development of a cost and time effective methodology for the monitoring or this population over an area of 200km2.

Blue Mountains Water Skink (Eulamprus leurensis) monitoring, Centennial Coal, 2018 – 2019

Rhys assisted in the development of a habitat model for this species in correlation with field monitoring to assess the population dynamics of Blue Mountains Water Skink within swamps of the Newnes Plateau.

Large monitor species research, Western Australia, 2018*

Rhys performed trapping and manual handling of large monitor species (*V. panoptes*); dissection of reproductive tracts from specimens; recording data taken on morphometrics and reproductive tracts; engagement with local Indigenous communities to exchange information about the study; and assisted in cryopreservation of germ cells obtained from dissected specimens.

Project Manager, University of Newcastle for Newcastle Coal and Infrastructure Group, 2016 – 2018*

Responsible for managing the captive breeding program for endangered amphibians. This included managing and conducting the reintroduction and monitoring of green and golden bell frogs to the NCIG created habitat areas on Kooragang Island. Rhys organised, translocated, housed and monitored tadpoles in constructed offset habitat; developed effective ecological restoration strategies for endangered amphibians; regulated and maintained the health and well-being of the population.

Ecologist, University of Newcastle / University of Melbourne, 2015 – 2018*

Engaged to detect and quantify the amphibian chytrid fungus from samples using TaqMan qPCR assays for various clients using aseptic techniques.

Research for Conservation Biology Group, University of Newcastle, 2014 – 2016*

Rhys worked as part of the team to conduct research into the conservation of amphibians threatened with extinction. He conducted field surveys as part of the works for the Newcastle Coal and Infrastructure Group (NCIG); detected and quantified the amphibian chytrid fungus from samples using TaqMan qPCR assays in a controlled laboratory setting.

** projects undertaken for previous employers*



Tara Boreham

Ecologist

Role at RPS
Ecologist

Location
Newcastle, NSW, Australia

Qualifications
Bachelor of Science (Chemistry; Biology), Macquarie University

Certificate IV in Design

First Aid Certificate

White Card

Coal Order 43 Medical

Rail Industry Worker

RIIVEH305E Operate and maintain a four wheel drive vehicle

Why Tara for this role

Tara is an experienced Ecologist with a sound understanding of State and Commonwealth legislation. She has been involved in numerous Management Plans, Review of Environmental Factors, Biodiversity Assessments, flora and fauna targeted surveys, flora and fauna monitoring, vegetation surveys, weed mapping and Biodiversity Assessment Methodology surveys.

Tara has been responsible for desktop research and scientific database assessment, field surveys, reporting, mapping, data management and project management.

Relevant projects

Airly Coal Mine Flora and Fauna Surveys and Assessment, Centennial Coal, 2019 – present

Tara undertook a range of flora and fauna surveys to inform the Annual Airly Coal Mine Flora and Fauna Report. Project tasks included diurnal bird surveys, assessment of fauna habitat quality and value to threatened species, identification of project impacts and measures to avoid or mitigate potential impacts.

Newnes Plateau Shrub Swamp EEC, Centennial Coal Springvale, 2019 – present

Assistance on a long term monitoring project of Endangered Ecological Communities (EEC) across the Newnes Plateau; adjacent to Springvale Colliery. Tasks included flora monitoring, due diligence, fauna and ecological community monitoring and biodiversity management planning. Tara is also responsible for data management, mapping and aspects of reporting for the project.

Biodiversity Development Assessment Report, Centennial Coal Angus Place West, 2021

Tara was responsible for undertaking ecological investigations as according to the Biodiversity Assessment Methodology to inform a Biodiversity Development Assessment Report. She was responsible for field works, data management, plant identification and vegetation mapping.

Relevant projects

Review of Environmental Factors (Part 5)

The Horsley Drive Upgrade, Transport for NSW, 2021

Provision of a Biodiversity Assessment Report to inform the REF for the upgrade of The Horsley Drive, Fairfield.

Waratah West Cliffline Rehabilitation Works, Newcastle City Council, 2021

Provision of a Biodiversity Assessment Report to inform an REF for the rehabilitation of a cliff line in Waratah West.

Fern Creek Rehabilitation Works Warriewood, Northern Beaches Council, 2020*

Report reparation, site survey and mapping for the REF for the creek rehabilitation works and RFS creek crossing upgrades for the Northern Beaches Council. The project encountered a potential significant impact on the threatened Red-crowned Toadlet, therefore recommendations were made to first avoid and minimise impacts.

Centre Trail upgrade REF, NSW National Parks and Wildlife Service (NPWS), 2020*

Provision of a Review of Environmental Factors (REF) for the upgrade of Centre Trail fire trail in Ku-ring-gai Chase National Park.

Medowie Road Flora and Fauna Impact Assessment, Port Stephens Council, 2020*

Tara undertook a flora and fauna impact assessment at Medowie Road in Port Stephens.

Bundeena Drive REF, Sutherland Shire Council, 2020*

Provision of a Review of Environmental Factors (REF) for the reconstruction of a section of Bundeena Drive in the Royal National Park.

Dobroyd Head REF, NSW National Parks and Wildlife Service (NPWS), 2020*

Provision of a Review of Environmental Factors (REF) for the Dobroyd Head walking track upgrade.

Honeymoon Track Upgrade, NSW National Parks and Wildlife Service (NPWS), 2021*

Provision of a Constraints Assessment Report for the works on a popular walking track within the Royal National Park. The purpose of the report is to determine if sensitive features are present warranting the requirement for a Review of Environmental Factors (REF).

Two Creeks Track REF, NSW National Parks and Wildlife Service (NPWS), 2020*

Provision of a Review of Environmental Factors (REF) for the Two Creeks walking track upgrade.

Biodiversity Assessment Reports (Part 4)

Biodiversity Development Assessment Report, Private Landowner, 2020*

Provision of a Biodiversity Development Assessment Report (BDAR) for private development in Allambie Heights.

Georges River FFIA, Private Client, 2020*

Tara was engaged for the provision of a Flora and Fauna Impact Assessment (FFIA) for a development adjacent to the Georges River in the Canterbury-Bankstown LGA.

International Centre of Training Excellence FFIA, Blacktown City Council, 2020*

Tara undertook a Flora and Fauna Impact Assessment (FFIA) for the International Centre of Training Excellence at the Blacktown International Sports Park.

Targeted Threatened Species Searches

Dee Why Lagoon surveys, Northern Beaches Council, 2019-2020*

Tara undertook seasonal woodland and wetland bird surveys at Dee Why Lagoon for Northern Beaches Council.

Mustons Road Targeted Surveys, Port Stephens Council, 2020*

Tara undertook targeted Surveys for multiple cryptic threatened species at Mustons Road within the Port Stephens LGA.

Monitoring, MTE Developments, 2019 – 2020*

Tara undertook Dural Land Snail and Yellow-bellied Glider Monitoring at Cattai.

Targeted surveys, Centennial Coal, 2019 – 2020

Tara undertook targeted surveys for a number of threatened flora species and threatened species monitoring.

Cockle Creek catchment monitoring, Office of Environment and Heritage, 2020*

Tara undertook *Persoonia Mollis* subsp. *maxima* monitoring within the Cockle Creek catchment.

Biodiversity Monitoring

Newnes Plateau Shrub Swamp EEC, Centennial Coal Springvale, 2021 – present

Assistance on a long term monitoring project of Endangered Ecological Communities (EEC) across the Newnes Plateau; adjacent to Springvale Colliery. Tasks included flora monitoring, due diligence, fauna and ecological community monitoring and biodiversity management planning. Tara is also

responsible for data management, baseline, seasonal and annual reporting for the project.

Airly Coal Mine Flora and Fauna Surveys and Assessment, Centennial Coal, 2019 – present

Tara undertook a range of flora and fauna surveys to inform the Annual Airly Coal Mine Flora and Fauna Report. Project tasks included diurnal bird surveys, assessment of fauna habitat quality and value to threatened species, identification of project impacts and measures to avoid or mitigate potential impacts.

Vegetation Management Plans

Vegetation Management Plan, private client 2020*

Preparation of a three-year management plan for a private client within Sydney's north shore area aimed at habitat protection and enhancement.

Ecological Bushfire Management Plan, Williamtown and Orchard Hills RAAF, BGIS, 2020*

Preparation of a ecological bushfire management plan and environmental assessment as according to the RFS Bush Fire Environmental Assessment Code.

Vegetation and Heritage Management Plan, BGIS, 2020*

Preparation of a vegetation and heritage management plan for the historical garden at Glenbrook RAAF Base.

Vegetation Management Plan for Johnstons Creek Naturalisation, Diona/Sydney Water, 2020*

Preparation of a five year management plan for the vegetation within and surrounding Johnstons Creek in Annandale including management actions for the Coastal Saltmarsh Endangered Ecological Community.

Georges River Vegetation Management Plan, Private Client, 2020*

Provision of a Vegetation Management Plan for a development adjacent to the Georges River in the Canterbury-Bankstown LGA.

Biodiversity Action Plan, Waverley Council, 2020*

Provision of a Biodiversity Action Plan for remnant vegetation sites across the Waverly LGA.

Other specialist experience

Biodiversity study to inform a Local Environment Plan, Georges River Council, 2020

Desktop and field analysis of biodiversity hotspots within the local government area.

Post Fire Habitat Assessment, Centennial Coal, 2019

Tara undertook a Post Fire Habitat Assessment at Newnes Plateau for Centennial Coal.

Various floristic studies and bush regeneration, 2019-2020*

Bush regeneration, floristic studies and site monitoring at various sites across the Central Coast, Northern Beaches, Ku-ring-gai and Hornsby Shire LGAs, including works within the Umina Coastal Sandplain Woodland, Coorumbine Creek and ongoing WSUD maintenance.

Kangaroo River surveys, Macquarie University, 2018*

Tara undertook Kangaroo River longitudinal aquatic ecology surveys (AUSRIVA) and a rapid riparian assessment.

** projects undertaken for previous employers*

Appendix B

EPBC Act Protected Matters Search

Australian Government

Department of Agriculture, Water and the Environment

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

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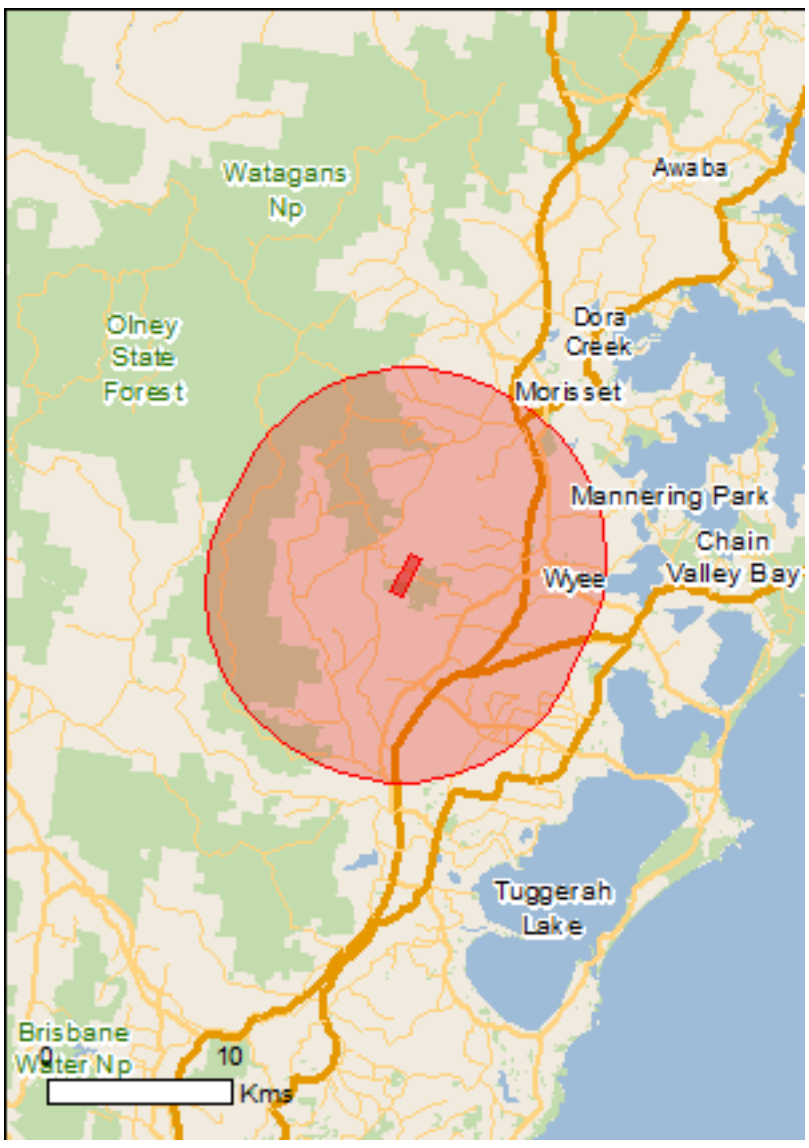
Summary

Details

- Matters of NES
- Other Matters Protected by the EPBC Act
- Extra Information

Caveat

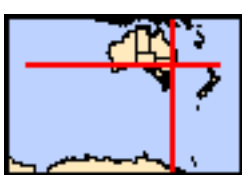
Acknowledgements



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Coordinates

Buffer: 10.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	3
Listed Threatened Species:	51
Listed Migratory Species:	20

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	1
Commonwealth Heritage Places:	None
Listed Marine Species:	26
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	2
Regional Forest Agreements:	1
Invasive Species:	49
Nationally Important Wetlands:	1
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community	Endangered	Community likely to occur within area
River-flat eucalypt forest on coastal floodplains of southern New South Wales and eastern Victoria	Critically Endangered	Community likely to occur within area
Subtropical and Temperate Coastal Saltmarsh	Vulnerable	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Anthochaera phrygia Regent Honeyeater [82338]	Critically Endangered	Species or species habitat known to occur within area
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Falco hypoleucos Grey Falcon [929]	Vulnerable	Species or species habitat may occur within area
Grantiella picta Painted Honeyeater [470]	Vulnerable	Species or species habitat likely to occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat known to occur within area
Limosa lapponica baueri Nunivak Bar-tailed Godwit, Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species

Name	Status	Type of Presence
		habitat known to occur within area
Pachyptila turtur subantarctica Fairy Prion (southern) [64445]	Vulnerable	Species or species habitat known to occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat known to occur within area
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Species or species habitat may occur within area
Thinornis cucullatus cucullatus Eastern Hooded Plover, Eastern Hooded Plover [90381]	Vulnerable	Species or species habitat may occur within area
Frogs		
Heleioporus australiacus Giant Burrowing Frog [1973]	Vulnerable	Species or species habitat likely to occur within area
Litoria aurea Green and Golden Bell Frog [1870]	Vulnerable	Species or species habitat known to occur within area
Litoria littlejohni Littlejohn's Tree Frog, Heath Frog [64733]	Vulnerable	Species or species habitat known to occur within area
Mixophyes balbus Stuttering Frog, Southern Barred Frog (in Victoria) [1942]	Vulnerable	Species or species habitat known to occur within area
Mixophyes iteratus Giant Barred Frog, Southern Barred Frog [1944]	Endangered	Species or species habitat known to occur within area
Mammals		
Chalinolobus dwyeri Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat known to occur within area
Dasyurus maculatus maculatus (SE mainland population) Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population) [75184]	Endangered	Species or species habitat known to occur within area
Petauroides volans Greater Glider [254]	Vulnerable	Species or species habitat known to occur within area
Petrogale penicillata Brush-tailed Rock-wallaby [225]	Vulnerable	Species or species habitat likely to occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT) Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat known to occur within area
Potorous tridactylus tridactylus Long-nosed Potoroo (SE Mainland) [66645]	Vulnerable	Species or species habitat likely to occur within area
Pseudomys novaehollandiae New Holland Mouse, Pookila [96]	Vulnerable	Species or species habitat known to occur within area
Pteropus poliocephalus Grey-headed Flying-fox [186]	Vulnerable	Roosting known to occur within area
Plants		

Name	Status	Type of Presence
Acacia bynoeana Bynoe's Wattle, Tiny Wattle [8575]	Vulnerable	Species or species habitat known to occur within area
Angophora inopina Charmhaven Apple [64832]	Vulnerable	Species or species habitat known to occur within area
Caladenia tessellata Thick-lipped Spider-orchid, Daddy Long-legs [2119]	Vulnerable	Species or species habitat likely to occur within area
Corunastylis insignis Wyong Midge Orchid 1, Variable Midge Orchid 1 [84692]	Critically Endangered	Species or species habitat known to occur within area
Cryptostylis hunteriana Leafless Tongue-orchid [19533]	Vulnerable	Species or species habitat known to occur within area
Cynanchum elegans White-flowered Wax Plant [12533]	Endangered	Species or species habitat likely to occur within area
Diuris praecox Newcastle Doubletail [55086]	Vulnerable	Species or species habitat likely to occur within area
Eucalyptus camfieldii Camfield's Stringybark [15460]	Vulnerable	Species or species habitat known to occur within area
Euphrasia arguta [4325]	Critically Endangered	Species or species habitat may occur within area
Genoplesium baueri Yellow Gnat-orchid, Bauer's Midge Orchid, Brittle Midge Orchid [7528]	Endangered	Species or species habitat may occur within area
Grevillea parviflora subsp. parviflora Small-flower Grevillea [64910]	Vulnerable	Species or species habitat known to occur within area
Melaleuca biconvexa Biconvex Paperbark [5583]	Vulnerable	Species or species habitat known to occur within area
Melaleuca deanei Deane's Melaleuca [5818]	Vulnerable	Species or species habitat may occur within area
Persicaria elatior Knotweed, Tall Knotweed [5831]	Vulnerable	Species or species habitat known to occur within area
Persoonia hirsuta Hairy Geebung, Hairy Persoonia [19006]	Endangered	Species or species habitat may occur within area
Rhizanthella slateri Eastern Underground Orchid [11768]	Endangered	Species or species habitat may occur within area
Rhodamnia rubescens Scrub Turpentine, Brown Malletwood [15763]	Critically Endangered	Species or species habitat known to occur within area
Rhodomyrtus psidioides Native Guava [19162]	Critically Endangered	Species or species habitat known to occur within area

Name	Status	Type of Presence
Rutidosis heterogama		
Heath Wrinklewort [13132]	Vulnerable	Species or species habitat known to occur within area
Syzygium paniculatum		
Magenta Lilly Pilly, Magenta Cherry, Daguba, Scrub Cherry, Creek Lilly Pilly, Brush Cherry [20307]	Vulnerable	Species or species habitat known to occur within area
Tetratheca juncea		
Black-eyed Susan [21407]	Vulnerable	Species or species habitat known to occur within area
Thelymitra adorata		
Wyong Sun Orchid [84724]	Critically Endangered	Species or species habitat known to occur within area
Thesium australe		
Austral Toadflax, Toadflax [15202]	Vulnerable	Species or species habitat may occur within area
Reptiles		
Hoplocephalus bungaroides		
Broad-headed Snake [1182]	Vulnerable	Species or species habitat likely to occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus		
Common Noddy [825]		Species or species habitat likely to occur within area
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Fregata minor		
Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat known to occur within area
Migratory Terrestrial Species		
Cuculus optatus		
Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area
Hirundapus caudacutus		
White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area
Monarcha melanopsis		
Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus		
Spectacled Monarch [610]		Species or species habitat may occur within area
Motacilla flava		
Yellow Wagtail [644]		Species or species habitat likely to occur within area
Myiagra cyanoleuca		
Satin Flycatcher [612]		Species or species habitat known to occur within area
Rhipidura rufifrons		
Rufous Fantail [592]		Species or species habitat known to occur within area
Migratory Wetlands Species		

Name	Threatened	Type of Presence
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land - Australian Telecommunications Commission

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Anous stolidus Common Noddy [825]		Species or species habitat likely to occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea ibis Cattle Egret [59542]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
[Calidris acuminata](#) Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
[Calidris canutus](#) Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
[Calidris ferruginea](#) Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
[Calidris melanotos](#) Pectoral Sandpiper [858]		Species or species habitat known to occur within area
[Fregata minor](#) Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat known to occur within area
[Gallinago hardwickii](#) Latham's Snipe, Japanese Snipe [863]		Species or species habitat known to occur within area
[Haliaeetus leucogaster](#) White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
[Hirundapus caudacutus](#) White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area
[Lathamus discolor](#) Swift Parrot [744]	Critically Endangered	Species or species habitat known to occur within area
[Limosa lapponica](#) Bar-tailed Godwit [844]		Species or species habitat known to occur within area
[Merops ornatus](#) Rainbow Bee-eater [670]		Species or species habitat may occur within area
[Monarcha melanopsis](#) Black-faced Monarch [609]		Species or species habitat known to occur within area
[Monarcha trivirgatus](#) Spectacled Monarch [610]		Species or species habitat may occur within area
[Motacilla flava](#) Yellow Wagtail [644]		Species or species habitat likely to occur within area
[Myiagra cyanoleuca](#) Satin Flycatcher [612]		Species or species habitat known to occur within area
[Numenius madagascariensis](#) Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
[Pachyptila turtur](#) Fairy Prion [1066]		Species or species habitat known to occur within area
[Pandion haliaetus](#) Osprey [952]		Species or species habitat known to occur

Name	Threatened	Type of Presence within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat known to occur within area
Thinornis rubricollis rubricollis Hooded Plover (eastern) [66726]	Vulnerable*	Species or species habitat may occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Jilliby	NSW
LNE Special Management Zone No1	NSW

Regional Forest Agreements [Resource Information]

Note that all areas with completed RFAs have been included.

Name	State
North East NSW RFA	New South Wales

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Alauda arvensis Skylark [656]		Species or species habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis European Goldfinch [403]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Lonchura punctulata Nutmeg Mannikin [399]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Pycnonotus jocosus Red-whiskered Bulbul [631]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Turdus merula Common Blackbird, Eurasian Blackbird [596]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat known to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Feral deer Feral deer species in Australia [85733]		Species or species habitat likely to occur within area
Lepus capensis Brown Hare [127]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Alternanthera philoxeroides Alligator Weed [11620]		Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Anredera cordifolia Madeira Vine, Jalap, Lamb's-tail, Mignonette Vine, Anredera, Gulf Madeiravine, Heartleaf Madeiravine, Potato Vine [2643]		Species or species habitat likely to occur within area
Asparagus aethiopicus Asparagus Fern, Ground Asparagus, Basket Fern, Sprengi's Fern, Bushy Asparagus, Emerald Asparagus [62425]		Species or species habitat likely to occur within area
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Asparagus plumosus Climbing Asparagus-fern [48993]		Species or species habitat likely to occur within area
Asparagus scandens Asparagus Fern, Climbing Asparagus Fern [23255]		Species or species habitat likely to occur within area
Cabomba caroliniana Cabomba, Fanwort, Carolina Watershield, Fish Grass, Washington Grass, Watershield, Carolina Fanwort, Common Cabomba [5171]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. monilifera Boneseed [16905]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera subsp. rotundata Bitou Bush [16332]		Species or species habitat likely to occur within area
Cytisus scoparius Broom, English Broom, Scotch Broom, Common Broom, Scottish Broom, Spanish Broom [5934]		Species or species habitat likely to occur within area
Dolichandra unguis-cati Cat's Claw Vine, Yellow Trumpet Vine, Cat's Claw Creeper, Funnel Creeper [85119]		Species or species habitat likely to occur within area
Eichhornia crassipes Water Hyacinth, Water Orchid, Nile Lily [13466]		Species or species habitat likely to occur within area
Genista monspessulana Montpellier Broom, Cape Broom, Canary Broom, Common Broom, French Broom, Soft Broom [20126]		Species or species habitat likely to occur within area
Genista sp. X Genista monspessulana Broom [67538]		Species or species habitat may occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Lycium ferocissimum African Boxthorn, Boxthorn [19235]		Species or species habitat likely to occur within area
Nassella neesiana Chilean Needle grass [67699]		Species or species habitat likely to occur within area
Opuntia spp. Prickly Pears [82753]		Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Pinus radiata Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Sagittaria platyphylla Delta Arrowhead, Arrowhead, Slender Arrowhead [68483]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Senecio madagascariensis Fireweed, Madagascar Ragwort, Madagascar Groundsel [2624]		Species or species habitat likely to occur within area
Ulex europaeus Gorse, Furze [7693]		Species or species habitat likely to occur within area

Nationally Important Wetlands	[Resource Information]
Name	State
Tuggerah Lake	NSW

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-33.189222 151.407781,-33.18678 151.402116,-33.171191 151.411472,-33.173418 151.416707,-33.189222 151.407781

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Appendix C

Likelihood of Occurrence

Scientific Name (Common Name)	BC Act	EPBC Act	Habitat	Records (DPIE 2021a)	Likelihood of Occurrence
Acacia bynoeana (Bynoe's Wattle)	E	V	Grows mainly in heath and dry sclerophyll forest in sandy soils. Mainly south of Dora Creek-Morisset area to Berrima and the Illawarra region, west to the Blue Mountains, also recorded from near Kurri Kurri in the Hunter Valley and from Morton National Park.	0	**Low**. Vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are present; however, species specific habitat types (i.e. important habitat features) are either absent, in low abundance and/ or in a disturbed state. The Project Area is likely to be located outside the species known 'area of occurrence' but may be within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are likely to be negatively influencing the likelihood of habitat occupancy. If detected, species activity is most likely low and associated with landscape scale habitat use such as movement between areas of higher value habitat, the use of supplementary habitat or reflect the negative effects of active/ uncontrolled KTPs. Species not recently observed in the locality (NSW BioNet records).
Angophora inopina	V	V	Endemic to the Central Coast region of NSW. The known northern limit is near Karuah where a disjunct population occurs; to the south populations extend from Toronto to Charmhaven with the main population occurring between Charmhaven and Morisset. Occurs most frequently in red bloodwood – scribbly gum woodland, wet heath, red mahogany – paperbark sedge woodland and stringybark – red bloodwood forest.	5	**Low**. Vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are present; however, species specific habitat types (i.e. important habitat features) are either absent, in low abundance and/ or in a disturbed state. The Project Area is likely to be located outside the species known 'area of occurrence' but may be within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are likely to be negatively influencing the likelihood of habitat occupancy. If detected, species activity is most likely low and associated with landscape scale habitat use such as movement between areas of higher value habitat, the use of supplementary habitat or reflect the negative effects of active/ uncontrolled KTPs. Species recently observed in the locality (NSW BioNet records).
Anseranas semipalmata (Magpie Goose)	V	-	Mainly found in shallow wetlands less than 1 m deep, with a dense growth of rushes or sedges.	0	**None**. Species specific habitat types (i.e. important habitat features) and known vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are absent from the Project Area. The Project Area is also likely located outside the species known 'area of occurrence' and may also occur outside the species 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Species incidence is not expected and, if detected, would likely represent atypical

Scientific Name (Common Name)	BC Act	EPBC Act	Habitat	Records (DPIE 2021a)	Likelihood of Occurrence
					occurrence (e.g. incidence linked with transient activity). Presence unlikely associated with habitat occupancy involving important lifecycle processes.
Anthochaera phrygia (Regent Honeyeater)	CE	E,M	The Regent Honeyeater mainly inhabits temperate woodlands and open forests of the inland slopes of south-east Australia. Birds are also found in drier coastal woodlands and forests in some years. The distribution of the species has contracted dramatically in the last 30 years to between north-eastern Victoria and south-eastern Queensland. There are only three known key breeding regions remaining: north-east Victoria (Chiltern-Albury), and in NSW at Capertee Valley and the Bundarra-Barraba region. In NSW the distribution is very patchy and mainly confined to the two main breeding areas and surrounding fragmented woodlands. In some years flocks converge on flowering coastal woodlands and forests.	0	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Not recently observed in the locality (NSW BioNet records).
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 and spikerushes.	0	**None**. Species specific habitat types (i.e. important habitat features) and known vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are absent from the Project Area. The Project Area is also likely located outside the species known 'area of occurrence' and may also occur outside the species 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Species incidence is not expected and, if detected, would likely represent atypical occurrence (e.g. incidence linked with transient activity). Presence unlikely associated with habitat occupancy involving important lifecycle processes.
Burhinus grallarius (Bush Stone-curlew)	E	-	The Bush Stone-curlew is found throughout Australia except for the central southern coast and inland, the far south-east corner, and Tasmania. Only in northern Australia is it still common however and in the south-east it is either rare or extinct throughout its former range. Inhabits open forests and woodlands with a sparse grassy groundlayer and fallen timber. Largely nocturnal, being especially active on moonlit nights.	0	**Low**. Vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are present; however, species specific habitat types (i.e. important habitat features) are either absent, in low abundance and/ or in a disturbed state. The Project Area is likely to be located outside the species known 'area of occurrence' but may be within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are likely to be negatively influencing the likelihood of habitat occupancy. If detected, species

Scientific Name (Common Name)	BC Act	EPBC Act	Habitat	Records (DPIE 2021a)	Likelihood of Occurrence
					activity is most likely low and associated with landscape scale habitat use such as movement between areas of higher value habitat, the use of supplementary habitat or reflect the negative effects of active/ uncontrolled KTPs. Not recently observed in the locality (NSW BioNet records).
Caladenia tessellata (Thick-lip Spider Orchid)	E	V	The Tessellated Spider Orchid is found in grassy sclerophyll woodland on clay loam or sandy soils, though the population near Braidwood is in low woodland with stony soil. Known from the Sydney area (old records), Wyong, Ulladulla and Braidwood in NSW. Populations in Kiama and Queanbeyan are presumed extinct.	0	**None**. Species specific habitat types (i.e. important habitat features) and known vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are absent from the Project Area. The Project Area is also likely located outside the species known 'area of occurrence' and may also occur outside the species 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Species incidence is not expected and, if detected, would likely represent atypical occurrence (e.g. incidence linked with transient activity). Presence unlikely associated with habitat occupancy involving important lifecycle processes.
Calidris canutus (Red Knot)	-	E	The Red Knot is common in all the main suitable habitats around the coast of Australia. Very large numbers are regularly recorded in north-west Australia, with 80 Mile Beach and Roebuck Bay being particular strongholds. The only places it is not found in significant numbers are the northern part of the Great Australian Bight in South Australia and Western Australia, and along much of the NSW coast, where wader habitat is rather scarce (excluding the Hunter Estuary). It is widespread along the coast south of Townsville and along the coasts of NSW and Victoria. In Australasia the Red Knot mainly inhabit intertidal mudflats, sandflats and sandy beaches of sheltered coasts, in estuaries, bays, inlets, lagoons and harbours; sometimes on sandy ocean beaches or shallow pools on exposed wave-cut rock platforms or coral reefs. They are occasionally seen on terrestrial saline wetlands near the coast, such as lakes, lagoons, pools and pans, and recorded on sewage ponds and saltworks, but rarely use freshwater swamps. They rarely use inland lakes or swamps.	0	**None**. Species specific habitat types (i.e. important habitat features) and known vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are absent from the Project Area. The Project Area is also likely located outside the species known 'area of occurrence' and may also occur outside the species 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Species incidence is not expected and, if detected, would likely represent atypical occurrence (e.g. incidence linked with transient activity). Presence unlikely associated with habitat occupancy involving important lifecycle processes.
Calidris ferruginea (Curlew Sandpiper)	E	-	The Curlew Sandpiper is distributed around most of the coastline of Australia. It occurs along the entire coast of	0	**None**. Species specific habitat types (i.e. important habitat features) and known vegetation classification based habitat

Scientific Name (Common Name)	BC Act	EPBC Act	Habitat	Records (DPIE 2021a)	Likelihood of Occurrence
			NSW, particularly in the Hunter Estuary, and sometimes in freshwater wetlands in the Murray-Darling Basin. It generally occupies littoral and estuarine habitats, and in New South Wales is mainly found in intertidal mudflats of sheltered coasts. It also occurs in non-tidal swamps, lakes and lagoons on the coast and sometimes the inland		surrogates (i.e. PCT and/ or vegetation formations) are absent from the Project Area. The Project Area is also likely located outside the species known 'area of occurrence' and may also occur outside the species 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Species incidence is not expected and, if detected, would likely represent atypical occurrence (e.g. incidence linked with transient activity). Presence unlikely associated with habitat occupancy involving important lifecycle processes.
Callocephalon fimbriatum (Gang-gang Cockatoo)	V	-	In summer, occupies tall montane forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests. Also occur in subalpine snow gum woodland and occasionally in temperate or regenerating forest. In winter, occurs at lower altitudes in drier, more open eucalypt forests and woodlands, particularly in box-ironbark assemblages, or in dry forest in coastal areas. It requires tree hollows in which to breed.	2	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Species recently observed in the locality (NSW BioNet records).
Calyptorhynchus lathami (Glossy Black-Cockatoo)	V	-	Inhabits forest with low nutrients, characteristically with key Allocasuarina spp. Tends to prefer drier forest types with a middle stratum of Allocasuarina below Eucalyptus or Angophora. Often confined to remnant patches in hills and gullies. Breed in hollows stumps or limbs, either living or dead. Endangered population in the Riverina.	9	**Known**. Species observed and habitat values within the Project Area are generally consistent with descriptions provided in the BCD TSPD. Habitat is located within known 'extent of occurrence' and 'area of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Habitat occupancy is likely to be associated with important life cycle processes; however, the reliance on this habitat would depend on additional factors (e.g. size and extent of local population, effect of KTPs). Species recently observed in the locality (NSW BioNet records).
Cercartetus nanus (Eastern Pygmy-possum)	V	-	Inhabits rainforest through to sclerophyll forest and tree heath. Banksias and myrtaceous shrubs and trees are a favoured food source. Will often nest in tree hollows, but can also construct its own nest . Because of its small size it is able to utilise a range of hollow sizes including very small hollows. Individuals will use a number of different hollows and an individual has been recorded	0	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat

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			using up to 9 nest sites within a 0.5ha area over a 5 month period.		quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Not recently observed in the locality (NSW BioNet records).
Chalinolobus dwyeri (Large-eared Pied Bat)	V	V	Located in a variety of drier habitats, including the dry sclerophyll forests and woodlands to the east and west of the Great Dividing Range. Can also be found on the edges of rainforests and in wet sclerophyll forests. This species roosts in caves and mines in groups of between 3 and 37 individuals.	5	**High**. Habitat values within the Project Area are generally consistent with descriptions provided in the BCD TSPD. Habitat is likely to be located within the known 'extent of occurrence' and 'area of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are unlikely to adversely influence the capacity of the species to occupy the habitat. Pre-existing and active KTPs are unlikely to be substantially influencing species incidence and/ or habitat occupancy. Species recently observed in the locality (NSW BioNet records).
Chthonicola sagittata (Speckled Warbler)	V	-	The Speckled Warbler lives in a wide range of eucalypt dominated communities that have a grassy understorey, often on rocky ridges or in gullies. Typical habitat would include scattered native tussock grasses, a sparse shrub layer, some eucalypt regrowth and an open canopy.	0	**High**. Habitat values within the Project Area are generally consistent with descriptions provided in the BCD TSPD. Habitat is likely to be located within the known 'extent of occurrence' and 'area of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are unlikely to adversely influence the capacity of the species to occupy the habitat. Pre-existing and active KTPs are unlikely to be substantially influencing species incidence and/ or habitat occupancy. Not recently observed in the locality (NSW BioNet records).
Climacteris picumnus victoriae (Brown Treecreeper (eastern subspecies))	V	-	Found in eucalypt woodlands (including box-gum woodland) and dry open forest of the inland slopes and plains inland of the Great Dividing Range; mainly inhabits woodlands dominated by stringybarks or other rough-barked eucalypts, usually with an open grassy understorey, sometimes with one or more shrub species; also found in mallee and river red gum forest bordering wetlands with an open understorey of acacias, saltbush, lignum, cumbungi and grasses; usually not found in woodlands with a dense shrub layer; fallen timber is an important habitat component for foraging; also recorded,	2	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Species recently observed in the locality (NSW BioNet records).

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			though less commonly, in similar woodland habitats on the coastal ranges and plains.		
Corybas dowlingii	E	-	Sheltered areas such as gullies and southerly slopes in tall open forest on well-drained gravelly soil at elevations of 10-200 m.	18	**High**. Habitat values within the Project Area are generally consistent with descriptions provided in the BCD TSPD. Habitat is likely to be located within the known 'extent of occurrence' and 'area of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are unlikely to adversely influence the capacity of the species to occupy the habitat. Pre-existing and active KTPs are unlikely to be substantially influencing species incidence and/ or habitat occupancy. Species recently observed in the locality (NSW BioNet records).
Cryptostylis hunteriana (Leafless Tongue-orchid)	V	V	Does not appear to have well defined habitat preferences and is known from a range of communities, including swamp-heath and woodland. The larger populations typically occur in woodland dominated by Scribbly Gum (Eucalyptus sclerophylla), Silvertop Ash (E. sieberi), Red Bloodwood (Corymbia gummifera) and Black Sheoak (Allocasuarina littoralis); appears to prefer open areas in the understorey of this community and is often found in association with the Large Tongue Orchid (C. subulata) and the Tartan Tongue Orchid (C. erecta).	0	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known ‘area of occurrence’ but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Species not recently observed in the locality (NSW BioNet records).
Cynanchum elegans (White-flowered Wax Plant)	E	E	Recorded from rainforest gullies scrub and scree slopes from the Gloucester district to the Wollongong area and inland to Mt Dangar.	0	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known ‘area of occurrence’ but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Species not recently observed in the locality (NSW BioNet records).

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Daphoenositta chrysoptera (Varied Sittella)	V	-	Inhabits wide variety of dry eucalypt forests and woodlands, usually with either shrubby under storey or grassy ground cover or both, in all climatic zones of Australia. Usually in areas with rough-barked trees, such as stringybarks or ironbarks, but also in paperbarks or mature Eucalypts with hollows.	2	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Species recently observed in the locality (NSW BioNet records).
Dasyornis brachypterus (Eastern Bristlebird)	E	E	Found in coastal woodlands, dense scrub and heathlands, particularly where it borders taller woodlands.	0	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Not recently observed in the locality (NSW BioNet records).
Dasyurus maculatus maculatus (Spotted-tailed Quoll)	V	E	Spotted-tailed Quoll are found on the east coast of NSW, Tasmania, eastern Victoria and north-eastern Queensland. Only in Tasmania is it still considered common. Recorded across a range of habitat types, including rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline.	0	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Not recently observed in the locality (NSW BioNet records).

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Diuris praecox (Rough Doubletail)	V	V	Occurs between Ourimbah and Nelson Bay. Grows on hills and slopes of near-coastal districts in open forests which have a grassy to fairly dense understorey. Exists as subterranean tubers most of the year. It produces leaves and flowering stems in winter.	0	**Low**. Vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are present; however, species specific habitat types (i.e. important habitat features) are either absent, in low abundance and/ or in a disturbed state. The Project Area is likely to be located outside the species known 'area of occurrence' but may be within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are likely to be negatively influencing the likelihood of habitat occupancy. If detected, species activity is most likely low and associated with landscape scale habitat use such as movement between areas of higher value habitat, the use of supplementary habitat or reflect the negative effects of active/ uncontrolled KTPs. Species not recently observed in the locality (NSW BioNet records).
Ephippiorhynchus asiaticus (Black-necked Stork)	E	-	Mainly found on shallow, permanent, freshwater terrestrial wetlands, and surrounding marginal vegetation, including swamps, floodplains, watercourses and billabongs, freshwater meadows, wet heathland, farm dams and shallow floodwaters, as well as extending into adjacent grasslands, paddocks and open savannah woodlands. They also forage within or around estuaries and along intertidal shorelines, such as saltmarshes, mudflats and sandflats, and mangrove vegetation.	0	**None**. Species specific habitat types (i.e. important habitat features) and known vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are absent from the Project Area. The Project Area is also likely located outside the species known 'area of occurrence' and may also occur outside the species 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Species incidence is not expected and, if detected, would likely represent atypical occurrence (e.g. incidence linked with transient activity). Presence unlikely associated with habitat occupancy involving important lifecycle processes.
Eucalyptus camfieldii	V	V	Restricted distribution in a narrow band with the most northerly records in the Raymond Terrace Area south to Waterfall. Localised and scattered distribution includes sites at Norah Head (Tuggerah Lakes), Peats Ridge, Mt Colah, Elvina Bay Trail (West Head), Terrey Hills, Killara, North Head, Menai, Wattamolla and a few other sites in Royal National Park. Poor coastal country in shallow sandy soils overlying Hawkesbury sandstone. Coastal heath mostly on exposed sandy ridges. Occurs mostly in small scattered stands near the boundary of tall coastal heaths and low open woodland of the slightly more fertile inland areas.	0	**Low**. Vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are present; however, species specific habitat types (i.e. important habitat features) are either absent, in low abundance and/ or in a disturbed state. The Project Area is likely to be located outside the species known 'area of occurrence' but may be within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are likely to be negatively influencing the likelihood of habitat occupancy. If detected, species activity is most likely low and associated with landscape scale habitat use such as movement between areas of higher value

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					habitat, the use of supplementary habitat or reflect the negative effects of active/ uncontrolled KTPs. Species not recently observed in the locality (NSW BioNet records).
Euphrasia arguta	CE	CE	Occur in eucalypt forest with a mixed grass and shrub understorey within Nundle State forest. Sites have either been logged in the last few decades, or appear to have regrown from past clearing.	0	**Low**. Vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are present; however, species specific habitat types (i.e. important habitat features) are either absent, in low abundance and/ or in a disturbed state. The Project Area is likely to be located outside the species known 'area of occurrence' but may be within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are likely to be negatively influencing the likelihood of habitat occupancy. If detected, species activity is most likely low and associated with landscape scale habitat use such as movement between areas of higher value habitat, the use of supplementary habitat or reflect the negative effects of active/ uncontrolled KTPs. Species not recently observed in the locality (NSW BioNet records).
Falco hypoleucos (Grey Falcon)	E	-	Usually restricted to shrubland, grassland and wooded watercourses of arid and semi-arid regions, although it is occasionally found in open woodlands near the coast. Also occurs near wetlands where surface water attracts prey.	0	**Low**. Vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are present; however, species specific habitat types (i.e. important habitat features) are either absent, in low abundance and/ or in a disturbed state. The Project Area is likely to be located outside the species known 'area of occurrence' but may be within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are likely to be negatively influencing the likelihood of habitat occupancy. If detected, species activity is most likely low and associated with landscape scale habitat use such as movement between areas of higher value habitat, the use of supplementary habitat or reflect the negative effects of active/ uncontrolled KTPs. Not recently observed in the locality (NSW BioNet records).
Falsistrellus tasmaniensis (Eastern False Pipistrelle)	V	-	Inhabit sclerophyll forests, preferring wet habitats where trees are more than 20 m high. Two observations have been made of roosts in stem holes of living eucalypts. There is debate about whether or not this species moves to lower altitudes during winter, or whether they remain	1	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known

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			sedentary but enter torpor . This species also appears to be highly mobile and records showing movements of up to 12 km between roosting and foraging sites .		'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Species recently observed in the locality (NSW BioNet records).
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.	0	**Low**. Vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are present; however, species specific habitat types (i.e. important habitat features) are either absent, in low abundance and/ or in a disturbed state. The Project Area is likely to be located outside the species known 'area of occurrence' but may be within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are likely to be negatively influencing the likelihood of habitat occupancy. If detected, species activity is most likely low and associated with landscape scale habitat use such as movement between areas of higher value habitat, the use of supplementary habitat or reflect the negative effects of active/ uncontrolled KTPs. Species not recently observed in the locality (NSW BioNet records).
Genoplesium insigne (Variable Midge Orchid)	E	-	Grows in patches of kangaroo grass amongst shrubs and sedges in heathland and forest. Associated vegetation at Chain Valley Bay is described as dry sclerophyll woodland dominated by scribbly gum, red bloodwood, smooth-barked apple and black she-oak.	3	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Species recently observed in the locality (NSW BioNet records).
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	11	**High**. Habitat values within the Project Area are generally consistent with descriptions provided in the BCD TSPD. Habitat is likely to be located within the known 'extent of occurrence' and 'area of occurrence' [i.e. standard grid size of

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			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.		2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are unlikely to adversely influence the capacity of the species to occupy the habitat. Pre-existing and active KTPs are unlikely to be substantially influencing species incidence and/ or habitat occupancy. Species recently observed in the locality (NSW BioNet records).
Grantiella picta (Painted Honeyeater)	V	-	The Painted Honeyeater is nomadic and occurs at low densities throughout its range. The greatest concentrations of the bird and almost all breeding occurs on the inland slopes of the Great Dividing Range in NSW, Victoria and southern Queensland. During the winter it is more likely to be found in the north of its distribution. Inhabits boree, brigalow and box-gum woodlands and box-ironbark forests.	0	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Not recently observed in the locality (NSW BioNet records).
Grevillea parviflora subsp. parviflora (Small-flowered Grevillea)	V	V	Grows in sandy or light clay soils usually over thin shales. Occurs in a range of vegetation types from heath and shrubby woodland to open forest. Found over a range of altitudes from flat, low-lying areas to upper slopes and ridge crests. Often occurs in open, slightly disturbed sites such as along tracks.	8	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Species recently observed in the locality (NSW BioNet records).
Haliaeetus leucogaster (White-bellied Sea-Eagle)	V	M	Inhabits coastal and near coastal areas, building large stick nests, and feeding mostly on marine and estuarine fish and aquatic fauna.	2	**High**. Habitat values within the Project Area are generally consistent with descriptions provided in the BCD TSPD. Habitat is likely to be located within the known 'extent of occurrence' and 'area of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are unlikely to adversely influence the capacity of the species to occupy the habitat.

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					Pre-existing and active KTPs are unlikely to be substantially influencing species incidence and/ or habitat occupancy. Species recently observed in the locality (NSW BioNet records).
Heleioporus australiacus (Giant Burrowing Frog)	V	V	The Giant Burrowing Frog has been recorded breeding in a range of water bodies associated with more sandy environments of the coast and adjacent ranges from the Sydney Basin south the eastern Victoria. It breeds in hanging swamps, perennial non-flooding creeks and occasionally permanent pools, but permanent water must be present to allow its large tadpoles time to reach metamorphosis.	0	**Low**. Vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are present; however, species specific habitat types (i.e. important habitat features) are either absent, in low abundance and/ or in a disturbed state. The Project Area is likely to be located outside the species known 'area of occurrence' but may be within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are likely to be negatively influencing the likelihood of habitat occupancy. If detected, species activity is most likely low and associated with landscape scale habitat use such as movement between areas of higher value habitat, the use of supplementary habitat or reflect the negative effects of active/ uncontrolled KTPs. Not recently observed in the locality (NSW BioNet records).
Hirundapus caudacutus (White-throated Needletail)	-	M	An aerial species found in feeding concentrations over cities, hilltops and timbered ranges.	1	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Species recently observed in the locality (NSW BioNet records).
Hoplocephalus bitorquatus (Pale-headed Snake)	V	-	The Pale-Headed Snake has a patchy distribution from north-east Queensland to north-east NSW. In NSW it occurs from the coast to the western side of the Great Divide as far south as Tuggerah and out to the western plains. It is found mainly in dry eucalypt forests and woodlands, cypress woodland and occasionally in rainforest or moist eucalypt forest where it favours	0	**Low**. Vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are present; however, species specific habitat types (i.e. important habitat features) are either absent, in low abundance and/ or in a disturbed state. The Project Area is likely to be located outside the species known 'area of occurrence' but may be within the known 'extent of occurrence' [i.e. standard grid size of 2x2km

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			streamside areas, particularly in drier habitats. They shelter during under loose bark or in hollows and have a preference for frogs as prey, although lizards and small mammals are also taken. This species breeds and shelters in hollows in live and dead trees and in and under fallen timber. It is best detected from mid spring to mid autumn and is mostly nocturnal.		(IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are likely to be negatively influencing the likelihood of habitat occupancy. If detected, species activity is most likely low and associated with landscape scale habitat use such as movement between areas of higher value habitat, the use of supplementary habitat or reflect the negative effects of active/ uncontrolled KTPs. Not recently observed in the locality (NSW BioNet records).
Hoplocephalus bungaroides (Broad-headed Snake)	E	V	Occurs almost exclusively in association with communities occurring on Triassic sandstone within the Sydney Basin. Typically found among exposed sandstone outcrops with vegetation types ranging from woodland to heath. Within these habitats they spend most of the year sheltering in and under rock crevices and exfoliating rock. However, some individuals will migrate to tree hollows to find shelter during hotter parts of summer.	0	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Not recently observed in the locality (NSW BioNet records).
Hoplocephalus stephensii (Stephens' Banded Snake)	V	-	The Stephens Banded Snake is found through the coast and adjacent ranges of NSW from the Central Coast northwards and into SE Queensland. It is most commonly found living in wet sclerophyll and rainforest areas, but can be found in taller dry forest areas and even in some areas of dry forest where there is significant rock outcropping. They spend the majority of the time in tree tops, either in large hollows or in dense vegetation, coming to the gound for forage for a range of vertebrates.	0	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Not recently observed in the locality (NSW BioNet records).
Irediparra gallinacea (Comb-crested Jacana)	V	-	Inhabits permanent wetlands with a good surface cover of floating vegetation, especially water-lilies.	0	**None**. Species specific habitat types (i.e. important habitat features) and known vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are absent from the Project Area. The Project Area is also likely located outside the species known 'area of occurrence' and may also occur outside the species 'extent of occurrence' [i.e. standard

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					grid size of 2x2km (IUCN 2017)]. Species incidence is not expected and, if detected, would likely represent atypical occurrence (e.g. incidence linked with transient activity). Presence unlikely associated with habitat occupancy involving important lifecycle processes.
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.	0	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Not recently observed in the locality (NSW BioNet records).
Limosa lapponica (Bar-tailed Godwit)	-	M	Found mainly in coastal habitats such as large intertidal sandflats, banks, mudflats, estuaries, inlets, harbours, coastal lagoons and bays. It is found often around beds of seagrass and, sometimes, in nearby saltmarsh. It has been sighted in coastal sewage farms and saltworks, saltlakes and brackish wetlands near coasts, sandy ocean beaches, rock platforms, and coral reef-flats. It is rarely found on inland wetlands or in areas of short grass, such as farmland, paddocks and airstrips, although it is commonly recorded in paddocks at some locations overseas.	0	**None**. Species specific habitat types (i.e. important habitat features) and known vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are absent from the Project Area. The Project Area is also likely located outside the species known 'area of occurrence' and may also occur outside the species 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Species incidence is not expected and, if detected, would likely represent atypical occurrence (e.g. incidence linked with transient activity). Presence unlikely associated with habitat occupancy involving important lifecycle processes.
Litoria aurea (Green and Golden Bell Frog)	E	V	Inhabits a very wide range of water bodies including marshes, dams and streams, particularly those containing emergent vegetation such as bullrushes or spikerushes. It also inhabits numerous types of man-made water bodies including quarries and sand extraction sites. Optimum habitat includes water-bodies that are un-shaded, free of predatory fish such as Plague Minnow, have a grassy area nearby and diurnal sheltering sites available.	0	**Low**. Vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are present; however, species specific habitat types (i.e. important habitat features) are either absent, in low abundance and/ or in a disturbed state. The Project Area is likely to be located outside the species known 'area of occurrence' but may be within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are likely to be negatively influencing the likelihood of habitat occupancy. If detected, species

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					activity is most likely low and associated with landscape scale habitat use such as movement between areas of higher value habitat, the use of supplementary habitat or reflect the negative effects of active/ uncontrolled KTPs. Not recently observed in the locality (NSW BioNet records).
Litoria brevipalmata (Green-thighed Frog)	V	-	This species is distributed from south-east Queensland to the NSW Central Coast. It occurs in a range of habitat types including rainforest, moist eucalypt forest, dry eucalypt forest and heath, but is most closely associated with wetter forest types in the southern part of its range. Calling and breeding is highly correlated with heavy rainfalls that lead to the formation of large ephemeral pools in a range of sites, but always in association with some native vegetation. Calling occurring only for one or two nights at a time anywhere between September and May.	1	**High**. Habitat values within the Project Area are generally consistent with descriptions provided in the BCD TSPD. Habitat is likely to be located within the known 'extent of occurrence' and 'area of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are unlikely to adversely influence the capacity of the species to occupy the habitat. Pre-existing and active KTPs are unlikely to be substantially influencing species incidence and/ or habitat occupancy. Species recently observed in the locality (NSW BioNet records).
Litoria littlejohni (Littlejohn's Tree Frog)	V	V	Occurs in wet and dry sclerophyll forests and heathland associated with sandstone outcrops between 280 and 1000 m on the eastern slopes of the Great Dividing Range from the Central Coast down into Victoria. Individuals have been collected from a wide range of water bodies that includes semi-permanent dams, permanent ponds, temporary pools and permanent streams, with calling occurring from fringing vegeation or on the banks. Individuals have been observed sheltering under rocks on high exposed ridges during summer and within deep leaf litter adjacent to the breeding site. Calling occurs in all months of the year, often in association with heavy rains. The tadpoles are distinctive, being large and very dark in colouration.	0	**Low**. Vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are present; however, species specific habitat types (i.e. important habitat features) are either absent, in low abundance and/ or in a disturbed state. The Project Area is likely to be located outside the species known ‘area of occurrence’ but may be within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are likely to be negatively influencing the likelihood of habitat occupancy. If detected, species activity is most likely low and associated with landscape scale habitat use such as movement between areas of higher value habitat, the use of supplementary habitat or reflect the negative effects of active/ uncontrolled KTPs. Not recently observed in the locality (NSW BioNet records).
Lophoictinia isura (Square-tailed Kite)	V	-	Typically inhabits coastal forested and wooded lands of tropical and temperate Australia. In NSW it is often associated with ridge and gully forests dominated by Eucalyptus longifolia, Corymbia maculata, E. elata or E. smithii. Individuals appear to occupy large hunting ranges of more than 100km2. They require large living trees for breeding, particularly near water with	1	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known ‘area of occurrence’ but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat

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			surrounding woodland -forest close by for foraging habitat. Nest sites are generally located along or near watercourses, in a tree fork or on large horizontal limbs.		quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Species recently observed in the locality (NSW BioNet records).
Macropus parma (Parma Wallaby)	V	-	Once occurred from north-eastern NSW to the Bega area in the southeast. Their range is now confined to the coast and ranges of central and northern NSW from the Gosford district to the Queensland border. Preferred habitat is moist eucalypt forest with thick, shrubby understorey, often with nearby grassy areas, rainforest margins and occasionally drier eucalypt forest.	0	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Not recently observed in the locality (NSW BioNet records).
Maundia triglochinoides	V	-	Grows in swamps, creeks or shallow freshwater 30 - 60 cm deep on heavy clay, low nutrients. Flowering occurs during warmer months. Diaspore is the seed and root tubers, which are probably dispersed by water.	3	**Low**. Vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are present; however, species specific habitat types (i.e. important habitat features) are either absent, in low abundance and/ or in a disturbed state. The Project Area is likely to be located outside the species known 'area of occurrence' but may be within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are likely to be negatively influencing the likelihood of habitat occupancy. If detected, species activity is most likely low and associated with landscape scale habitat use such as movement between areas of higher value habitat, the use of supplementary habitat or reflect the negative effects of active/ uncontrolled KTPs. Species recently observed in the locality (NSW BioNet records).
Melaleuca biconvexa (Biconvex Paperbark)	V	V	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.	573	**Low**. Vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are present; however, species specific habitat types (i.e. important habitat features) are either absent, in low abundance and/ or in a disturbed state. The Project Area is likely to be located outside the species known 'area of occurrence' but may be within the

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					known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are likely to be negatively influencing the likelihood of habitat occupancy. If detected, species activity is most likely low and associated with landscape scale habitat use such as movement between areas of higher value habitat, the use of supplementary habitat or reflect the negative effects of active/ uncontrolled KTPs. Species recently observed in the locality (NSW BioNet records).
Melaleuca deanei (Deane's Paperbark)	V	V	Grows in wet heath on sandstone in coastal districts from Berowra to Nowra.	0	**None**. Species specific habitat types (i.e. important habitat features) and known vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are absent from the Project Area. The Project Area is also likely located outside the species known 'area of occurrence' and may also occur outside the species 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Species incidence is not expected and, if detected, would likely represent atypical occurrence (e.g. incidence linked with transient activity). Presence unlikely associated with habitat occupancy involving important lifecycle processes.
Melaleuca groveana	V	-	Grows in heath and shrubland, often in exposed sites, at high elevations, on rocky outcrops and cliffs. It also occurs in dry woodlands.	0	**Low**. Vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are present; however, species specific habitat types (i.e. important habitat features) are either absent, in low abundance and/ or in a disturbed state. The Project Area is likely to be located outside the species known 'area of occurrence' but may be within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are likely to be negatively influencing the likelihood of habitat occupancy. If detected, species activity is most likely low and associated with landscape scale habitat use such as movement between areas of higher value habitat, the use of supplementary habitat or reflect the negative effects of active/ uncontrolled KTPs. Species not recently observed in the locality (NSW BioNet records).
Miniopterus australis (Little Bentwing-bat)	V	-	Coastal north-eastern NSW and eastern Queensland. Little Bent-wing Bat is an insectivorous bat that roost in caves, in old mines, in tunnels, under bridges, or in	34	**High**. Habitat values within the Project Area are generally consistent with descriptions provided in the BCD TSPD. Habitat is likely to be located within the known 'extent of

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			similar structures. They breed in large aggregations in a small number of known caves and may travel 100s km from feeding home ranges to breeding sites. Little Bent-wing Bat has a preference for moist eucalypt forest, rainforest or dense coastal banksia scrub where it forages below the canopy for insects.		occurrence' and 'area of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are unlikely to adversely influence the capacity of the species to occupy the habitat. Pre-existing and active KTPs are unlikely to be substantially influencing species incidence and/ or habitat occupancy. Species recently observed in the locality (NSW BioNet records).
Miniopterus schreibersii oceanensis (Eastern Bentwing-bat)	V	-	Eastern Bent-wing Bats occur along the east and north-west coasts of Australia. Caves are the primary roosting habitat, but also use derelict mines, storm-water tunnels, buildings and other man-made structures. Form discrete populations centred on a maternity cave that is used annually in spring and summer for the birth and rearing of young.	13	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Species recently observed in the locality (NSW BioNet records).
Mixophyes balbus (Stuttering Frog)	E	V	Associated with streams in dry sclerophyll and wet sclerophyll forests and rainforests of more upland areas of the Great Dividing Range of NSW and down into Victoria. Breeding occurs along forest streams with permanent water where eggs are deposited within nests excavated in riffle zones by the females and the tadpoles swim free into the stream when large enough to do so. Outside of breeding, individuals range widely across the forest floor and can be found hundres of metres from water	1	**Low**. Vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are present; however, species specific habitat types (i.e. important habitat features) are either absent, in low abundance and/ or in a disturbed state. The Project Area is likely to be located outside the species known 'area of occurrence' but may be within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are likely to be negatively influencing the likelihood of habitat occupancy. If detected, species activity is most likely low and associated with landscape scale habitat use such as movement between areas of higher value habitat, the use of supplementary habitat or reflect the negative effects of active/ uncontrolled KTPs. Species recently observed in the locality (NSW BioNet records).
Mixophyes iteratus (Giant Barred Frog)	E	E	This species is found along larger streams of the coast and adjacent ranges of NSW and SE QLD. It inhabits rainforest and wet sclerophyll forest, but is also found	0	**Low**. Vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are present; however, species specific habitat types (i.e. important habitat features)

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			within cleared farmland where fringing vegetation is retained, including lantana beds. Many sites where the Giant Barred Frog is known to occur are the lower reaches of streams which have been affected by major disturbances such as clearing, timber harvesting and urban development in their headwaters.		are either absent, in low abundance and/ or in a disturbed state. The Project Area is likely to be located outside the species known 'area of occurrence' but may be within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are likely to be negatively influencing the likelihood of habitat occupancy. If detected, species activity is most likely low and associated with landscape scale habitat use such as movement between areas of higher value habitat, the use of supplementary habitat or reflect the negative effects of active/ uncontrolled KTPs. Not recently observed in the locality (NSW BioNet records).
Mormopterus norfolkensis (Eastern Freetail-bat)	V	-	Most records are from dry eucalypt forests and woodlands to the east of the Great Dividing Range. Appears to roost in trees, but little is known of this species' habits.	23	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Species recently observed in the locality (NSW BioNet records).
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.	2	**Low**. Vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are present; however, species specific habitat types (i.e. important habitat features) are either absent, in low abundance and/ or in a disturbed state. The Project Area is likely to be located outside the species known 'area of occurrence' but may be within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are likely to be negatively influencing the likelihood of habitat occupancy. If detected, species activity is most likely low and associated with landscape scale habitat use such as movement between areas of higher value habitat, the use of supplementary habitat or reflect the

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					negative effects of active/ uncontrolled KTPs. Species recently observed in the locality (NSW BioNet records).
Neophema pulchella (Turquoise Parrot)	V	-	The Turquoise Parrot's range extends from southern Queensland through to northern Victoria, from the coastal plains to the western slopes of the Great Dividing Range. Lives on the edges of eucalypt woodland adjoining clearings, timbered ridges and creeks in farmland. Nests in tree hollows, logs or posts, from August to December. It lays four or five white, rounded eggs on a nest of decayed wood dust.	0	**Low**. Vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are present; however, species specific habitat types (i.e. important habitat features) are either absent, in low abundance and/ or in a disturbed state. The Project Area is likely to be located outside the species known 'area of occurrence' but may be within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are likely to be negatively influencing the likelihood of habitat occupancy. If detected, species activity is most likely low and associated with landscape scale habitat use such as movement between areas of higher value habitat, the use of supplementary habitat or reflect the negative effects of active/ uncontrolled KTPs. Not recently observed in the locality (NSW BioNet records).
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.	0	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Not recently observed in the locality (NSW BioNet records).
Ninox strenua (Powerful Owl)	V	-	Occupies wet and dry eucalypt forests and rainforests. Can occupy both un-logged and lightly logged forests as well as undisturbed forests where it usually roosts on the limbs of dense trees in gully areas. It is most commonly recorded within red turpentine in tall open forests and black she-oak within open forests. Large mature trees with hollows at least 0.5 m deep are required for nesting. Tree hollows are particularly important for the Powerful Owl because a large proportion of the diet is made up of	5	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may

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			hollow-dependent arboreal marsupials. Nest trees for this species are usually emergent with a diameter at breast height of at least 100 cm.		potentially have a negative influence on species incidence and/ or habitat occupancy. Species recently observed in the locality (NSW BioNet records).
Numenius madagascariensis (Eastern Curlew)	-	CE	The Eastern curlew spends its breeding season in northeastern Asia, including Siberia to Kamchatka, and Mongolia. Its breeding habitat is composed of marshy and swampy wetlands and lakeshores. Most individuals winter in coastal Australia, with a few heading to South Korea, Thailand, Philippines and New Zealand, where they stay at estuaries, beaches, and salt marshes. It uses its long, decurved bill to probe for invertebrates in the mud. It may feed in solitary but it generally congregates in large flocks to migrate or roost. Its call is a sharp, clear whistle, cuuue-reee, often repeated.	0	**None**. Species specific habitat types (i.e. important habitat features) and known vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are absent from the Project Area. The Project Area is also likely located outside the species known 'area of occurrence' and may also occur outside the species 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Species incidence is not expected and, if detected, would likely represent atypical occurrence (e.g. incidence linked with transient activity). Presence unlikely associated with habitat occupancy involving important lifecycle processes.
Persicaria elatior	V	V	This species normally grows in damp places, especially beside streams and lakes. Occasionally in swamp forest or associated with disturbance.	0	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Species not recently observed in the locality (NSW BioNet records).
Persoonia hirsuta (Hairy Geebung)	E	E	Distributed from Singleton in the north, along the east coast to Bargo in the south and the Blue Mountains to the west. A large area of occurrence, but occurs in small populations, increasing the species's fragmentation in the landscape. Found in sandy soils in dry sclerophyll open forest, woodland and heath on sandstone. Usually present as isolated individuals or very small populations. Probably killed by fire (as other Persoonia spp. are) but will regenerate from seed.	0	**Low**. Vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are present; however, species specific habitat types (i.e. important habitat features) are either absent, in low abundance and/ or in a disturbed state. The Project Area is likely to be located outside the species known 'area of occurrence' but may be within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are likely to be negatively influencing the likelihood of habitat occupancy. If detected, species activity is most likely low and associated with landscape scale habitat use such as movement between areas of higher value

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					habitat, the use of supplementary habitat or reflect the negative effects of active/ uncontrolled KTPs. Species not recently observed in the locality (NSW BioNet records).
Petauroides volans (Greater Glider)	-	V	The Greater Glider occurs in eucalypt forests and woodlands. Utilise tree hollows	0	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Not recently observed in the locality (NSW BioNet records).
Petaurus australis (Yellow-bellied Glider)	V	-	Occur in tall mature eucalypt forest generally in areas with high rainfall and nutrient rich soils. forest type preferences vary with latitude and elevation; mixed coastal forests to dry escarpment forests in the north; moist coastal gullies and creek flats to tall montane forests in the south. Found along the eastern coast to the western slopes of the Great Dividing Range, from southern Queensland to Victoria.	24	**High**. Habitat values within the Project Area are generally consistent with descriptions provided in the BCD TSPD. Habitat is likely to be located within the known 'extent of occurrence' and 'area of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are unlikely to adversely influence the capacity of the species to occupy the habitat. Pre-existing and active KTPs are unlikely to be substantially influencing species incidence and/ or habitat occupancy. Species recently observed in the locality (NSW BioNet records).
Petaurus norfolcensis (Squirrel Glider)	V	-	Generally occurs in dry sclerophyll forests and woodlands but is absent from dense coastal ranges in the southern part of its range . Requires abundant hollow bearing trees and a mix of eucalypts, banksias and acacias . There is only limited information available on den tree use by Squirrel gliders, but it has been observed using both living and dead trees as well as hollow stumps. Within a suitable vegetation community at least one species should flower heavily in winter and one species of eucalypt should be smooth barked. Endangered population in the Wagga Wagga LGA.	1	**High**. Habitat values within the Project Area are generally consistent with descriptions provided in the BCD TSPD. Habitat is likely to be located within the known 'extent of occurrence' and 'area of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are unlikely to adversely influence the capacity of the species to occupy the habitat. Pre-existing and active KTPs are unlikely to be substantially influencing species incidence and/ or habitat occupancy. Species recently observed in the locality (NSW BioNet records).

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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.	0	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Not recently observed in the locality (NSW BioNet records).
Petroica boodang (Scarlet Robin)	V	-	The Scarlet Robin is found from SE Queensland to SE South Australia and also in Tasmania and SW Western Australia. In NSW, it occurs from the coast to the inland slopes. The Scarlet Robin lives in dry eucalypt forests and woodlands. The understorey is usually open and grassy with few scattered shrubs.	2	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Species recently observed in the locality (NSW BioNet records).
Phascogale tapoatafa (Brush-tailed Phascogale)	V	-	The Brush-tailed Phascogale has a patchy distribution around the coast of Australia. In NSW it is mainly found east of the Great Dividing Range although there are occasional records west to the divide. Prefer dry sclerophyll open forest with sparse groundcover of herbs, grasses, shrubs or leaf litter. Also inhabit heath, swamps, rainforest and wet sclerophyll forest.	0	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Not recently observed in the locality (NSW BioNet records).

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Phascolarctos cinereus (Koala)	V	V	Inhabits eucalypt forests and woodlands. The suitability of these forests for habitation depends on the size and species of trees present, soil nutrients, climate and rainfall .	0	**Low**. Vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are present; however, species specific habitat types (i.e. important habitat features) are either absent, in low abundance and/ or in a disturbed state. The Project Area is likely to be located outside the species known 'area of occurrence' but may be within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are likely to be negatively influencing the likelihood of habitat occupancy. If detected, species activity is most likely low and associated with landscape scale habitat use such as movement between areas of higher value habitat, the use of supplementary habitat or reflect the negative effects of active/ uncontrolled KTPs. Not recently observed in the locality (NSW BioNet records).
Phoniscus papuensis (Golden-tipped Bat)	V	-	Distributed along the east coast of Australia in scattered locations from Cape York Peninsula in Queensland to Bega in southern NSW. Found in rainforest and adjacent sclerophyll forest. Roost in abandoned hanging Yellow-throated Scrubwren and Brown Gerygone nests located in rainforest gullies on small first- and second-order streams.	1	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Species recently observed in the locality (NSW BioNet records).
Planigale maculata (Common Planigale)	V	-	Common Planigales inhabit rainforest, eucalypt forest, heathland, marshland, grassland and rocky areas where there is surface cover, and usually close to water. The female builds a nest lined with grass, eucalypt leaves or shredded bark.	0	**Low**. Vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are present; however, species specific habitat types (i.e. important habitat features) are either absent, in low abundance and/ or in a disturbed state. The Project Area is likely to be located outside the species known 'area of occurrence' but may be within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are likely to be negatively influencing the likelihood of habitat occupancy. If detected, species activity is most likely low and associated with landscape scale

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					habitat use such as movement between areas of higher value habitat, the use of supplementary habitat or reflect the negative effects of active/ uncontrolled KTPs. Not recently observed in the locality (NSW BioNet records).
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.	0	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Not recently observed in the locality (NSW BioNet records).
Pseudomys gracilicaudatus (Eastern Chestnut Mouse)	V	-	In NSW the Eastern Chestnut Mouse mainly occurs north from the Hawkesbury River area as scattered records along to coast and eastern fall of the Great Dividing Range extending north into Queensland. There are however isolated records in the Jervis Bay area. In NSW the Eastern Chestnut Mouse is mostly found, in low numbers, in heathland and is most common in dense, wet heath and swamps. In the tropics it is more an animal of grassy woodlands. Optimal habitat appears to be in vigorously regenerating heathland burnt from 18 months to four years previously. By the time the heath is mature, the larger Swamp Rat becomes dominant, and Eastern Chestnut Mouse numbers drop again.	1	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Species recently observed in the locality (NSW BioNet records).
Pseudomys novaehollandiae (New Holland Mouse)	-	V	The New Holland Mouse currently has a disjunct, fragmented distribution across Tasmania, Victoria, New South Wales and Queensland. Across the species' range the New Holland Mouse is known to inhabit open heathlands, open woodlands with a heathland understorey, and vegetated sand dunes.	0	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may

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					potentially have a negative influence on species incidence and/ or habitat occupancy. Not recently observed in the locality (NSW BioNet records).
Pseudophryne australis (Red-crowned Toadlet)	V	-	Occurs on wetter ridge tops and upper slopes of sandstone formations on which the predominant vegetation is dry open forests and heaths. This species typically breeds within small ephemeral creeks that feed into larger semi-perennial streams. After rain these creeks are characterised by a series of shallow pools lined by dense grasses, ferns and low shrubs and usually contain leaf litter for shelter. Eggs are terrestrial and laid under litter, vegetation or rocks where the tadpoles inside will reach a relatively late stage of development before waiting for flooding waters before hatching will occur.	0	**Low**. Vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are present; however, species specific habitat types (i.e. important habitat features) are either absent, in low abundance and/ or in a disturbed state. The Project Area is likely to be located outside the species known 'area of occurrence' but may be within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are likely to be negatively influencing the likelihood of habitat occupancy. If detected, species activity is most likely low and associated with landscape scale habitat use such as movement between areas of higher value habitat, the use of supplementary habitat or reflect the negative effects of active/ uncontrolled KTPs. Not recently observed in the locality (NSW BioNet records).
Pteropus poliocephalus (Grey-headed Flying-fox)	V	V	This species is a canopy-feeding frugivore and nectarivore of rainforests, open forests, woodlands, melaleuca swamps and banksia woodlands. Bats commute daily to foraging areas, usually within 15 km of the day roost although some individuals may travel up to 70 km.	7	**High**. Habitat values within the Project Area are generally consistent with descriptions provided in the BCD TSPD. Habitat is likely to be located within the known 'extent of occurrence' and 'area of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are unlikely to adversely influence the capacity of the species to occupy the habitat. Pre-existing and active KTPs are unlikely to be substantially influencing species incidence and/ or habitat occupancy. Species recently observed in the locality (NSW BioNet records).
Ptilinopus magnificus (Wompoo Fruit-dove)	V	-	Distributed north of the Hunter River in NSW on the coast and coastal ranges. Inhabits rainforest, monsoon forest, adjacent eucalypt forest and brush box forest.	0	**Low**. Vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are present; however, species specific habitat types (i.e. important habitat features) are either absent, in low abundance and/ or in a disturbed state. The Project Area is likely to be located outside the species known 'area of occurrence' but may be within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are likely to be negatively influencing

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					the likelihood of habitat occupancy. If detected, species activity is most likely low and associated with landscape scale habitat use such as movement between areas of higher value habitat, the use of supplementary habitat or reflect the negative effects of active/ uncontrolled KTPs. Not recently observed in the locality (NSW BioNet records).
Ptilinopus regina (Rose-crowned Fruit-dove)	V	-	Coast and ranges of eastern NSW and Queensland, from Newcastle to Cape York. Vagrants are occasionally found further south to Victoria. Rose-crowned Fruit-doves occur mainly in sub-tropical and dry rainforest and occasionally in moist eucalypt forest and swamp forest, where fruit is plentiful.	0	**Low**. Vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are present; however, species specific habitat types (i.e. important habitat features) are either absent, in low abundance and/ or in a disturbed state. The Project Area is likely to be located outside the species known 'area of occurrence' but may be within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are likely to be negatively influencing the likelihood of habitat occupancy. If detected, species activity is most likely low and associated with landscape scale habitat use such as movement between areas of higher value habitat, the use of supplementary habitat or reflect the negative effects of active/ uncontrolled KTPs. Not recently observed in the locality (NSW BioNet records).
Ptilinopus superbus (Superb Fruit-dove)	V	-	The Superb Fruit-dove occurs principally from north-eastern in Queensland to north-eastern NSW. It is much less common further south, where it is largely confined to pockets of suitable habitat as far south as Moruya. There are records of vagrants as far south as eastern Victoria and Tasmania. Inhabits rainforest and similar closed forests where it forages high in the canopy, eating the fruits of many tree species such as figs and palms. It may also forage in eucalypt or acacia woodland where there are fruit-bearing trees.	0	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Not recently observed in the locality (NSW BioNet records).
Rhizanthella slateri	V	E	Habitat requirements are poorly understood and no particular vegetation type has been associated with the species, although it is known to occur in sclerophyll forest.	0	**None**. Species specific habitat types (i.e. important habitat features) and known vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are absent from the Project Area. The Project Area is also likely located outside the species known 'area of occurrence' and may also

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					occur outside the species 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Species incidence is not expected and, if detected, would likely represent atypical occurrence (e.g. incidence linked with transient activity). Presence unlikely associated with habitat occupancy involving important lifecycle processes.
Rhodamnia rubescens (Scrub Turpentine)	CE	-	Found in littoral, warm temperate and subtropical rainforest and wet sclerophyll forest usually on volcanic and sedimentary soils. This species is characterised as highly to extremely susceptible to infection by Myrtle Rust. Myrtle Rust affects all plant parts.	322	**Known**. Species observed and habitat values within the Project Area are generally consistent with descriptions provided in the BCD TSPD. Habitat is located within known 'extent of occurrence' and 'area of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Habitat occupancy is likely to be associated with important life cycle processes; however, the reliance on this habitat would depend on additional factors (e.g. size and extent of local population, effect of KTPs). Species recently observed in the locality (NSW BioNet records).
Rhodomyrtus psidioides (Native Guava)	CE	-	Pioneer species found in littoral, warm temperate and subtropical rainforest and wet sclerophyll forest often near creeks and drainage lines. This species is characterised being extremely susceptible to infection by Myrtle Rust. Myrtle Rust affects all plant parts.	4	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known ‘area of occurrence’ but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Species recently observed in the locality (NSW BioNet records).
Rostratula australis (Australian Painted Snipe)	E	E, M	In NSW, this species has been recorded at the Paroo wetlands, Lake Cowell, Macquarie Marshes and Hexham Swamp. Most common in the Murray-Darling Basin. Prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber. Nests on the ground amongst tall vegetation, such as grasses, tussocks or reeds.	0	**None**. Species specific habitat types (i.e. important habitat features) and known vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are absent from the Project Area. The Project Area is also likely located outside the species known ‘area of occurrence’ and may also occur outside the species 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Species incidence is not expected and, if detected, would likely represent atypical occurrence (e.g. incidence linked with transient activity).

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					Presence unlikely associated with habitat occupancy involving important lifecycle processes.
Rutidosis heterogama	V	V	Grows in heath on sandy soils and moist areas in open forest, and has been recorded along disturbed roadsides.	0	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Species not recently observed in the locality (NSW BioNet records).
Saccolaimus flaviventris (Yellow-bellied Sheathtail-bat)	V	-	Roosts singly or in groups of up to six, in tree hollows and buildings; in treeless areas they are known to utilise mammal burrows. When foraging for insects, flies high and fast over the forest canopy, but lower in more open country. Forages in most habitats across its very wide range, with and without trees; appears to defend an aerial territory.	4	**Low**. Vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are present; however, species specific habitat types (i.e. important habitat features) are either absent, in low abundance and/ or in a disturbed state. The Project Area is likely to be located outside the species known 'area of occurrence' but may be within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are likely to be negatively influencing the likelihood of habitat occupancy. If detected, species activity is most likely low and associated with landscape scale habitat use such as movement between areas of higher value habitat, the use of supplementary habitat or reflect the negative effects of active/ uncontrolled KTPs. Species recently observed in the locality (NSW BioNet records).
Scoteanax rueppellii (Greater Broad-nosed Bat)	V	-	Prefer moist gullies in mature coastal forests and rainforests, between the Great Dividing Range and the coast. They are only found at low altitudes below 500 m. In dense environments they utilise natural and human-made opening in the forest for flight paths. Creeks and small rivers are favoured foraging habitat. This species roosts in hollow tree trunks and branches.	3	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may

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					potentially have a negative influence on species incidence and/ or habitat occupancy. Species recently observed in the locality (NSW BioNet records).
Sternula nereis nereis (Fairy Tern)	-	V	Distribution includes the southern half of NSW coast. Fairy Terns utilise a variety of habitats including offshore, islands in estuaries or lakes , wetlands, beaches and spits.	0	**None**. Species specific habitat types (i.e. important habitat features) and known vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are absent from the Project Area. The Project Area is also likely located outside the species known 'area of occurrence' and may also occur outside the species 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Species incidence is not expected and, if detected, would likely represent atypical occurrence (e.g. incidence linked with transient activity). Presence unlikely associated with habitat occupancy involving important lifecycle processes.
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	0	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Species not recently observed in the locality (NSW BioNet records).
Tetratheca juncea (Black-eyed Susan)	V	V	Confined to the northern portion of the Sydney Basin bioregion and the southern portion of the North Coast bioregion in the local government areas of Wyong, Lake Macquarie, Newcastle, Port Stephens, Great Lakes and Cessnock. It is usually found in low open forest-woodland with a mixed shrub understorey and grassy groundcover. The majority of populations occur on low nutrient soils associated with the Awaba Soil Landscape. Cryptic species that requires survey in September-October.	114	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Species recently observed in the locality (NSW BioNet records).

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Thelymitra adorata (Wyong Sun Orchid)	CE	-	Occurs from 10-40 m a.s.l. in grassy woodland or occasionally derived grassland in well-drained clay loam or shale derived soils. The vegetation type in which the majority of populations occur (including the largest colony) is a spotted gum - ironbark forest with a diverse grassy understorey and occasional scattered shrubs.	12	**Low**. Vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are present; however, species specific habitat types (i.e. important habitat features) are either absent, in low abundance and/ or in a disturbed state. The Project Area is likely to be located outside the species known 'area of occurrence' but may be within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are likely to be negatively influencing the likelihood of habitat occupancy. If detected, species activity is most likely low and associated with landscape scale habitat use such as movement between areas of higher value habitat, the use of supplementary habitat or reflect the negative effects of active/ uncontrolled KTPs. Species recently observed in the locality (NSW BioNet records).
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.	0	**Low**. Vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are present; however, species specific habitat types (i.e. important habitat features) are either absent, in low abundance and/ or in a disturbed state. The Project Area is likely to be located outside the species known 'area of occurrence' but may be within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are likely to be negatively influencing the likelihood of habitat occupancy. If detected, species activity is most likely low and associated with landscape scale habitat use such as movement between areas of higher value habitat, the use of supplementary habitat or reflect the negative effects of active/ uncontrolled KTPs. Species not recently observed in the locality (NSW BioNet records).
Thinornis rubricollis rubricollis (Hooded Plover)	CE	V	The Hooded Plover occurs on sandy beaches and inland saltlakes of south-eastern and south-western Australia. Within NSW, the Hooded Plover occurs along the southern coast, north to Jervis Bay. In souther-eastern Australian, the Hooded Plover is found mostly on long stretches of sandy shore, backed by tussock and creeper covered dunes with nearby inland lakes.	0	**None**. Species specific habitat types (i.e. important habitat features) and known vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are absent from the Project Area. The Project Area is also likely located outside the species known 'area of occurrence' and may also occur outside the species 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Species incidence is not expected and, if detected, would likely represent atypical

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					occurrence (e.g. incidence linked with transient activity). Presence unlikely associated with habitat occupancy involving important lifecycle processes.
Thylogale stigmatica (Red-legged Pademelon)	V	-	Inhabits forest with a dense understorey and ground cover, including rainforest, moist eucalypt forest and vine scrub.	0	**Low**. Vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are present; however, species specific habitat types (i.e. important habitat features) are either absent, in low abundance and/ or in a disturbed state. The Project Area is likely to be located outside the species known 'area of occurrence' but may be within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are likely to be negatively influencing the likelihood of habitat occupancy. If detected, species activity is most likely low and associated with landscape scale habitat use such as movement between areas of higher value habitat, the use of supplementary habitat or reflect the negative effects of active/ uncontrolled KTPs. Not recently observed in the locality (NSW BioNet records).
Turnix maculosus (Red-backed Button-quail)	V	-	Red-backed Button-quail inhabit grasslands, open and savannah woodlands with grassy ground layer, pastures and crops of warm temperate areas, typically only in regions subject to annual summer rainfall greater than 400 mm. In NSW, said to occur in grasslands, heath and crops. Said to prefer sites close to water, especially when breeding. Observations of populations in other parts of its range suggest the species prefers sites near water, including grasslands and sedgelands near creeks, swamps and springs, and wetlands.	0	**Low**. Vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) are present; however, species specific habitat types (i.e. important habitat features) are either absent, in low abundance and/ or in a disturbed state. The Project Area is likely to be located outside the species known 'area of occurrence' but may be within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality are likely to be negatively influencing the likelihood of habitat occupancy. If detected, species activity is most likely low and associated with landscape scale habitat use such as movement between areas of higher value habitat, the use of supplementary habitat or reflect the negative effects of active/ uncontrolled KTPs. Not recently observed in the locality (NSW BioNet records).
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. 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	0	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known

Scientific Name (Common Name)	BC Act	EPBC Act	Habitat	Records (DPIE 2021a)	Likelihood of Occurrence
			living but sometimes dead. Nest hollows are usually located within dense forests or woodlands. Masked owls prey upon hollow-dependent arboreal marsupials, but terrestrial mammals make up the largest proportion of the diet.		'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Not recently observed in the locality (NSW BioNet records).
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 less than 500 metres. Nests and roosts in hollows of tall emergent trees, mainly eucalypts often located in gullies. Nests have been located in trees 125 to 161 centimetres in diameter.	9	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Species recently observed in the locality (NSW BioNet records).
Vespadelus troughtoni (Eastern Cave Bat)	V	-	The Eastern Cave Bat is found in a broad band on both sides of the Great Dividing Range from Cape York to Kempsey, with records from the New England Tablelands and the upper north coast of NSW. The western limit appears to be the Warrumbungle Range, and there is a single record from southern NSW, east of the ACT. A cave-roosting species that is usually found in dry open forest and woodland, near cliffs or rocky overhangs; has been recorded roosting in disused mine workings, occasionally in colonies of up to 500 individuals.	0	**Moderate**. Species specific (i.e. important habitat features) and vegetation classification based habitat surrogates (i.e. PCT and/ or vegetation formations) occur within the Project Area. The Project Area may or may not be located within the species known 'area of occurrence' but is within the known 'extent of occurrence' [i.e. standard grid size of 2x2km (IUCN 2017)]. Factors such as connectivity, patch size, habitat quantum and/ or quality may be influencing the capacity for habitat occupancy. Pre-existing and active KTPs may potentially have a negative influence on species incidence and/ or habitat occupancy. Not recently observed in the locality (NSW BioNet records).

Appendix D

BAM Plot Photographs

Plot	Bearing	PCT	Photograph Start	Photograph End
LW34-1	1588	Cleared/ Disturbed Land		
LW34-2				

Plot	Bearing	PCT	Photograph Start	Photograph End
LW34-3		1528		
LW34-4		1588		

Plot	Bearing	PCT	Photograph Start	Photograph End
LW34-5	1568	Cleared/ Disturbed Land		
LW34-6				

Plot	Bearing	PCT	Photograph Start	Photograph End
LW34-7		1573		
LW34-8		1556		

Plot	Bearing	PCT	Photograph Start	Photograph End
LW34-9		1556		
LW34-10		1556		

Plot	Bearing	PCT	Photograph Start	Photograph End
LW34-11		1556		
LW34-12		1556		

Plot	Bearing	PCT	Photograph Start	Photograph End
LW34-13		1568		
LW34-14		1588		

Plot	Bearing	PCT	Photograph Start	Photograph End
Plot 12 – PR144986		1568		
Plot 19 – PR144986		1568		

Plot	Bearing	PCT	Photograph	
			Start	End
		1573		
Plot 20 – PR144986				

Appendix E

BAM Plot Data

Plot[1]	PCT	Area	Patchsize	Condition class	zone	easting	northing	bearing	compTree	compShrub	compGrass	compForbs	compFerns	compOther	strucTree	strucShrub	strucGrass	strucForbs	strucFerns	strucOther	funLargeTrees	funHollowtrees	funLitterCover	funLogsnLogs	funLenFalle	funTreeSte m5to9	funTreeSte m10to19	funTreeSte m20to29	funTreeSte m30to49	funTreeSte m50to79	funTreeSte	funTreeReg en	funHighThr eatExotic
LW34_1	1568	2	1001	Zone6_Poor	56	351854	6328374	234	1	0	4	14	0	1	0	0	3	9	0	0	0	0	7	0	0	0	0	1	1	0	0
LW34_2	1588	15	1001	Zone5_Moderate	56	351651	6328385	220	6	11	8	13	2	10	58	35	16	6	1	4	0	0	80	53	1	1	1	1	1	1	0
LW34_3	1528	0	1001	Zone1_Moderate_Good	56	351584	6328190	305	4	12	3	7	9	12	26	55	0	1	23	27	0	0	48	25	1	1	1	1	0	1	0
LW34_4	1588	15	1001	Zone5_Moderate	56	351550	6328049	136	5	5	8	7	4	12	62	1	14	1	0	2	1	5	91	51	1	1	1	1	1	1	0
LW34_5	1568	2	1001	Zone6_Poor	56	351619	6327569	335	2	2	4	9	1	4	0	0	2	3	1	2	0	0	9	7	0	1	1	1	0	1	2
LW34_6	1568	7	1001	Zone3_Moderate	56	351735	6327459	343	5	3	4	5	3	11	65	15	1	1	1	14	0	0	73	23	1	1	1	1	0	1	0
LW34_7	1573	2	1001	Zone4_Moderate_Good	56	351528	6327704	301	5	10	1	1	7	11	46	34	0	0	8	75	1	0	80	80	1	1	1	1	1	1	0
LW34_8	1556	25	1001	Zone2_Moderate	56	351524	6327809	315	8	8	7	13	4	8	78	4	7	3	2	11	0	0	66	48	1	1	1	1	1	1	0
LW34_9	1556	25	1001	Zone2_Moderate	56	351701	6327734	102	7	4	6	11	5	14	61	22	1	3	8	20	0	0	55	67	1	1	1	1	1	1	0
LW34_10	1556	25	1001	Zone2_Moderate	56	351490	6327155	223	5	5	4	15	3	13	38	10	1	3	72	28	1	0	68	95	1	1	1	1	1	1	0
LW34_11	1556	25	1001	Zone2_Moderate	56	351305	6327569	336	4	8	4	11	6	13	31	25	3	1	2	40	2	0	85	85	1	1	1	1	0	1	0
LW34_12	1556	25	1001	Zone2_Moderate	56	351232	6327199	172	7	6	8	8	1	12	57	3	8	2	1	2	1	6	90	35	1	1	1	1	1	1	0
LW34_13	1568	7	1001	Zone3_Moderate	56	351065	6326874	221	7	4	4	5	4	10	63	35	1	1	2	11	1	0	89	31	1	1	1	1	1	1	0
LW34_14	1588	15	1001	Zone5_Moderate	56	351922	6328029	274	6	5	10	7	1	6	113	17	21	4	0	6	0	0	92	11	1	1	1	1	1	1	0
144986_12	1568	7	1001	Zone3_Moderate	56	351681	6328206	241	10	11	2	2	4	10	84	69	6	1	11	15	1	1	85	51	0	1	1	1	1	0	0
144986_19	1568	7	1001	Zone3_Moderate	56	351451	6327761	316	10	15	6	9	12	17	45	70	1	1	17	4	0	0	74	75	1	1	1	1	1	1	0
144986_20	1573	2	1001	Zone4_Moderate_Good	56	351579	6327669	266	6	9	10	11	8	16	32	26	14	2	1	75	1	0	85	66	1	1	1	1	1	1	10

1.Plot data provided above is for the entire Project Area. Within the BAM-C finalised case, the plot data presented represented the Zones to be impacted by ponding only (i.e. Zones 2, 3 and 4).

Appendix F

Flora list

Scientific Name	LW34-1		LW34-2		LW34-3		LW34-4		LW34-5		LW34-6		LW34-7		LW34-8		LW34-9		LW34-10		LW34-11		LW34-12		LW34-13		LW34-14		PR144986 Plot 12		PR144986 Plot 19		PR144986 Plot 20	
	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	A
Acacia elongata									0.2	1					0.2	2											1.5	3								
Acacia floribunda																															0.1	2		
Acacia implexa																															4.0	2		
Acacia longissima																			0.2	2			0.5	4										
Acacia maidenii							3.0	15					0.2	1																				
Acacia ulicifolia			0.2	2																							0.2	2						
Acianthus fornicatus			0.1	50											0.1	1																		
Acianthus spp.																			0.1	10														
Acmena smithii													2.0	5											15.0	7			5.0	10				
Adiantum aethiopicum																			0.5	20	0.1	20			0.1	10							0.1	3
Adiantum formosum													1.0	20			2.0	25			0.1	5							1.0	50	0.6	6	0.1	8
Adiantum hispidulum					0.3	50							0.6	30			1.0	30			0.1	10									0.2	15	0.4	20
*Ageratina Adenophora**									0.2	15																								
Alectryon spp.																			0.1	1														
Alectryon subcinereus					0.3	5							0.3	1															0.2	1				
Allocasuarina torulosa							30.0	33							15.0	13	10.0	5	1.0	3	7.0	4	8.0	7	1.0	2	20.0	16			0.2	1		
Alphitonia excelsa					8.0	3																											15.0	2
*Alternanthera philoxeroides**	0.1	2																																
Aneilema acuminatum																															0.2	30		
Angophora floribunda															5.0	1													15.0	2				
Aphanopetalum resinosum																							0.1	2					0.5	1				
Apium australe																	0.1	1																
Archontophoenix cunninghamiana					15.0	20					0.1	1	70.0	50			0.1	1			0.2	4			3.0	5			5.0	8	0.2	1	0.2	4
Arthropodium milleflorum																															0.1	6		
Arthropodium spp.			0.1	1																														
Asplenium australasicum					0.2	10					0.1	1									0.1	2												
Asplenium flabellifolium																															0.1	3		
*Axonopus compressus**	1.0	30																																
Backhousia leptopetala					5.0	5					55.0	80																			8.0	4	3.0	2
Backhousia myrtifolia					5.0	5					15.0	11													25.0	20			50.0	12	55.0	13		
Baloghia inophylla																															0.3	1		
*Bidens pilosa**									0.1	2																								
Billardiera scandens			0.1	10			0.1	2							0.1	1							0.1	2			0.1	5						
Blechnum cartilagineum													0.3	5											0.1	5					0.5	6		
Blechnum nudum															0.2	5	0.2	5																

Scientific Name	LW34-1		LW34-2		LW34-3		LW34-4		LW34-5		LW34-6		LW34-7		LW34-8		LW34-9		LW34-10		LW34-11		LW34-12		LW34-13		LW34-14		PR144986 Plot 12		PR144986 Plot 19		PR144986 Plot 20	
Blechnum spp.									1.0	40																								
*Bouteloua dactyloides**									95.0	1,000																								
Breynia oblongifolia			0.1	1			0.1	1					0.1	3																	0.1	6		
Brunoniella pumilio																															0.1	10		
Calanthe triplicata					0.5	5																			0.5	5								
Callitris muelleri																							0.5	1										
Calochlaena dubia	0.1	2											0.2	5			10.0	250			0.5	20											0.4	20
*Cardamine hirsuta**									1.0	50																								
Carex brunnea																																	2.0	15
Carex inversa																																	2.0	30
Carex maculata																															0.1	5	0.8	15
Carex spp.	2.0	200			0.1	5																												
Cassytha glabella							0.1	3									0.1	1											0.1	2				
Cassytha pubescens			0.2	50																														
Cayratia clematidea									0.1	3									0.1	5	0.2	10											0.1	8
Centella asiatica	0.2	20																															0.1	15
Ceratopetalum apetalum																			0.1	1														
Cheilanthes sieberi							0.1	3																					0.2	15				
Christella dentata																															0.1	4	0.1	4
*Cinnamomum camphora**																															0.1	1		
Cissus antarctica			0.1	5	5.0	30	0.1	5			5.0	15	0.1	2	0.1	1	0.3	8	0.1	5	20.0	40					0.1	1	1.0	25	0.3	8	5.0	20
Cissus hypoglauca					5.0	20					8.0	15	2.0	20			3.0	15	25.0	50	15.0	30			4.0	10					0.2	8		
Claoxylon australe																					6.0	5												
Clematis aristata					0.1	1	0.1	1	0.1	1							0.1	2																
Clerodendrum tomentosum											0.1	1															0.1	1			0.2	6	0.2	5
Commelina cyanea					0.1	10									0.1	8	0.2	10															0.5	30
*Conyza spp. **									0.4	25																								
Cordyline stricta					0.5	10																			0.5	5			0.5	5				
Corybas pruinosus																			0.1	20														
Corybas spp.																									0.1	10								
Corymbia maculata			20.0	6			25.0	11							5.0	2	5.0	1					15.0	4	10.0	2	40.0	13	8.0	2				
Croton verreauxii					0.1	1															0.1	1			0.2	2								
Cryptocarya glaucescens					15.0	2																												
Cryptocarya microneura			0.2	2									40.0	4															0.5	1				
Cyathea australis																																	0.3	1
Cyclophyllum longipetalum	0.1	10																											0.5	1				

Scientific Name	LW34-1		LW34-2		LW34-3		LW34-4		LW34-5		LW34-6		LW34-7		LW34-8		LW34-9		LW34-10		LW34-11		LW34-12		LW34-13		LW34-14		PR144986 Plot 12		PR144986 Plot 19		PR144986 Plot 20	
Cymbidium spp.																			0.1	1														
Cynodon dactylon									1.0	20																								
*Cyperus eragrostis**	0.1	10																																
Cyperus flaccidus																															0.2	15	0.5	50
Cyperus gracilis																																	3.0	60
Cyperus laevigatus																																	0.2	20
Cyperus spp.					0.1	5			0.2	3																								
Daviesia squarrosa			0.1	5																							15.0	15						
Dendrobium speciosum																			0.1	1														
Denhamia silvestris			0.2	15	0.1	10					0.2	10	0.2	15	0.2	15											0.2	15						
Desmodium rhytidophyllum			0.1	2			0.3	20							0.2	10	0.2	10					0.1	5			0.2	10						
Dianella caerulea			0.5	20													0.2	5	0.1	5	0.1	10	1.0	20										
Dianella caerulea var. producta					0.1	2	0.1	3							0.3	10											0.6	35			0.1	6	0.1	3
Dianella spp.															0.5	8																		
Dichondra repens	0.1	10							0.5	100																							0.2	30
Dioscorea transversa					0.2	20					0.1	1	0.1	1			0.1	5	1.0	50	2.0	20			1.0	20			0.5	20	0.8	15	0.2	10
Diospyros australis													1.0	3							0.1	1							5.0	10	2.0	6	10.0	8
Diploglottis australis																															0.2	10		
Doodia aspera			8.0	200							0.5	30	3.0	70			4.0	200	1.0	40	0.5	30			2.0	40			8.0	400	5.0	30		
Dysoxylum fraserianum																															0.8	2		
Elaeodendron australe																									0.2	2			5.0	4				
Embelia australiana							0.1	1			0.1	1	0.1	1			0.4	201	0.2	30	0.1	20			0.1	2			0.5	5	0.1	2	0.1	5
Empodisma minus																							0.2	30	0.1	10								
Entolasia marginata																																	0.3	4
Entolasia stricta	0.5	20			0.1	5									0.2	4			0.1	10			0.2	30	0.1	10	1.5	45			0.1	10		
Eucalyptus fergusonii																							2.0	2										
Eucalyptus microcorys	2.0	1	3.0	1	3.0	25	0.2	1	20.0	3					30.0	6	15.0	3	2.0	1			6.0	1			15.0	2			4.0	2		
Eucalyptus pilularis	30.0	6													20.0	2	10.0	1	30.0	5	15.0	2												
Eucalyptus propinqua					1.0	5			20.0	7																	8.0	1	20.0	1				
Eucalyptus punctata	5.0	10																			8.0	2			6.0	2								
Eucalyptus saligna									10.0	5																					35.0	3		
Eucalyptus siderophloia															0.4	1											30.0	7						
Eupomatia laurina			20.0	25									25.0	10			0.5	1			0.5	2												
Eustrephus latifolius									0.1	1																					0.1	6		
Ficus coronata			0.2	2									5.0	15							3.0	2							5.0	10	1.0	2	5.0	2
Ficus rubiginosa									0.1	2																								
Ficus spp.																	1.0	1																

Scientific Name	LW34-1	LW34-2		LW34-3		LW34-4		LW34-5		LW34-6		LW34-7	LW34-8		LW34-9		LW34-10		LW34-11		LW34-12		LW34-13		LW34-14		PR144986 Plot 12	PR144986 Plot 19		PR144986 Plot 20	
Gahnia radula																												0.2	4		
Gahnia sieberiana																	0.1	2	2.0	10											
Gahnia spp.															0.5	1															
Galium spp.		0.1	50														0.1	10	0.1	1	0.1	2									
*Gamochaeta spp. **								0.2	10																						
Geitonoplesium cymosum		0.1	5	0.1	1	0.1	8			0.1	2		0.1	10	0.1	5	0.2	20	0.2	20	0.1	4	0.1	5	5.0	1					
Geranium neglectum																														0.1	10
Geranium spp.								0.6	150																						
Glochidion ferdinandi																												3.0	2	8.0	3
Glycine clandestina						0.1	1																					0.1	4		
Glycine tabacina																	0.1	20	0.1	10	0.1	4									
Gonocarpus spp.		0.2	50																												
Goodenia hederacea																	0.1	3													
Goodenia heterophylla		0.5	40										0.2	5											0.3	50					
Guioa semiglauca																														4.0	3
Gymnostachys anceps				0.1	1					0.2	5				0.1	5	0.1	1	0.1	2			0.5	5			1.0	5		0.2	5
Gynochthodes jasminoides																												0.2	20		
Hardenbergia violacea		0.1	5																												
Hibbertia dentata						0.1	1						10.0	300	0.2	10	0.2	20	0.1	5								0.1	3		
Hibbertia scandens		0.2	6			0.3	10										0.2	3			0.1	1									
Hibiscus heterophyllus subsp. heterophyllus								0.2	1																					8.0	6
Homalanthus populifolius		0.1	1	0.1	5	0.1	1			0.1	1								0.1	2											
Hydrocotyle laxiflora										0.1	30		0.1	15	1.0	300			0.1	20											
Hydrocotyle spp.				0.1	10												0.2	30												0.2	10
Hydrocotyle tripartita	2.0	200						0.2	50																						
Hymenophyllum cupressiforme																												3.0	50		
Hymenosporum flavum																												0.1	2		
Hypericum gramineum	0.2	20																													
Hypericum spp.								0.1	5																						
*Hypochaeris radicata**	0.4	30																												0.1	3
Imperata cylindrica						5.0	100						0.4	20							0.4	30			0.2	10					
Juncus subsecundus																														0.2	20
Juncus usitatus	1.0	80																													
Lagenifera stipitata		0.1	5										0.1	5							0.1	1									
*Lantana camara**				2.0	3	4.0	15																					0.1	5	10.0	20

Scientific Name	LW34-1		LW34-2		LW34-3		LW34-4		LW34-5		LW34-6		LW34-7		LW34-8		LW34-9		LW34-10		LW34-11		LW34-12		LW34-13		LW34-14		PR144986 Plot 12		PR144986 Plot 19		PR144986 Plot 20	
Lastreopsis decomposita					2.0	75							0.5	20																				
Lastreopsis microsora																															0.2	8	0.2	10
Legnephora moorei																																	0.1	1
Lepidosperma laterale			0.1	2							1.0	6											0.1	10			0.1	5						
Leucopogon lanceolatus			0.2	10																			0.1	1										
Lindsaea dimorpha			0.5	40																														
Lindsaea linearis															0.1	5																		
Lindsaea microphylla							0.1	2							0.1	3																		
Livistona australis															0.3	2			0.2	2			0.1	4							0.2	2	65.0	10
Lobelia pratioides									0.2	50	0.1	5																						
Lobelia purpurascens	0.1	20	3.0	80			0.1	20							0.2	50	0.1	15	0.2	20	0.1	10	0.2	30			2.0	150			0.1	10		
Lomandra confertifolia																											0.1	1						
Lomandra filiformis											0.1	1																			0.1	3		
Lomandra longifolia			1.0	15			6.0	50							5.0	30	0.2	2			0.2	10	6.0	10	0.5	10	8.0	75	3.0	12				
Lomandra multiflora subsp. multiflora			0.2	10			0.1	2							0.1	1	0.1	1					0.2	20			0.6	20						
*Lysimachia arvensis**	0.3	30																																
Marsdenia rostrata					0.2	3																											0.1	4
Melicope micrococca																															1.0	3		
Melodinus australis													0.2	5																				
Microlaena stipoides	0.1	30					0.1	5			0.1	1			0.5	15	0.1	5	0.5	40	0.1	20					0.5	25			0.1	15		
Microsorum diversifolium					10.0	250							2.0	50																				
Microsorum pustulatum																															6.0	25	0.2	15
*Modiola caroliniana**	0.1	20							5.0	150																								
Morinda jasminoides					0.3	60					0.3	10	0.2	5					0.1	2	0.1	10	0.1	1	0.1	5			0.3	20			0.5	20
Myrsine howittiana																															0.8	10		
Myrsine variabilis					20.0	50							0.5	1	0.3	20																		
*Nasturtium officinale**	0.1	10																																
Neolitsea dealbata													0.3	1																			0.2	2
Notelaea longifolia																									0.2	1			2.0	5				
Notelaea spp.																															0.1	1		
Omalanthus populifolius																															0.1	4	0.1	8
Opercularia diphylla			0.1	10			0.1	3											0.1	10			0.1	5			0.2	25						
Oplismenus aemulus	0.2	30																											3.0	200				
Oplismenus imbecillis			0.5	60	0.2	40	0.2	120	0.2	15	0.2	10	0.2	10	0.1	3	0.1	10	0.5	50	1.0	80	0.8	30	0.1	10	0.2	20					5.0	100
Ottochloa gracillima																																	0.2	15
Oxalis perennans	0.6	40																			0.1	20	0.1	10										

Scientific Name	LW34-1		LW34-2		LW34-3		LW34-4		LW34-5		LW34-6		LW34-7		LW34-8		LW34-9		LW34-10		LW34-11		LW34-12		LW34-13		LW34-14		PR144986 Plot 12		PR144986 Plot 19		PR144986 Plot 20	
Oxalis spp.			0.1	15					0.3	30							0.1	25													0.1	5		
Pandorea jasminoides																											0.1	2						
Pandorea pandorana											0.1	1			0.1	1	0.1	5					0.1	2							0.1	6	0.1	10
Parsonsia straminea			0.1	3			0.1	2									0.5	5					0.1	10			0.1	1						
Paspalum dilatatum									2.0	25																								
Pellaea falcata					2.0	5							1																0.3	25			0.2	10
Pellaea paradoxa					0.2	20					0.2	15									1.0	30									0.5	20		
Pellaea spp.					0.1	5	0.1	2																										
Peperomia blanda																															0.1	5		
Persoonia linearis							0.6	4							1.0	5							1.0	3			0.3	1						
Phyllanthus spp.							0.1	3																										
Pittosporum multiflorum			0.2	5	2.0	10							1.0	20															0.5	5	0.2	4	0.1	4
Pittosporum revolutum																													0.2	5	0.3	2	0.1	2
Pittosporum undulatum			3.0	4																			1.0	5					0.1	3				
*Plantago lanceolata**	0.3	30																																
Platycerium spp.																									0.1	1								
Platysace lanceolata															0.5	30																		
Plectorrhiza spp.					0.1	3																												
Plectranthus parviflorus	0.1	1							0.1	3	0.1	5			0.2	10					0.2	20											0.1	10
Plectranthus spp.																	0.2	5																
Poa labillardierei var. labillardierei			1.0	20																														
Podolobium ilicifolium			0.2	5																			0.1	1										
Pollia crispata																															0.1	4		
Polystichum australiense																													2.0	50	0.2	10		
Pomax umbellata															1.0	100											0.2	30						
Pseuderanthemum variabile	5.0	50	1.0	50	0.1	10					0.2	10	0.1	10	0.1	2	0.2	50	0.5	30	0.2	20	0.5	30	0.1	10	0.2	75			0.1	15	0.1	10
Psychotria loniceroides			0.1	1											0.1	1	1.0	5	2.0	10	0.1	5									0.1	2	0.1	1
Pteridium esculentum			0.1	2			0.1	1							2.0	25			70.0	100			0.5	20										
Pterostylis nutans			0.1	20																														
Pterostylis spp.					0.1	30									0.2	50			0.1	30														
Pyrrosia rupestris					0.3	50							0.2	15			0.4	50													0.8	25	0.1	10
Ranunculus spp.	0.1	10																																
Rhodamnia rubescens[1]							0.1	1									0.3	1													1.0	3		
*Richardia humistrata**	11.0	530																																
Ripogonum album																																	2.0	10
Ripogonum fawcettianum													1.0	10															5.0	50				

Scientific Name	LW34-1		LW34-2		LW34-3		LW34-4		LW34-5		LW34-6		LW34-7		LW34-8		LW34-9		LW34-10		LW34-11		LW34-12		LW34-13		LW34-14		PR144986 Plot 12		PR144986 Plot 19		PR144986 Plot 20	
*Rosa spp. **									0.5	5																								
Rubus moluccanus																			0.3	10														
Rubus nebulosus													0.5	8																			0.1	5
Rumex spp.	0.2	20							1.0	50																								
Rytidosperma pallidum			8.0	25																														
Rytidosperma spp.							0.1	1																			0.2	6						
Sarcochilus hillii																															0.1	25		
Sarcochilus olivaceus																															0.1	4		
Sarcochilus spp.																									0.1	2								
Sarcopetalum harveyanum																															0.3	4		
Schelhammera undulata																			1.0	50					0.1	5								
Schizomeria ovata																																	5.0	2
Schoenus spp.									0.2	20																								
Scolopia braunii					0.2	1																							5.0	50				
Senecio linearifolius																																	0.1	10
*Senna septemtrionalis**																																	0.1	4
*Setaria sphacelata**									0.5	25																							1.0	40
*Sida rhombifolia**									0.1	5																								
Sigesbeckia orientalis subsp. orientalis							0.1	1																									0.1	5
Smilax australis			0.2	10	0.5	20	0.2	5			0.2	5			0.1	1	0.3	10	0.2	20	1.0	20	0.2	5	2.0	20			1.0	20	0.2	8	0.1	1
*Solanum nigrum**																																	0.1	2
Solanum prinophyllum							0.1	1											0.1	1	0.1	2												
*Stellaria media**									1.0	200																								
*Stenotaphrum secundatum**	80.0	1,000																																
Stephania japonica									0.2	1																								
Syncarpia glomulifera			1.0	3							15.0	5	3.0	1	1.0	10	15.0	2	5.0	3	0.5	1	25.0	20	30.0	9			25.0	1				
Synoum glandulosum subsp. glandulosum			31.0	1	0.3	10							0.5	5	1.0	5	20.0	30	7.0	7	15.0	10	0.5	3					1.0	5	4.0	8	2.0	8
Syzygium australe					5.0	3																			10.0	3			0.5	25				
*Taraxacum officinale**									0.1	1																								
Tetrastigma nitens			0.1	1	0.2	8	0.1	2			0.1	1	1.0	15	0.1	1	5.0	30			0.1	10	0.1	2	0.1	3			0.5	20	0.6	10	0.6	8
Themeda triandra			5.0	20			2.0	100							1.0	50	0.2	20					0.5	40			10.0	100						
*Trifolium repens**	0.2	80																																
Trochocarpa laurina															2.0	4	5.0	6					0.5	2	1.0	2			3.0	5	1.0	1		
Tylophora barbata																															0.1	1		
Verbena spp.	0.1	1																																
Veronica plebeia																					0.1	10												

Scientific Name	LW34-1		LW34-2		LW34-3		LW34-4		LW34-5		LW34-6	LW34-7		LW34-8		LW34-9		LW34-10		LW34-11		LW34-12		LW34-13	LW34-14	PR144986 Plot 12		PR144986 Plot 19	PR144986 Plot 20	
Viola betonicifolia									0.3	50																			
Viola hederacea	0.2	40					0.1	1								0.3	200	0.2	30	0.1	20				0.2	50			
Wilkiea huegeliana					2.0	5						0.2	1												1.0	1		0.1	2
Xanthorrhoea resinosa			3.0	4																									
Xanthorrhoea spp.																						1.0	5						
Zieria smithii														0.5	15														

1. BC Act: Critically Endangered; EPBC Act: Critically Endangered; * = exotic species

Appendix G

Fauna List

Family	Scientific Name	Common Name	Number	Detection method
Amphibians				
Myobatrachidae	*Mixophyes fasciolatus*	Great Barred Frog	3	Heard; Observed
Myobatrachidae	*Pseudophryne coriacea*	Red-Backed Toadlet	10+	Heard
Myobatrachidae	*Uperoleia laevigata*	Smooth Toadlet	10+	Heard
Pelodryadidae	*Litoria fallax*	Eastern Dwarf Tree Frog	10+	Heard
Pelodryadidae	*Litoria tylerii*	Tylers Tree Frog	1	Heard
Pelodryadidae	*Limnodynastes peronii*	Perons Tree Frog	2	Heard; Observed
Pelodryadidae	*Litoria revelata*	Whirring Tree Frog	2	Heard
Birds				
Accipitridae	*Haliaeetus leucogaster*	White-bellied sea eagle	1	Observed
Alcedinidae	*Dacelo novaeguineae*	Kookaburra	2	Observed
Artamidae	*Strepera graculina*	Pied currawong	1	Heard
Cacatuidae	*Cacatua galerita*	Sulphur-crested cockatoo	1	Heard
Campephagidae	*Coracina novaehollandiae*	Black-faced cuckooshrike	1	Heard
Campephagidae	*Edolisoma tenuirostre*	Common Circadbird	1	Heard
Climacteridae	*Cormobates leucophaea*	White-throated treecreeper	1	Heard; Observed
Climacteridae	*Climacteris picumnus*	Brown treecreeper	2	Heard
Columbidae	*Leucosarcia melanoleuca*	Wonga Pigeon	2	Observed
Columbidae	*Macropygia phasianella*	Brown cuckoo-dove	1	Observed
Coraciidae	*Eurystomus orientalis*	Oriental dollarbird	1	Heard
Corcoracidae	*Corcorax melanorhamphos*	White-winged chough	1	Heard
Cuculidae	*Chrysococcyx lucidus*	Shining bronze cuckoo	1	Heard
Cuculidae	*Cacomantis flabelliformis*	Fan-tailed cuckoo	2	Observed/ Heard
Maluridae	*Malurus cyaneus*	Superb Fairy-wren	10	Observed
Meliphagidae	*Caligavis chrysops*	Yellow-faced honeyeater	1	Observed
Meliphagidae	*Lichmera indistincta*	Brown Honeyeater	1	Heard
Meliphagidae	*Manorina melanophrys*	Bell Miner	1	Heard
Meliphagidae	*Myzomela sanguinolenta*	Scarlet Myzomela	1	Heard
Menuridae	*Menura novaehollandiae*	Superb lyrebird	2	Heard
Monarchidae	*Myiagra inquieta*	Restless flycatcher	1	Heard
Monarchidae	*Monarcha melanopsis*	Black-faced monarch	1	Observed
Pachycephalidae	*Pachycephala rufiventris*	Rufous whistler	1	Heard
Pardalotidae	*Pardalotus punctatus*	Spotted Pardalote	1	Heard
Pardalotidae	*Pardalotus striatus*	Striated Pardalote	1	Heard
Phasianidae	*Coturnix ypsilophora*	Brown quail	1	Observed
Psittaculidae	*Trichoglossus chlorolepidotus*	Scaly-breasted lorikeet	1	Heard
Psittaculidae	*Trichoglossus moluccanus*	Rainbow lorikeet	1	Heard
Ptilonorhynchidae	*Ailuroedus crassirostris*	Green Catbird	1	Observed
Ptilonorhynchidae	*Ptilonorhynchus violaceus*	Satin bowerbird	1	Observed
Rallidae	*Fulica atra*	Eurasian coot	1	Observed
Rallidae	*Porphyrio melanotus*	Australasian swamphen	5	Observed

Family	Scientific Name	Common Name	Number	Detection method
Rhipiduridae	*Rhipidura rufifrons*	Rufous fantail	1	Observed
Tytonidae	*Tyto novaehollandiae*	Masked Owl	1	Observed
Tytonidae	*Tyto tenebricosa*	Sooty Owl	1	Heard
Mammals				
Acrobatidae	*Acrobates pygmaeus*	Feather-tailed Glider	3	Observed
Vespertilionidae	*Chalinolobus dwyeri*	Large-eared Pied Bat	8 calls to high confidence	Anabat; see **Appendix I**
Dasyuridae	*Antechinus stuartii*	Brown Antechinus	1	Elliot trap
Macropodidae	*Macropus rufogriseus*	Red-necked Wallaby	5	Observed
Vespertilionidae	*Miniopterus australis*	Little Bent-winged Bat	1 call to high confidence	Anabat; see **Appendix I**
Petauridae	*Petaurus norfolcensis*	Squirrel Glider	2	Heard
Pteropodidae	*Pteropus poliocephalus*	Grey-headed Flying Fox	1	Heard
Petauridae	*Petaurus australis*	Yellow-bellied Glider	5	Observed
Muridae	*Rattus fuscipes*	Bush Rat	3	Camera trap; Elliot trap
Rhinolophidae	*Rhinolophus megaphyllus*	Eastern Horseshoe Bat	10; 1,886 calls to high confidence	Observed; Anabat; see **Appendix I**
Phalangeridae	*Trichosurus vulpecula*	Common brushtail possum	1	Camera trap
Caninae	*Vulpes vulpes**	Red Fox	1	Camera trap
Reptiles				
Carphodactylidae	*Phyllurus platurus*	Broad-tailed gecko	3	Observed
Colubridae	*Dendrelaphis punctulatus*	Common tree snake	1	Observed
Elapidae	*Pseudonaja textilis*	Eastern brown snake	1	Observed
Varanidae	*Varanus varius*	Goanna	1	Observed

* = introduced species.

Appendix H

Anabat data analysis

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5th February 2021

Results of microbat echolocation call survey at sandstone overhangs, near Mandalong, New South Wales.

Dear Hayden,

Following are the results from your microbat echolocation call survey at potential control and impact sites, near Mandalong, New South Wales. Six predominantly cave roosting microbats could be expected to occur along sandstone escarpments and areas containing overhangs in the Mandalong area; the Eastern Horseshoe Bat (*Rhinolophus megaphyllus*), Large-eared Pied Bat (*Chalinolobus dwyeri*), Little Bent-winged Bat (*Miniopterus australis*), Large Bent-winged Bat (*Miniopterus orianae oceanensis*), Southern Myotis (*Myotis macropus*) and Eastern Cave Bat (*Vespadelus troughtoni*).

The results from analysis of microbat echolocation calls at control and impact sites are detailed in *Table 1*. The total echolocation passes are noted with passes identified to a confident level in brackets.

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Table 1: Activity of target microbat species at control and impact sites

Site	Date	R.meg	C.dwy	M.aus	M.oce	M.mac	V.tro
Control 1*	11/01/2021	12(11)	0(0)	0(0)	0(0)	0(0)	0(0)
Control 1	12/01/2021	22(20)	0(0)	0(0)	0(0)	0(0)	0(0)
Control 2	11/01/2021	11(4)	0(0)	1(0)	0(0)	0(0)	0(0)
Control 2	12/01/2021	32(25)	0(0)	0(0)	0(0)	0(0)	0(0)
Control 3	11/01/2021	519(503)	0(0)	0(0)	0(0)	0(0)	0(0)
Control 3	12/01/2021	191(172)	0(0)	0(0)	0(0)	0(0)	0(0)
Control 4**	13/01/2021	1(1)	0(0)	0(0)	0(0)	0(0)	0(0)
Control 4**	14/01/2021	-	-	-	-	-	-
Control 5	13/01/2021	2(2)	0(0)	2(2)	0(0)	0(0)	0(0)
Control 5	14/01/2021	3(3)	0(0)	2(0)	0(0)	0(0)	0(0)
Control 6	13/01/2021	50(31)	0(0)	0(0)	0(0)	0(0)	0(0)
Control 6	14/01/2021	121(87)	0(0)	0(0)	0(0)	0(0)	0(0)
Impact 1	11/01/2021	7(6)	0(0)	0(0)	0(0)	0(0)	0(0)
Impact 1	12/01/2021	4(3)	0(0)	0(0)	0(0)	0(0)	0(0)
Impact 2	11/01/2021	236(214)	1(0)	4(0)	0(0)	0(0)	0(0)
Impact 2	12/01/2021	174(163)	0(0)	8(6)	0(0)	0(0)	0(0)
Impact 3	11/01/2021	9(9)	0(0)	0(0)	0(0)	0(0)	0(0)
Impact 3	12/01/2021	11(11)	2(0)	0(0)	0(0)	0(0)	0(0)
Impact 4	13/01/2021	7(7)	6(6)	1(0)	0(0)	0(0)	0(0)
Impact 4	14/01/2021	7(6)	3(2)	1(1)	0(0)	0(0)	0(0)
Impact 5	13/01/2021	579(541)	0(0)	0(0)	0(0)	0(0)	0(0)
Impact 5	14/01/2021	9(8)	0(0)	0(0)	0(0)	0(0)	0(0)
Impact 6	13/01/2021	9(0)	0(0)	0(0)	1(0)	0(0)	0(0)
Impact 6	14/01/2021	59(59)	0(0)	0(0)	1(0)	0(0)	0(0)

*check detector settings, division ratio caused problems with data presentation.

**detector ran out of battery after first call recorded on 13/01/2021. No data, needs resampling, especially since the photos show large numbers of scats on the floor of the cave.

The number of echolocation calls identified to a high level of confidence to a species are marked in brackets.

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As seen in *Table 1*, the Eastern Horseshoe Bat was recorded at all sites, with very high activity at control sites 3 and 6 and impact sites 2, 5 and 6. This activity may be indicative of a largish roost in the vicinity of these sites and thought should be given to undertaking capture of this species at these sites to establish if a maternity roost or large non maternity roost is present. While this species is not listed as threatened loss of a maternity roost would significantly impact local populations. Impact site 4 had the highest activity of the Large-eared Pied Bat, with lesser activity at impact sites 3 and 2. The Little Bent-winged Bat was generally recorded at lower levels of activity at the control and impact sites. The Eastern Bent-winged Bat, Southern Myotis and Eastern Cave Bat were either not recorded or only recorded from a couple of passes.

Trapping for the Large-eared Pied Bat should be undertaken at impact sites 2, 3 and 4 next breeding season (Nov-Jan) to ascertain if breeding is taking place in the vicinity. Harp trapping of the Eastern Horseshoe Bat should be undertaken next summer at control sites 3 and 6 and impact sites 2, 5 and 6 to determine if these sites are used for breeding or are substantial non-breeding roost sites. Control sites 3 and 6 and impact sites 2, 4, 5 and 6 would be worth maintaining as monitoring sites. Investigation of additional sites would be warranted, particularly to ascertain sites where the Large-eared Pied Bat occurs at similar activity levels as impact site 4.

Detectors failed on a number of nights: control 4 on 13/01/2021 and 14/01/2021. Data from these sites should be recollected. Data from control 1 on 11/01/2021 looked to be missing until it was found to be hundreds of kHz higher than it should have been. The date on the detector was reading 1970. This unit should be thoroughly checked and tested before being redeployed. Also, check the division ratios and setting on all your detectors are set the same, and ensure division ratio on CFread is correct when downloading flash cards from older detector.

From viewing the photos of the detectors from sites, placement of the detectors may have also impacted the results. Detectors placed facing into cave entrances, or across narrow entrances is not the most optimal sampling location. Bats often give non characteristic calls within the confines of caves. Placement of the detector outside the cave either facing along the cliffline (across the entrance) of larger caves, or facing from the cave mouth out along the expected exit flyway, will record better pulses and give a better indication of cave use.

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References

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Best wishes



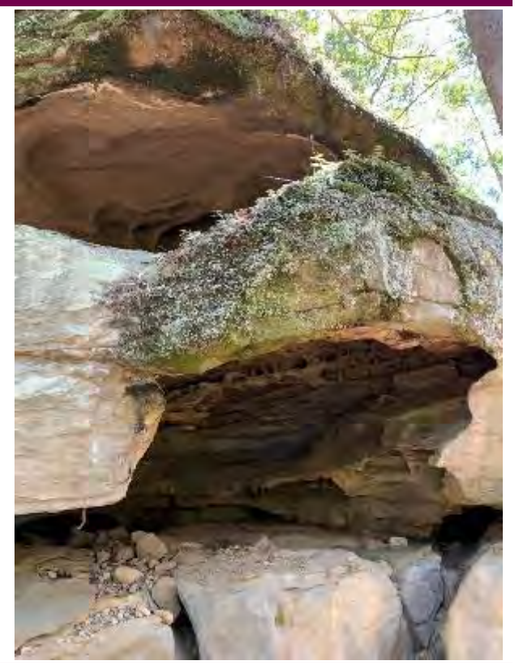
Glenn Hoye

Appendix I

Cave survey

Cave Attribute Measurements

Number	Grid East	Grid North	Cliff Height (m)	Slope (°)	Fissures			Cave/Overhang			Honeycombing area (m2)	Bat Scats	Bat Species/No.	Photograph
					Max width (m)	Max Depth (m)	Length (m)	Width (m)	Max Height (m)	Length (m)				
C32	351293	6327345	5	10	-	-	-	2.66	1.9	1.83	0	-	-	
C33	351270	6327128	1.8	10	-	-	-	2.6	1.51	1.99	0	-	-	
C34	351476	6327551	5	10	-	-	-	5.27	2.53	2.97	6	-	-	

Number	Grid East	Grid North	Cliff Height (m)	Slope (°)	Fissures			Cave/Overhang			Honeycombing area (m2)	Bat Scats	Bat Species/No.	Photograph
					Max width (m)	Max Depth (m)	Length (m)	Width (m)	Max Height (m)	Length (m)				
C35	351463	6327572	5.5	10	-	-	-	4.24	2.01	2.94	5	-	-	
C36	351352	6327581	5.5	10	-	-	-	4.07	3.07	4.64	0.5	-	-	

Number	Grid East	Grid North	Cliff Height (m)	Slope (°)	Fissures			Cave/Overhang			Honeycombing area (m2)	Bat Scats	Bat Species/No.	Photograph
					Max width (m)	Max Depth (m)	Length (m)	Width (m)	Max Height (m)	Length (m)				
C37	351355	6327574	3	15	20	>2	1.5	4.44	1.6	7.22	1	-	-	
C38	351367	6327551	4	10	1.5	2.24	2.5	4.43	3.08	4.3	0.5	-	-	

Number	Grid East	Grid North	Cliff Height (m)	Slope (°)	Fissures			Cave/Overhang			Honeycombing area (m2)	Bat Scats	Bat Species/No.	Photograph
					Max width (m)	Max Depth (m)	Length (m)	Width (m)	Max Height (m)	Length (m)				
C39	351375	6327499	6	40	-	-	-	5.05	1.62	4.56	2	-	-	
C40	351373	6327501	6	40	-	-	-	2.98	1.52	4.85	1.5	-	-	
C41	351411	6327484	2.5	8	-	-	-	2.61	1.49	2.76	0.5	-	-	

Number	Grid East	Grid North	Cliff Height (m)	Slope (°)	Fissures			Cave/Overhang			Honeycombing area (m2)	Bat Scats	Bat Species/No.	Photograph
					Max width (m)	Max Depth (m)	Length (m)	Width (m)	Max Height (m)	Length (m)				
C42	351414	6327387	5.5	15	1.5	2	1.5	3.23	3.14	2.68	1	-	-	
C43	351399	6327263	4	15	-	-	-	3.61	1.83	2.73	0	-	-	

Number	Grid East	Grid North	Cliff Height (m)	Slope (°)	Fissures			Cave/Overhang			Honeycombing area (m2)	Bat Scats	Bat Species/No.	Photograph
					Max width (m)	Max Depth (m)	Length (m)	Width (m)	Max Height (m)	Length (m)				
C44	351370	6327243	5	10	-	-	-	3.25	2.07	3.64	0.5	-	-	
C45	351419	6327147	1.8	10	-	-	-	2.31	1.25	2.97	0.2	Yes - small amount	-	
C46	351538	6327268	4.5	5	-	-	-	2.27	1.39	1.95	0	-	-	

Number	Grid East	Grid North	Cliff Height (m)	Slope (°)	Fissures			Cave/Overhang			Honeycombing area (m2)	Bat Scats	Bat Species/No.	Photograph
					Max width (m)	Max Depth (m)	Length (m)	Width (m)	Max Height (m)	Length (m)				
C47	351536	6327294	4	5	-	-	-	4.15	2.61	3.79	0	-	-	
C56	351407.46	6327676.62	7	10	-	-	-	7.1	4.69	4.69	1.5	Yes	-	
C57	351455.94	6327536.73	-	-	-							Yes	-	NA

Appendix J

EPBC Act: Assessment of Significance

Significant Impact Criteria for Endangered or Critically Endangered Species	*Rhodamnia rubescens*
Lead to a long-term decrease in the size of a population	**Unlikely.** *Rhodamnia rubescens* is relatively common throughout the local area, as indicated by frequent records in the local area (i.e. 163 ind. within 10 km search area, as per DPIE 2021a). Targeted surveys were undertaken by RPS across the Project Area using parallel transects to find 89 individuals within the Project Area. None of these were located within areas where ponding is predicted due to subsidence associated with MOD 10. To date, annual monitoring of *R. rubescens* for extracted longwalls LW22-24a and LW25-29 has yet to detect impacts associated with ponding on this species. Further, annual monitoring of Groundwater Dependent Ecosystems for these extracted longwalls has yet to detect any more than negligible changes that may be associated with subsidence-related ponding, even within the valley flats where ponding impacts for Mandalong South Extension were predicted to be most extensive. Hence, even under a ponding scenario, the loss of *R. rubescens* due to mining activities by Mandalong Mine have yet to be detected. Moreover, the key threat to this species which led to its conservation listing is related to Myrtle Rust infection, rather than land clearing. Hence, under the unlikely case that one individual were impacted by ponding (either directly or indirectly through incurring stress), this is not expected to translate to a long-term decrease of a population since a 96-99% decline is predicted for this species due to Myrtle Rust alone over the next 30-40 years (NSW TSSC 2018a). To minimise and avoid impacts to biodiversity values (including *R. rubescens*), the following steps were also undertaken to reduce impacts associated with MOD 10: • LW30 (as part of MOD 9) will no longer be extracted. The potential impacts on biodiversity associated with this longwall (including R. rubescens recorded in the vicinity would be avoided; • An original version of MOD 10 included the extension of LW30-33. By avoiding this extension, potential impacts to biodiversity in this area was avoided; and • The original version of MOD 10 and addition of LW34 (MOD 10; Project) initially extended into Lot 502 DP730395. This land parcel was inaccessible for survey. To avoid uncertain impacts on biodiversity values on that property, LW34 was shortened to avoid potential impacts on this property. As such, although it is considered possible that the Project may impact no individuals, this is not expected to lead to a long-term decrease in the size of a *R. rubescens* population given the lack of impact detected when monitoring this species in already extracted areas, limited predicted impact (i.e. no individuals impacted given the small extent of expected ponding), whilst a widespread loss of the species is expected solely due to disease.
Reduce the area of occupancy of the species	**Unlikely.** The area of occupancy (AOO) for *R. rubescens* is estimated to be 3,360 km^2 (NSW TSSC 2018a). *R. rubescens* is relatively common throughout Wet Sclerophyll Forest and Rainforest within the local area, as indicated by frequent records throughout Mandalong Valley (i.e. 163 ind. within 10 km search area, as per DPIE 2021a). Given the expression of subsidence-related ponding has yet to be detected within annual monitoring of *R. rubescens* for extracted areas of LW22-24a and LW25-29, it is not expected that the ponding would directly impact the occupancy of *R. rubescens*. Hence, it is not predicted that the Project would reduce the area of occupancy of *R. rubescens.*
Fragment an existing population into two or more populations	**Unlikely.** Suitable habitat for this species is available throughout the local area, including the Mandalong valley. This is evidenced by relatively high frequency of and widely dispersed records throughout the local area (i.e. 163 ind. within 10 km search area, as per DPIE 2021a). Based on the availability of suitable habitat, and minor extent of

Significant Impact Criteria for Endangered or Critically Endangered Species	*Rhodamnia rubescens*
	habitat that may be impacted by ponding (i.e. <0.001 ha), it is considered that the action is unlikely to fragment a population of this species.
Adversely affect habitat critical to the survival of a species	**Unlikely.** Suitable habitat for this species is available throughout the local area, including the Mandalong valley. This is evidenced by a relatively high frequency of and widely dispersed records throughout the local area (i.e. 163 ind. within 10 km search area, as per DPIE 2021a). Based on the availability of suitable habitat, and minor extent of bushland that may be impacted by ponding (i.e. <0.001 ha), it is considered that the proposed action is unlikely to affect habitat critical to the survival of the species.
Disrupt the breeding cycle of a population	**Unlikely.** The breeding success of this species is highly impacted by Myrtle Rust infection, with few viable seeds in the wild (Sommerville et al. 2019). Based on its' limited reproductive success, the extent of suitable habitat in the local area, and the relatively small extent of land to be impacted by ponding (i.e. <0.001 ha), it is considered unlikely that the ponding would disrupt the breeding cycle of a population.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	**Unlikely.** Suitable habitat for this species is available throughout the gullies of Mandalong Valley. Much of this suitable habitat in the local area is also located within the Olney State Forest, which is largely protected from harmful activities. As such, the relatively small area of potential habitat located within the inaccessible property does present habitat for the species. However, only a very minor extent (i.e. <0.001 ha) may be prone to increased ponding associated with mining. As more than negligible mining related impact (i.e. ponding) is yet to be detected for existing Mandalong mine workings on groundwater dependant threatened plants or ecosystems, any impact expressed by the action is expected to be negligible in the context of the habitat availability in the local area. As such, it is not expected that the action would modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat	**Unlikely.** The action is restricted to coal extraction only, with no surface works. Hence, it is not expected that the action would result in invasive species harmful to *R. rubescens*. The key threat to this species is Myrtle Rust. This pathogen is already widespread throughout the Mandalong Valley, and it is not expected that the ponding associated with the Project would increase the amplify the spread of the disease.
Introduce disease that may cause the species to decline	**Unlikely.** This species is threatened by Myrtle Rust. All plant parts have been documented as being affected by Myrtle Rust infection, including leaves, stems, flowers and fruits. Across the range of the species, infection is widespread (i.e. disease was detected in all 43 sites surveyed across the species range of 18 sites by Carnegie et al 2016). Moreover, Myrtle Rust has been widely documented throughout the Mandalong Valley associated with *R. rubescens* (H. Beck, Pers. Obs. 2021). Hence, it is not expected that the action would introduce disease, as the primary threat to the species (i.e. Myrtle Rust) is already present.
Interfere with the recovery of the species	**Unlikely.** There is no recovery plan for the species under the EPBC Act. Currently, 13% of the species' distribution occurs on reserve, which does not encompass the Project Area (within NSW National Parks and Wildlife Service estate; DPIE 2021a). There are no priority management sites in or nearby to the Project Area. Hence, it is considered unlikely that the Project would interfere with the recovery of this species.

Appendix B
Current and future VI Scores

Note that data was collected electronically, so datasheets have not been appended. Please see summary of plot data and estimated future VI (following ponding impacts) as entered into BAM-C below. See Appendix A for species composition data for plots.

Table A1 BAM-C Input for Zone 1: PCT 1528 (Moderate)

Plot	Comp Tree	Comp Shrub	Comp Grass	Comp Forbs	Comp Ferns	Comp Other	Struc Tree	Struc Shrub	Struc Grass	Struc Forbs	Struc Ferns	Struc Other	Fun Large Trees	Fun Hollow trees	Fun Litter Cover	Fun Len Fallen Logs	Fun Tree Stem 5to9	Fun Tree Stem 10to19	Fun Tree Stem 20to29	Fun Tree Stem 30to49	Fun TreeStem 50 to79	Fun Tree Regen	Fun High Threat Exotic
LW34-3	4	12	3	7	9	12	26.2	55.1	0.4	1.1	23.1	27.2	0	0	48.2	25.0	1	1	1	1	0	1	0.0

Table A2 BAM-C Input for Zone 2: PCT 1556 (Moderate)

Plot	Comp Tree	Comp Shrub	Comp Grass	Comp Forbs	Comp Ferns	Comp Other	Struc Tree	Struc Shrub	Struc Grass	Struc Forbs	Struc Ferns	Struc Other	Fun Large Trees	Fun Hollow trees	Fun Litter Cover	Fun Len Fallen Logs	Fun Tree Stem 5to9	Fun Tree Stem 10to19	Fun Tree Stem 20to29	Fun Tree Stem 30to49	Fun TreeStem 50 to79	Fun Tree Regen	Fun High Threat Exotic
LW34-8	8	8	7	13	4	8	78.4	3.8	7.3	3.3	2.4	10.9	0	0	66.4	48.0	1	1	1	1	1	1	0.0
LW34-9	7	4	6	11	5	14	61.0	21.8	1.2	2.7	7.6	20.3	0	0	55.0	67.0	1	1	1	1	1	1	0.0
LW34-10	5	5	4	15	3	13	38.1	9.6	1.2	3.1	71.5	27.7	1	0	68.0	95.0	1	1	1	1	1	1	0.0
LW34-11	4	8	4	11	6	13	30.5	24.9	3.3	1.3	1.9	39.6	2	0	84.8	85.0	1	1	1	1	0	1	0.0
LW34-12	7	6	8	8	1	12	57.0	3.2	8.4	2.2	0.5	2.2	1	6	90.4	35.0	1	1	1	1	1	1	0.0

Table A3 Average VI scores and future VI score assuming half loss of vegetation condition due to ponding for Zone 2: PCT 1556 (Moderate)

Plot	Comp Tree	Comp Shrub	Comp Grass	Comp Forbs	Comp Ferns	Comp Other	Struc Tree	Struc Shrub	Struc Grass	Struc Forbs	Struc Ferns	Struc Other	Fun Large Trees	Fun Hollow trees	Fun Litter Cover	Fun Len Fallen Logs	Stem classes	Exotic[1]
Average score	6.20	6.20	5.80	11.60	3.80	12.00	53.00	12.66	4.28	2.52	16.78	20.14	0.80	1.20	72.92	66.00	4.8	0.0
Future VI (Half Average)	3.10	3.10	2.90	5.80	1.90	6.00	26.50	6.33	2.14	1.26	8.39	10.07	0.40	0.60	36.46	33.00	2.40	0.0

1. Exotic cover was held constant.

Table A4 BAM-C Input for Zone 3: PCT 1568 (Moderate)

Plot	Comp Tree	Comp Shrub	Comp Grass	Comp Forbs	Comp Ferns	Comp Other	Struc Tree	Struc Shrub	Struc Grass	Struc Forbs	Struc Ferns	Struc Other	Fun Large Trees	Fun Hollow trees	Fun Litter Cover	Fun Len Fallen Logs	Fun Tree Stem 5to9	Fun Tree Stem 10to19	Fun Tree Stem 20to29	Fun Tree Stem 30to49	Fun TreeStem 50to79	Fun Tree Regen	Fun High Threat Exotic
LW34-6	5	3	4	5	3	11	65.1	15.3	1.4	0.7	0.8	14.2	0	0	72.6	23.0	1	1	1	1	0	1	0.0
LW34-13	7	4	4	5	4	10	63.2	35.4	0.8	1.3	2.3	11.0	1	0	88.8	31.0	1	1	1	1	1	1	0.0
PR144986 Plot 12	10	11	2	2	4	10	84.0	68.5	6.0	1.2	11.3	14.8	1	1	85.0	51.0	0	1	1	1	1	0	0.0
PR144986 Plot 19	10	15	6	9	12	17	44.8	69.8	0.8	1.0	17.2	3.8	0	0	74.0	75.0	1	1	1	1	1	1	0.2

Table A5 Average VI scores and future VI score assuming half loss of vegetation condition due to ponding for Zone 3: PCT 1568 (Moderate)

Plot	Comp Tree	Comp Shrub	Comp Grass	Comp Forbs	Comp Ferns	Comp Other	Struc Tree	Struc Shrub	Struc Grass	Struc Forbs	Struc Ferns	Struc Other	Fun Large Trees	Fun Hollow trees	Fun Litter Cover	Fun Len Fallen Logs	Stem classes	Exotic[1]
Average score	8.00	8.25	4.00	5.25	5.75	12.00	64.28	47.25	2.25	1.05	7.90	10.95	0.50	0.25	80.10	45.00	4.50	0.05
Future VI (Half Average)	4.00	4.13	2.00	2.63	2.88	6.00	32.14	23.63	1.13	0.53	3.95	5.48	0.25	0.13	40.05	22.50	2.25	0.05

1. Exotic cover was held constant.

Table A6 BAM-C Input for Zone 4: PCT 1573 (Moderate)

Plot	Comp Tree	Comp Shrub	Comp Grass	Comp Forbs	Comp Ferns	Comp Other	Struc Tree	Struc Shrub	Struc Grass	Struc Forbs	Struc Ferns	Struc Other	Fun Large Trees	Fun Hollow trees	Fun Litter Cover	Fun Len Fallen Logs	Fun Tree Stem 5to9	Fun Tree Stem 10to19	Fun Tree Stem 20to29	Fun Tree Stem 30to49	Fun TreeStem 50to79	Fun Tree Regen	Fun High Threat Exotic
LW34-7	5	10	1	1	7	11	45.5	33.8	0.2	0.1	7.6	75.4	1	0	80.4	80.0	1	1	1	1	1	1	0.0
PR144986 Plot 20	6	9	10	11	8	16	32.4	25.5	14.2	1.8	1.4	74.9	1	0	85.0	66.0	1	1	1	1	1	1	10.4

Table A7 Average VI scores and future VI score assuming half loss of vegetation condition due to ponding for Zone 4: PCT 1573 (Moderate)

Plot	Comp Tree	Comp Shrub	Comp Grass	Comp Forbs	Comp Ferns	Comp Other	Struc Tree	Struc Shrub	Struc Grass	Struc Forbs	Struc Ferns	Struc Other	Fun Large Trees	Fun Hollow trees	Fun Litter Cover	Fun Len Fallen Logs	Stem classes	Exotic[1]
Average score	5.50	9.50	5.50	6.00	7.50	13.50	38.95	29.65	7.20	0.95	4.50	75.15	1.00	0.00	82.70	73.00	5	5.50
Future VI (Half Average)	2.75	4.75	2.75	3.00	3.75	6.75	19.48	14.83	3.60	0.48	2.25	37.58	0.50	0.00	41.35	36.50	2.50	2.75

1. Exotic cover was held constant.

Table A8 BAM-C Input for Zone 5: PCT 1588 (Moderate)

Plot	Comp Tree	Comp Shrub	Comp Grass	Comp Forbs	Comp Ferns	Comp Other	Struc Tree	Struc Shrub	Struc Grass	Struc Forbs	Struc Ferns	Struc Other	Fun Large Trees	Fun Hollow trees	Fun Litter Cover	Fun Len Fallen Logs	Fun Tree Stem 5to9	Fun Tree Stem 10to19	Fun Tree Stem 20to29	Fun Tree Stem 30to49	Fun TreeStem 50to79	Fun Tree Regen	Fun High Threat Exotic
LW34-2	6	11	8	13	2	10	58.2	35.4	16.3	6.0	0.6	4.2	0	0	79.6	53.0	1	1	1	1	1	1	0.0
LW34-4	5	5	8	7	4	12	62.0	1.0	13.6	0.9	0.4	1.5	1	5	90.8	51.0	1	1	1	1	1	1	0.0
LW34-14	6	5	10	7	1	6	113.1	17.2	21.4	3.7	0.2	5.5	0	0	91.6	11.0	1	1	1	1	1	1	0.0

Table A9 BAM-C Input for Zone 6: Disturbed/ cleared land

Plot	Comp Tree	Comp Shrub	Comp Grass	Comp Forbs	Comp Ferns	Comp Other	Struc Tree	Struc Shrub	Struc Grass	Struc Forbs	Struc Ferns	Struc Other	Fun Large Trees	Fun Hollow trees	Fun Litter Cover	Fun Len Fallen Logs	Fun Tree Stem 5to9	Fun Tree Stem 10to19	Fun Tree Stem 20to29	Fun Tree Stem 30to49	Fun TreeStem 50to79	Fun Tree Regen	Fun High Threat Exotic
LW34-1	1	0	4	14	0	1	0.1	0.0	3.3	9.3	0.0	0.1	0	0	7.2	0.0	0	0	0	1	1	0	0.2
LW34-5	2	2	4	9	1	4	0.3	0.4	1.6	3.3	1.0	2.4	0	0	8.6	7.0	0	1	1	1	0	1	2.3

Appendix C

Biodiversity Credit Report

BAM Credit Summary Report

Proposal Details

Assessment Id
00026541/BAAS19000/21/00026542

Proposal Name
Centennial Mandalong SSD-5144 MOD 10

BAM data last updated *
10/06/2021

Assessor Name
Hayden John Beck

Report Created
23/08/2021

BAM Data version *
45

Assessor Number
BAAS19000

BAM Case Status
Open

Date Finalised
To be finalised

Assessment Revision
1

Assessment Type
Major Projects

* Disclaimer: BAM data last updated may indicate either complete or partial update of the BAM calculator database. BAM calculator database may not be completely aligned with Bionet.

Ecosystem credits for plant communities types (PCT), ecological communities & threatened species habitat

Zone	Vegetation zone name	TEC name	Current Vegetation integrity score	Change in Vegetation integrity (loss / gain)	Area (ha)	BC Act Listing status	EPBC Act listing status	Species sensitivity to gain class (for BRW)	Biodiversity risk weighting	Potential SAII	Ecosystem credits
Blackbutt - Turpentine - Sydney Blue Gum mesic tall open forest on ranges of the Central Coast											
2	1568_Zone 3_Moderate	Not a TEC	78.8	36.0	0.01			High Sensitivity to Potential Gain	1.50		1
										Subtotal	**1**

Sydney Blue Gum - Lilly Pilly mesic tall open forest of coastal ranges and tablelands escarpment											
3	1573_Zone4_Moderate_Good	Not a TEC	76.9	36.4	0.01			High Sensitivity to Potential Gain	1.50		1
										Subtotal	**1**
Tallowwood - Smooth-barked Apple - Blackbutt grass tall open forest of the Central and lower North Coast											
1	1556_Zone2_Moderate	Not a TEC	78.2	36.2	0.01			High Sensitivity to Potential Gain	1.50		1
										Subtotal	**1**
										Total	**3**

Species credits for threatened species

Vegetation zone name	Habitat condition (Vegetation Integrity)	Change in habitat condition	Area (ha)/Count (no. individuals)	BC Act Listing status	EPBC Act listing status	Biodiversity risk weighting	Potential SAII	Species credits
Callocephalon fimbriatum / Gang-gang Cockatoo (Fauna)								
1556_Zone2_Moderate	36.2	36.2	0.01	Vulnerable	Not Listed	2	False	1
1568_Zone3_Moderate	36.0	36.0	0	Vulnerable	Not Listed	2	False	0
1573_Zone4_Moderate_Good	36.4	36.4	0	Vulnerable	Not Listed	2	False	0
							Subtotal	**1**
Cercartetus nanus / Eastern Pygmy-possum (Fauna)								
1556_Zone2_Moderate	36.2	36.2	0.01	Vulnerable	Not Listed	2	False	1

1568_Zone3_Moderate	36.0	36.0	0	Vulnerable	Not Listed	2	False	0
1573_Zone4_Moderate_Good	36.4	36.4	0	Vulnerable	Not Listed	2	False	0
							Subtotal	**1**
Chalinolobus dwyeri / Large-eared Pied Bat (Fauna)								
1556_Zone2_Moderate	36.2	36.2	0	Vulnerable	Vulnerable	3	True	0
1568_Zone3_Moderate	36.0	36.0	0	Vulnerable	Vulnerable	3	True	0
1573_Zone4_Moderate_Good	36.4	36.4	0	Vulnerable	Vulnerable	3	True	0
							Subtotal	**0**
Cryptostylis hunteriana / Leafless Tongue Orchid (Flora)								
1556_Zone2_Moderate	36.2	36.2	0.01	Vulnerable	Vulnerable	1.5	False	1
1568_Zone3_Moderate	36.0	36.0	0	Vulnerable	Vulnerable	1.5	False	0
							Subtotal	**1**
Haliaeetus leucogaster / White-bellied Sea-Eagle (Fauna)								
1556_Zone2_Moderate	36.2	36.2	0.01	Vulnerable	Not Listed	2	False	1
1568_Zone3_Moderate	36.0	36.0	0	Vulnerable	Not Listed	2	False	0
							Subtotal	**1**

Hoplocephalus bitorquatus / Pale-headed Snake (Fauna)								
1556_Zone2_Moderate	36.2	36.2	0.01	Vulnerable	Not Listed	2	False	1
1568_Zone3_Moderate	36.0	36.0	0	Vulnerable	Not Listed	2	False	0
1573_Zone4_Moderate_Good	36.4	36.4	0	Vulnerable	Not Listed	2	False	0
							Subtotal	**1**
Hoplocephalus stephensii / Stephens' Banded Snake (Fauna)								
1556_Zone2_Moderate	36.2	36.2	0.01	Vulnerable	Not Listed	2	False	1
1568_Zone3_Moderate	36.0	36.0	0	Vulnerable	Not Listed	2	False	0
1573_Zone4_Moderate_Good	36.4	36.4	0	Vulnerable	Not Listed	2	False	0
							Subtotal	**1**
Litoria brevipalmata / Green-thighed Frog (Fauna)								
1556_Zone2_Moderate	36.2	36.2	0.01	Vulnerable	Not Listed	1.5	False	1
							Subtotal	**1**
Litoria littlejohni / Littlejohn's Tree Frog (Fauna)								
1568_Zone3_Moderate	36.0	36.0	0.01	Vulnerable	Vulnerable	2	False	1
							Subtotal	**1**

Lophoictinia isura / Square-tailed Kite (Fauna)								
1556_Zone2_Moderate	36.2	36.2	0.01	Vulnerable	Not Listed	1.5	False	1
1568_Zone3_Moderate	36.0	36.0	0	Vulnerable	Not Listed	1.5	False	0
							Subtotal	**1**
Miniopterus australis / Little Bent-winged Bat (Fauna)								
1556_Zone2_Moderate	36.2	36.2	0	Vulnerable	Not Listed	3	True	0
1568_Zone3_Moderate	36.0	36.0	0	Vulnerable	Not Listed	3	True	0
1573_Zone4_Moderate_Good	36.4	36.4	0	Vulnerable	Not Listed	3	True	0
							Subtotal	**0**
Miniopterus orianae oceanensis / Large Bent-winged Bat (Fauna)								
1556_Zone2_Moderate	36.2	36.2	0	Vulnerable	Not Listed	3	True	0
1568_Zone3_Moderate	36.0	36.0	0	Vulnerable	Not Listed	3	True	0
1573_Zone4_Moderate_Good	36.4	36.4	0	Vulnerable	Not Listed	3	True	0
							Subtotal	**0**
Mixophyes balbus / Stuttering Frog (Fauna)								
1556_Zone2_Moderate	36.2	36.2	0.01	Endangered	Vulnerable	3	True	1

1568_Zone3_Moderate	36.0	36.0	0	Endangered	Vulnerable	3	True	0
1573_Zone4_Moderate_Good	36.4	36.4	0	Endangered	Vulnerable	3	True	0
							Subtotal	**1**
Mixophyes iteratus / Giant Barred Frog (Fauna)								
1556_Zone2_Moderate	36.2	36.2	0.01	Endangered	Endangered	2	False	1
1568_Zone3_Moderate	36.0	36.0	0	Endangered	Endangered	2	False	0
1573_Zone4_Moderate_Good	36.4	36.4	0	Endangered	Endangered	2	False	0
							Subtotal	**1**
Myotis macropus / Southern Myotis (Fauna)								
1556_Zone2_Moderate	36.2	36.2	0.01	Vulnerable	Not Listed	2	False	1
1568_Zone3_Moderate	36.0	36.0	0	Vulnerable	Not Listed	2	False	0
1573_Zone4_Moderate_Good	36.4	36.4	0	Vulnerable	Not Listed	2	False	0
							Subtotal	**1**
Ninox connivens / Barking Owl (Fauna)								
1556_Zone2_Moderate	36.2	36.2	0.01	Vulnerable	Not Listed	2	False	1
1568_Zone3_Moderate	36.0	36.0	0	Vulnerable	Not Listed	2	False	0

							Subtotal	**1**
Ninox strenua / Powerful Owl (Fauna)								
1556_Zone2_Moderate	36.2	36.2	0.01	Vulnerable	Not Listed	2	False	1
1568_Zone3_Moderate	36.0	36.0	0	Vulnerable	Not Listed	2	False	0
							Subtotal	**1**
Petaurus norfolcensis / Squirrel Glider (Fauna)								
1556_Zone2_Moderate	36.2	36.2	0.01	Vulnerable	Not Listed	2	False	1
1568_Zone3_Moderate	36.0	36.0	0	Vulnerable	Not Listed	2	False	0
							Subtotal	**1**
Phascogale tapoatafa / Brush-tailed Phascogale (Fauna)								
1556_Zone2_Moderate	36.2	36.2	0.01	Vulnerable	Not Listed	2	False	1
1568_Zone3_Moderate	36.0	36.0	0	Vulnerable	Not Listed	2	False	0
							Subtotal	**1**
Pteropus poliocephalus / Grey-headed Flying-fox (Fauna)								
1556_Zone2_Moderate	36.2	36.2	0.01	Vulnerable	Vulnerable	2	False	1
1568_Zone3_Moderate	36.0	36.0	0	Vulnerable	Vulnerable	2	False	0
1573_Zone4_Moderate_Good	36.4	36.4	0	Vulnerable	Vulnerable	2	False	0

							Subtotal	**1**
Rhizanthella slateri / Eastern Australian Underground Orchid (Flora)								
1556_Zone2_Moderate	36.2	36.2	0.01	Vulnerable	Endangered	3	True	1
1568_Zone3_Moderate	36.0	36.0	0	Vulnerable	Endangered	3	True	0
1573_Zone4_Moderate_Good	36.4	36.4	0	Vulnerable	Endangered	3	True	0
							Subtotal	**1**
Rhodamnia rubescens / Scrub Turpentine (Flora)								
1556_Zone2_Moderate	N/A	N/A	0	Critically Endangered	Not Listed	3	True	0
1568_Zone3_Moderate	N/A	N/A	0	Critically Endangered	Not Listed	3	True	0
1573_Zone4_Moderate_Good	N/A	N/A	0	Critically Endangered	Not Listed	3	True	0
							Subtotal	**0**
Tetratheca juncea / Black-eyed Susan (Flora)								
1568_Zone3_Moderate	36.0	36.0	0.01	Vulnerable	Vulnerable	2	False	1
							Subtotal	**1**
Tyto novaehollandiae / Masked Owl (Fauna)								
1556_Zone2_Moderate	36.2	36.2	0.01	Vulnerable	Not Listed	2	False	1
1568_Zone3_Moderate	36.0	36.0	0	Vulnerable	Not Listed	2	False	0

							Subtotal	**1**
Tyto tenebricosa / Sooty Owl (Fauna)								
1568_Zone3_Moderate	36.0	36.0	0.01	Vulnerable	Not Listed	3	True	1
							Subtotal	**1**

Appendix D
Offset Trading Groups

BAM Biodiversity Credit Report (Like for like)

Proposal Details

Assessment Id
00026541/BAAS19000/21/00026542

Proposal Name
Centennial Mandalong SSD-5144 MOD 10

BAM data last updated *
10/06/2021

Assessor Name
Hayden John Beck

Assessor Number
BAAS19000

BAM Data version *
45

Proponent Names

Report Created
23/08/2021

BAM Case Status
Open

Assessment Revision
1

Assessment Type
Major Projects

Date Finalised
To be finalised

* Disclaimer: BAM data last updated may indicate either complete or partial update of the BAM calculator database. BAM calculator database may not be completely aligned with Bionet.

Potential Serious and Irreversible Impacts

Name of threatened ecological community	Listing status	Name of Plant Community Type/ID
Nil		

Species
Chalinolobus dwyeri / Large-eared Pied Bat
Miniopterus australis / Little Bent-winged Bat
Miniopterus orianae oceanensis / Large Bent-winged Bat

Mixophyes balbus / Stuttering Frog
Tyto tenebricosa / Sooty Owl
Rhodamnia rubescens / Scrub Turpentine
Rhizanthella slateri / Eastern Australian Underground Orchid

Additional Information for Approval

PCTs With Customized Benchmarks

PCT
No Changes

Predicted Threatened Species Not On Site

Name
No Changes

Ecosystem Credit Summary (Number and class of biodiversity credits to be retired)

BAM Biodiversity Credit Report (Like for like)

Name of Plant Community Type/ID	Name of threatened ecological community	Area of impact	HBT Cr	No HBT Cr	Total credits to be retired
1556-Tallowwood - Smooth-barked Apple - Blackbutt grass tall open forest of the Central and lower North Coast	Not a TEC	0.0	1	0	1
1568-Blackbutt - Turpentine - Sydney Blue Gum mesic tall open forest on ranges of the Central Coast	Not a TEC	0.0	1	0	1
1573-Sydney Blue Gum - Lilly Pilly mesic tall open forest of coastal ranges and tablelands escarpment	Not a TEC	0.0	0	1	1

1556-Tallowwood - Smooth-barked Apple - Blackbutt grass tall open forest of the Central and lower North Coast

Like-for-like credit retirement options

Class	Trading group	Zone	HBT	Credits	IBRA region
Northern Hinterland Wet Sclerophyll Forests This includes PCT's: 690, 697, 698, 755, 1092, 1262, 1267, 1268, 1281, 1385, 1548, 1549, 1550, 1556, 1557, 1558, 1564, 1565, 1580, 1582, 1584, 1585, 1845, 1846, 1847, 1914	Northern Hinterland Wet Sclerophyll Forests <50%	1556_Zone2_Moderate	Yes	1	Wyong, Hunter, Pittwater and Yengo. or Any IBRA subregion that is within 100 kilometers of the outer edge of the impacted site.

1568-Blackbutt - Turpentine - Sydney Blue Gum mesic tall open forest on ranges of the Central Coast	**Like-for-like credit retirement options**					
	Class	Trading group	Zone	HBT	Credits	IBRA region
	North Coast Wet Sclerophyll Forests This includes PCT's: 487, 613, 661, 684, 686, 692, 693, 694, 695, 699, 747, 748, 752, 812, 826, 827, 1073, 1208, 1217, 1222, 1237, 1244, 1245, 1257, 1259, 1260, 1261, 1265, 1266, 1282, 1284, 1285, 1504, 1561, 1562, 1563, 1566, 1567, 1568, 1569, 1572, 1573, 1575, 1579, 1841, 1843, 1915	North Coast Wet Sclerophyll Forests <50%	1568_Zone3_Moderate	Yes	1	Wyong, Hunter, Pittwater and Yengo. or Any IBRA subregion that is within 100 kilometers of the outer edge of the impacted site.
1573-Sydney Blue Gum - Lilly Pilly mesic tall open forest of coastal ranges and tablelands escarpment	**Like-for-like credit retirement options**					
	Class	Trading group	Zone	HBT	Credits	IBRA region

	North Coast Wet Sclerophyll Forests This includes PCT's: 487, 613, 661, 684, 686, 692, 693, 694, 695, 699, 747, 748, 752, 812, 826, 827, 1073, 1208, 1217, 1222, 1237, 1244, 1245, 1257, 1259, 1260, 1261, 1265, 1266, 1282, 1284, 1285, 1504, 1561, 1562, 1563, 1566, 1567, 1568, 1569, 1572, 1573, 1575, 1579, 1841, 1843, 1915	North Coast Wet Sclerophyll Forests <50%	1573_Zone4_Moderate_Good	No	1	Wyong, Hunter, Pittwater and Yengo. or Any IBRA subregion that is within 100 kilometers of the outer edge of the impacted site.

Species Credit Summary

Species	Vegetation Zone/s	Area / Count	Credits
Callocephalon fimbriatum / Gang-gang Cockatoo	**1556_Zone2_Moderate, 1568_Zone3_Moderate, 1573_Zone4_Moderate_Good**	0.0	1.00

Cercartetus nanus / Eastern Pygmy-possum	**1556_Zone2_Moderate, 1568_Zone3_Moderate, 1573_Zone4_Moderate_Good**	0.0	1.00
Chalinolobus dwyeri / Large-eared Pied Bat	**1556_Zone2_Moderate, 1568_Zone3_Moderate, 1573_Zone4_Moderate_Good**	0.0	0.00
Cryptostylis hunteriana / Leafless Tongue Orchid	**1556_Zone2_Moderate, 1568_Zone3_Moderate**	0.0	1.00
Haliaeetus leucogaster / White-bellied Sea-Eagle	**1556_Zone2_Moderate, 1568_Zone3_Moderate**	0.0	1.00
Hoplocephalus bitorquatus / Pale-headed Snake	**1556_Zone2_Moderate, 1568_Zone3_Moderate, 1573_Zone4_Moderate_Good**	0.0	1.00
Hoplocephalus stephensii / Stephens' Banded Snake	**1556_Zone2_Moderate, 1568_Zone3_Moderate, 1573_Zone4_Moderate_Good**	0.0	1.00
Litoria brevipalmata / Green-thighed Frog	**1556_Zone2_Moderate**	0.0	1.00
Litoria littlejohni / Littlejohn's Tree Frog	**1568_Zone3_Moderate**	0.0	1.00
Lophoictinia isura / Square-tailed Kite	**1556_Zone2_Moderate, 1568_Zone3_Moderate**	0.0	1.00
Miniopterus australis / Little Bent-winged Bat	**1556_Zone2_Moderate, 1568_Zone3_Moderate, 1573_Zone4_Moderate_Good**	0.0	0.00

Miniopterus orianae oceanensis / Large Bent-winged Bat	**1556_Zone2_Moderate, 1568_Zone3_Moderate, 1573_Zone4_Moderate_Good**	0.0	0.00
Mixophyes balbus / Stuttering Frog	**1556_Zone2_Moderate, 1568_Zone3_Moderate, 1573_Zone4_Moderate_Good**	0.0	1.00
Mixophyes iteratus / Giant Barred Frog	**1556_Zone2_Moderate, 1568_Zone3_Moderate, 1573_Zone4_Moderate_Good**	0.0	1.00
Myotis macropus / Southern Myotis	**1556_Zone2_Moderate, 1568_Zone3_Moderate, 1573_Zone4_Moderate_Good**	0.0	1.00
Ninox connivens / Barking Owl	**1556_Zone2_Moderate, 1568_Zone3_Moderate**	0.0	1.00
Ninox strenua / Powerful Owl	**1556_Zone2_Moderate, 1568_Zone3_Moderate**	0.0	1.00
Petaurus norfolcensis / Squirrel Glider	**1556_Zone2_Moderate, 1568_Zone3_Moderate**	0.0	1.00
Phascogale tapoatafa / Brush-tailed Phascogale	**1556_Zone2_Moderate, 1568_Zone3_Moderate**	0.0	1.00
Pteropus poliocephalus / Grey-headed Flying-fox	**1556_Zone2_Moderate, 1568_Zone3_Moderate, 1573_Zone4_Moderate_Good**	0.0	1.00

Rhizanthella slateri / Eastern Australian Underground Orchid	**1556_Zone2_Moderate, 1568_Zone3_Moderate, 1573_Zone4_Moderate_Good**	0.0	1.00
Rhodamnia rubescens / Scrub Turpentine	**1556_Zone2_Moderate, 1568_Zone3_Moderate, 1573_Zone4_Moderate_Good**	0.0	0.00
Tetratheca juncea / Black-eyed Susan	**1568_Zone3_Moderate**	0.0	1.00
Tyto novaehollandiae / Masked Owl	**1556_Zone2_Moderate, 1568_Zone3_Moderate**	0.0	1.00
Tyto tenebricosa / Sooty Owl	**1568_Zone3_Moderate**	0.0	1.00

Credit Retirement Options

Like-for-like credit retirement options

Callocephalon fimbriatum / Gang-gang Cockatoo	Spp	IBRA subregion
	Callocephalon fimbriatum / Gang-gang Cockatoo	Any in NSW
Cercartetus nanus / Eastern Pygmy-possum	Spp	IBRA subregion
	Cercartetus nanus / Eastern Pygmy-possum	Any in NSW
Chalinolobus dwyeri / Large-eared Pied Bat	Spp	IBRA subregion
	Chalinolobus dwyeri / Large-eared Pied Bat	Any in NSW

Cryptostylis hunteriana / Leafless Tongue Orchid	Spp	IBRA subregion
	Cryptostylis hunteriana / Leafless Tongue Orchid	Any in NSW
Haliaeetus leucogaster / White-bellied Sea-Eagle	Spp	IBRA subregion
	Haliaeetus leucogaster / White-bellied Sea-Eagle	Any in NSW
Hoplocephalus bitorquatus / Pale-headed Snake	Spp	IBRA subregion
	Hoplocephalus bitorquatus / Pale-headed Snake	Any in NSW
Hoplocephalus stephensii / Stephens' Banded Snake	Spp	IBRA subregion
	Hoplocephalus stephensii / Stephens' Banded Snake	Any in NSW
Litoria brevipalmata / Green-thighed Frog	Spp	IBRA subregion
	Litoria brevipalmata / Green-thighed Frog	Any in NSW
Litoria littlejohni / Littlejohn's Tree Frog	Spp	IBRA subregion
	Litoria littlejohni / Littlejohn's Tree Frog	Any in NSW
Lophoictinia isura / Square-tailed Kite	Spp	IBRA subregion

	Lophoictinia isura / Square-tailed Kite	Any in NSW
Miniopterus australis / Little Bent-winged Bat	Spp	IBRA subregion
	Miniopterus australis / Little Bent-winged Bat	Any in NSW
Miniopterus orianae oceanensis / Large Bent-winged Bat	Spp	IBRA subregion
	Miniopterus orianae oceanensis / Large Bent-winged Bat	Any in NSW
Mixophyes balbus / Stuttering Frog	Spp	IBRA subregion
	Mixophyes balbus / Stuttering Frog	Any in NSW
Mixophyes iteratus / Giant Barred Frog	Spp	IBRA subregion
	Mixophyes iteratus / Giant Barred Frog	Any in NSW
Myotis macropus / Southern Myotis	Spp	IBRA subregion
	Myotis macropus / Southern Myotis	Any in NSW
Ninox connivens / Barking Owl	Spp	IBRA subregion
	Ninox connivens / Barking Owl	Any in NSW

Ninox strenua / Powerful Owl	Spp	IBRA subregion
	Ninox strenua / Powerful Owl	Any in NSW
Petaurus norfolcensis / Squirrel Glider	Spp	IBRA subregion
	Petaurus norfolcensis / Squirrel Glider	Any in NSW
Phascogale tapoatafa / Brush-tailed Phascogale	Spp	IBRA subregion
	Phascogale tapoatafa / Brush-tailed Phascogale	Any in NSW
Pteropus poliocephalus / Grey-headed Flying-fox	Spp	IBRA subregion
	Pteropus poliocephalus / Grey-headed Flying-fox	Any in NSW
Rhizanthella slateri / Eastern Australian Underground Orchid	Spp	IBRA subregion
	Rhizanthella slateri / Eastern Australian Underground Orchid	Any in NSW
Rhodamnia rubescens / Scrub Turpentine	Spp	IBRA subregion
	Rhodamnia rubescens / Scrub Turpentine	Any in NSW
Tetratheca juncea / Black-eyed Susan	Spp	IBRA subregion

	Tetratheca juncea / Black-eyed Susan	Any in NSW
Tyto novaehollandiae / Masked Owl	Spp	IBRA subregion
	Tyto novaehollandiae / Masked Owl	Any in NSW
Tyto tenebricosa / Sooty Owl	Spp	IBRA subregion
	Tyto tenebricosa / Sooty Owl	Any in NSW

Appendix E
BCD Correspondence

Hayden Beck

From: Denise Wallace <Denise.Wallace@environment.nsw.gov.au> on behalf of OEH ROD BAM Support Mailbox <bam.support@environment.nsw.gov.au>
Sent: Monday, 9 August 2021 5:18 PM
To: Hayden Beck
Subject: BSM-3443 Your form "Biodiversity Offsets Scheme enquiry form" got a response

CAUTION: This email originated from outside of RPS.

Hayden

Thank you for contacting the BAM Support Team. Your reference number is BSM-3443. Your enquiry has been forwarded to a subject matter expert for attention.

Subject Matter Expert
Please respond to the bam.support@environment.nsw.gov.au mailbox

Kind regards
The BAM Support Team

-----Original Message-----
From: Response Report <report@formassembly.com>
Sent: Monday, 9 August 2021 3:00 PM
To: OEH ROD BAM Support Mailbox <bam.support@environment.nsw.gov.au>
Subject: Your form "Biodiversity Offsets Scheme enquiry form" got a response

Your form "Biodiversity Offsets Scheme enquiry form" has received the following response:

Submitted on: 08/09/2021 03:00:18 PM
Completion time: 41 sec.

Biodiversity Offsets Scheme enquiry form Q. Your enquiry related to:
R. Accredited Assessors

Q. What would you like to ask about
R. Biodiversity Assessment Method Support (including BAM-C/BOAMS)

Q. Tell us more:
R. Good afternoon,

I am currently preparing a BDAR for an underground mine (SSD MOD) and assessing the matter of subsidence. I am in need of some support about inputting data into BAM-C and applicability of the BOS if a negligible impact on native vegetation and or habitat is expected.

On a project I am working on there is a potential subtle increase in ponding of surface water, which may have a very minor impact upon native vegetation (i.e. <0.001 ha). No native vegetation associated with the MOD will be cleared.

The modelled impact is an increase in ponding of <0.001 ha, which is split across three PCTs. Within the BAM-C, when these areas are entered it comes up automatically as zero due to their small size (i.e. it does not recognise these very low values). What is the correct way forward in this case? Is it to: 1. Round-up to 0.01 ha (the minimum value recognised in BAM-C) or 2. accept the value assigned (which is 0)? If the later, would this mean that an offset may not be applicable?

Also, should I: 1. add all zones, even though no impact on them is expected? Or 2. only enter the zones where impacts are expected? If the later, I note that BAM-C does not allow for a zero Area Value when calculating Vegetation Integrity Scores.

More broadly, are BDARs still required for SSD MODs for underground mining projects where no impacts on native vegetation/habitat are expected? For example, first workings can lead to <100mm subsidence, and have negligible impacts on ground/surface water and or impacts to rock habitat features (i.e. cliffs, crevices, caves etc). Would the requirement still be a BDAR but with no offset?

Your timely advice on this matter would be much appreciated.

Warm regards,

Hayden

Your details
Q. First name:
R. Hayden

Q. Surname:
R. Beck

Q. Email:
R. hayden.beck@rpsgroup.com.au

Q. Phone:
R. 0421440518

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PLEASE CONSIDER THE ENVIRONMENT BEFORE PRINTING THIS EMAIL

Appendix F

Socio-economic assessment









Mandalong Mine Modification 10

SSD-5144

Socioeconomic Assessment

Centennial Mandalong Pty Limited

September 2021

AIGISGROUP

This report was prepared by Dr Mark Sargent, Principal Consultant, Aigis Group.

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Abbreviations

DPIE	Department of Planning, Industry and Environment
EA	Economic assessment
FTE	Full time equivalent
FX	Foreign exchange
GHG	Greenhouse gas/es
Km	Kilometres
LGA	Local Government Area
LMCC	Lake Macquarie City Council
LW	Longwall mining panel
MR	Modification Report
MSEP	Mandalong Southern Extension Project
Mt	Million tonnes
Mtpa	Million tonnes per annum
NSWMC	NSW Minerals Council
PV	Present value
Tpa	Tonnes per annum

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1 Introduction

1.1 Report purpose and approach

This Socioeconomic Assessment (SEA) has been prepared as part of the Modification Report (MR) for a proposed modification to consent SSD-5144 for Mandalong Mine (MOD 10). Details of the proposed modification and the justification for the proposed changes are presented in Sections 1.2 and 1.3. These have been extracted from a notification to the NSW Department of Planning, Industry and Environment (DPIE) from EMM Consulting on behalf of Centennial Mandalong, dated 10 June 2021. The SEA has been prepared with reference to the DPIE *Guidelines for the economic assessment of mining and coal seam gas proposals* (December 2015), and the *Technical Notes* supporting the guidelines (April 2018), to the extent practicable for a modification as proposed.

Generally, the economic effects of the proposed modification are effectively substitutions for the loss of production associated with the previously planned longwalls that will no longer be extracted, and the proposed changes to the mine plan to allow extraction of the proposed longwall (LW34). This being the case, the longer-run assumptions in relation to economic effects of ongoing mining as approved under SSD-5144 remain largely unchanged. The economic assessment is presented in this context. Table 1 summarises the potential for the various effects addressed in the guidelines, in the context of this limited, short-term adjustment to planned mining activity.

Table 1: Summary of economic assessment approach to specific effects

Effect/impact category	Description of approach
Aboriginal cultural heritage	Quantitative assessment included (Section 2.4).
Historical heritage	Historical heritage included in ACHAR, not addressed, based on this technical assessment.
Noise	Not proposed for assessment as part of MR.
Visual amenity	Not proposed for assessment as part of MR.
Air quality	Not proposed for assessment as part of MR.
Ground and surface water	Consistent with previous SSD-5144 assessments, therefore no material change anticipated.
Biodiversity	Quantitative assessment included (Section 2.4).
Transport impacts	Not proposed for assessment as part of MR.
Greenhouse gas emissions (GHG)	Nominal reduction due to reduced extraction, remains within SSD-5144 parameters (based on maximum output).
Subsidence	The proposed additional longwall involves mining under parts of some privately owned properties. However, direct undermining of buildings will occur in relation to one property only as indicated by diagrammatic material

1.2 Background

Mandalong Mine is an existing underground coal mine near Morisset, approximately 35 kilometres (km) south-west of Newcastle in the Lake Macquarie local government area (LGA). The mine is operated by Centennial Mandalong Pty Limited (Centennial Mandalong). Centennial Mandalong has approval to extract run-of-mine (ROM) coal from the West Wallarah and Wallarah-Great Northern seams using a combination of longwall and continuous mining methods.

The mine operates under State significant development (SSD) consent SSD-5144, which was granted on 12 October 2015 by the NSW Planning Assessment Commission under Part 4, Division 4.1 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act).

Centennial Mandalong is seeking to modify SSD-5144, pursuant to Section 4.55(2) of the EP&A Act to change Mandalong's approved longwall mine plan.

DPIE approved SSD-5144-MOD 9 (MOD 9) on 1 April 2021. As part of MOD 9, Centennial Mandalong sought approval to amend the approved mine plan, including the reorientation of LW30-LW33. Subsequent to the approval of MOD 9, Centennial Mandalong has continued to review the progression of underground mining within the Mandalong Southern Extension Area. As a result of these investigations, the decision has been made to shorten LW30 and remove LW33 from the mine plan.

The length of LW30 was reduced through the Extraction Plan process to avoid mining through a high strength igneous dyke. The amendment to LW30 reduces the extent of potential subsidence impacts on rock-face features, a tributary to Mannering Creek, Kiar Ridge Road, and identified Aboriginal cultural heritage sites. LW33 has been removed from the mine plan due to the extent of an igneous sill intrusion and resultant impacts on panel length, tonnages available for extraction, and financial viability of mining in this area. The removal of LW33 will reduce the extent of potential subsidence impacts on surface features, including TransGrid's TL25/26 330 kV electricity transmission line and identified Aboriginal cultural heritage sites.

The shortening of LW30 and removal of LW33 are estimated to result in the sterilisation of approximately 0.4 million tonnes (Mt) and 1.6 Mt of coal, respectively. Consequently, Centennial Mandalong has explored options to optimise the mine plan to access additional coal resources and to continue production during the period in which extraction of LW33 in particular was planned.

The proposed modification will seek approval for the addition of LW34, which will maximise resource extraction within the West Wallarah Seam and Mandalong's development consent boundary. The addition of LW34 will also improve the continuity of coal extraction and employment at Mandalong. The additional coal resource within LW34 can be extracted efficiently using existing infrastructure.

1.3 Project description

Centennial Mandalong is seeking to modify SSD-5144, pursuant to Section 4.55(2) of the EP&A Act, to include Longwall 34 (LW34). LW34 will align with adjacent panels by maintaining the existing panel width of 200 m and all other mining geometry aspects will remain unchanged. Secondary extraction of coal as part of the proposed modification will remain within the currently assessed and approved footprint for secondary extraction. No changes to the development consent boundary are required.

2 Economic assessment – Cost Benefit Analysis (CBA)

This cost-benefit analysis (CBA) has been prepared in the context of the specifics of the proposed modification. As such, it does not equate to a fully-developed CBA for SSD-5144. However, relevant elements required to present a modified CBA and Local Effects Analysis (LEA) are assessed.

2.1 Project scenarios

2.1.1 Base case

The base case assumes that LW34 is not approved for extraction. There are several aspects to the economic effects on NSW that would result from this outcome. There are also effects at a national level in relation to tax revenues. Potential effects are summarised as:

- In addition to the previously foregone royalties from the reduced production relating to shortening of LW30 and removal of LW33, the potential royalties due from extraction of LW34 would also not accrue to the state;
- The planned future mining of previously approved areas requires new equipment, which it is expected may take 12 to 18 months, for the procurement, manufacture, delivery and commissioning of the equipment. In the absence of extraction of LW34, a temporary suspension of full production of ten (10) months may become necessary, which would result in effects including on employment, with the resultant negative effects on payroll tax (NSW Government), and personal income taxes and GST associated with employees' household economic activity (Federal Government). There may also be similar derived effects associated with reduced demand for goods and services provided by suppliers and contractors;
- Reduced corporate income taxes (Federal Government).

2.1.2 Modification 10 approval

Grant of consent for MOD 10 would result in royalties and corporate income taxes being paid to the relevant levels of government (as described in Section 2.1.1). The potential for a related suspension of operations (Section 2.1.1) would also be avoided, with the resultant avoidance of economic costs relating to Mandalong Mine's employment and commercial activity.

2.2 Comparison of assessments for alternative scenarios

2.2.1 Assumptions - royalties

Foregone production for LW30 (0.4 Mt) and LW33 (1.6 Mt) was noted in Section 1.2. Budgeted production from LW34 is 1,345,000 tonnes. Therefore, the net reduction in tonnage is assumed as 655,000 tonnes. As LW30 is being extracted at present (FY21-22). LW34 would effectively replace LW33 in the mining schedule, with planned extraction in FY22-23. Present values (PV) are presented in Table 2, and were assessed on these bases.

2.2.2 Assessments - royalties

The combined loss of royalties (PV) for LW30 and LW33 at the central discount rate is approximately $16.4 million. Approval and extraction of LW34 would generate approximately $10.0 million in royalties, thus reducing the net cost of foregone royalties to approximately $6.4 million.

Table 2: Production scenarios – nominal & present values – royalties

	Nominal	7% discount rate	10% discount rate	4% discount rate
LW30 (FY21-22)	**$2,577,779**	$3,546,336	$3,449,617	$3,648,634
LW33 (FY22-23)	**$11,083,506**	$12,845,445	$12,495,115	$13,215,987
Total	**$13,661,285**	$16,391,781	$15,944,732	$16,864,621
LW34 (FY22-23)	**$9,425,505**	**$10,899,541**	**$10,602,281**	**$11,213,951**
Net loss royalties	**$4,235,781**	**$5,492,240**	**$5,342,452**	**$5,650,670**

2.3 Employment effects

2.3.1 Assumptions – employment

The Mandalong workforce has been advised as comprising 543 direct full time equivalent (FTE) employees. As is noted in Section 2.2.1, extraction of LW34 would effectively substitute for the cancelled extraction of LW33, and would take place in FY22-23. In the absence of approval for LW34, suspension of longwall production would become necessary, as described in Section 2.1.1.

Centennial Mandalong modelling for a scenario in which LW34 is not approved, indicates that 78 FTE positions would be suspended. This would extend over a period commencing March 2022 (commencement of development under an approval) to January 2023 (completion of extraction under an approval). Therefore, the 78 FTE would be suspended for a period of approximately 10 months.

The MOD 10 approval scenario would result in the retention of these positions and their deployment on LW34 works. As is identified in Figure 5 (page 32) of the attached socio-economic profile, approximately 32% of the Mandalong workforce resides in the locality (the Lake Macquarie [West] SA3), as defined in the guidelines. Applying this to the assessed suspension of FTE employment results in an estimate of 25 affected FTE employees residing in the locality. It is noted for reference that 61% of employees reside in the LGA (48 FTE) and 89% (69 FTE) in the broader region, defined as the Newcastle – Maitland SUA[1].

Table 3 presents an adaptation of the employment effects calculation identified in the guidelines (2015:22). The adaptation is predicated on the loss of employment benefits for Mandalong employees, as compared to the addition of positions contemplated by the guidelines. The table also includes assessments for employees who are resident in the LGA and the SUA. It is submitted that these are relevant in establishing that the majority of the workforce is resident in the region and that, consequently, the majority of employee benefit is captured regionally.

[1] ABS Significant Urban Area.

Table 3: Assessment of employment effects: 78 FTE (25 FTE in SA3)

	Ordinarily reside in locality
Direct employment positions maintained on approval	25
Average net income – Mandalong employees[2]	$83,544
Average net income – other industries[3]	$44,030
Average net decrease in income per employee	$39,514
Decrease in total net employee incomes (10 months)	$823,208
Decrease in total net employee incomes – LGA (10 months)	$1,580,560
Decrease in total net employee incomes – SUA (10 months)	$2,272,055

It is noted that the potential effect of the suspension in production would also result in foregone payroll tax revenues at state level, and corporate and employee personal income taxes at federal level. The guidelines exclude consideration of payroll tax effects, based on the assumption that these would be substituted for by alternative employment elsewhere in the economy. This is consistent with the treatment of incomes in Table 3.

The guidelines include provision for reporting of federally levied corporate income taxes as a component of the economic benefit of projects[4]. Tax liability in respect of Centennial Mandalong comprises part of tax assessment by Centennial Coal Pty Ltd at aggregate level for the entire corporate entity, and not for individual operations. Therefore, Centennial Mandalong does not report corporate taxes as a stand-alone entity. As a result, corporate tax is not reported in this assessment. The exclusion of this material will contribute to a conservative estimate of benefit, as ordinarily some component of tax paid by Centennial would be returned to NSW (assessed as approximately 32% in the guidelines, on a per capita basis).

2.4 Economic benefit to suppliers

The socio-economic profile for Mandalong Mine (Annexure 4) identifies average annual expenditure with suppliers over the most recent four (4) financial years for the mine. Average gross supplier benefit that would be maintained on approval of LW34 is summarised in Table 4. As is apparent in the data, the majority of supplier benefit for NSW accrues to businesses in the broader Hunter/Central Coast region. As LW33 has already been removed from the mine plan, the alternative case may result in loss of this benefit. It is advised that this estimate should be interpreted as a maximum effect, as in the absence of LW34, there would be ongoing activity at the mine, including, for example, maintenance, and development activity for extraction of subsequent longwall panels.

[2] Employee and other industries are calculated net of assumed 9.5% superannuation, tax at relevant schedule rate, and 2% Medicare levy.
[3] Alternative employment assumption. Mean employee income, SA3. ABS Data by Region for 2018 (most recent release). The nominal (gross) mean was $57,624.
[4] Calculated as a population-based proportional return to NSW.

Table 4: Summary supplier benefit

Area	4-year annual average ($M)	10-month impact ($M)
Local	34.4	28.7
Regional	124.5	103.8
NSW	190.6	158.9

2.5 Assessment of environmental effects

2.5.1 Method adopted for quantified assessments

The method adopted for comparative valuations between previous SSD-5144 economic assessments and those effects quantitatively valued for MOD 10 is benefit transfer. The relevant studies and the assessment/valuation parameters are presented in Annexure 1.

2.5.2 Qualitative assessments

The technical reports identified for inclusion in the MR were proposed in the notification document provided to DPIE (refer to Section 1.1). Each of the matters identified in the notification to DPIE are addressed in Table 5, including comments on qualitative assessments. Generally, potential effects are assessed as being not material, particularly in the context that from the perspective of cumulative impacts, the reduction in mining activity detailed in the MR and this SEA in relation to LW34 is likely to result in lower net impacts than would have been the case for mining of the full extent of LW30 and LW33.

2.5.3 Quantitative assessments

Comparative quantitative assessments for relevant effects are presented in Table 6. Essentially, the changes in assessments are related to changes in underlying assumptions on which the benefit transfer-based assessments were made. These changes are identified in the table. For both effects, it is submitted that the magnitude of changes in quantified effects cannot be considered as material, in the context of the proposed modification itself, and less so in the context of the existing SSD-5144 consent. As is noted in Table 5, there are qualitative considerations in respect of potential effects on Aboriginal heritage items in particular, that may be considered as taking precedence over the quantitative assessment.

Table 5: Qualitative summary of effects addressed in environmental assessment technical reports

Details	Assessment summary	Comments on economic assessment
Aboriginal Cultural Heritage (Umwelt Australia Pty Limited)	12 items identified (Umwelt 2021:63). Possibility of cracking and/or erosion effects on 3 items. Sections 9 and 11 describe mitigation and management strategies with respect to potential effects.	Quantitative assessment prepared as per Table 6. Qualitative assessment of potential impacts as presented in the ACHA is considered as prevailing over economic valuation in terms of criteria that may be applied by interested parties.
Historical heritage	No specific areas or items of historical value (including those with a direct association with Aboriginal people) were identified in the Modification Area during the assessment (Umwelt 2021:59).	Not assessed (no areas or items identified).
Water resources GHD Pty Ltd	The predicted impacts on alluvial groundwater and fractured and porous rock groundwater attributable to the proposed addition of LW34 are expected to be less than the Level 1 minimal impact considerations from the NSW Aquifer Interference Policy and are therefore considered to be acceptable (GHD 2021:ii). Slight changes in the water balance and salt balance of Mandalong Mine are expected as a result of the proposed modification, which were small relative to the predicted increase in groundwater inflows into the underground mining areas (GHD 2021:ii). One short reach of a first order tributary of Mannering Creek was identified as potentially impacted outside of the previously assessed angle of draw of the approved workings. The watercourse was considered bedrock confined and therefore has low susceptibility to geomorphic impacts (GHD 2021:iii).	Not quantitatively assessed based on generally low impact predictions for all elements of ground and surface water measures.

Water resources (cont…)	No potentially impacted downstream surface water users were identified and therefore no impacts are expected (GHD 2021:iii).	
Biodiversity RPS Group	MOD 10 is expected to lead to a minor increase in remnant ponding. For this reason, a precautionary approach was applied by applying a reduction in vegetation integrity to vegetation (worst-case scenario of halving of vegetation condition scores) where ponding is predicted and assuming presence of Species Credit Species in these areas where surveys were not sufficient to rule out their presence (RPS 2021:77). Ecosystem credits for 3 PCTs and species credits for 21 threatened species indicated. 3 additional individual species identified as requiring further survey work (RPS 2021:77-78)	Quantitative assessment prepared as per Table 6. The assessment is considered to be conservative (i.e. high) based on the precautionary approach taken to inclusion of PCTs and species.
GHG emissions (EMM Consulting)	The only emission source anticipated to change as a result of MOD 10 is downstream energy production from product coal (i.e. Scope 3 - end-user combustion of the coal). Scope 1 and Scope 2 emissions are not anticipated to change as GHG assessments completed to date have been based on the annual maximum coal production rate of 6.5 Mtpa, which will not change as part of MOD 10. (EMM 2021:3)	Scope 3 estimated to increase by 2.2%, however this does not allow for reduced Scope 3 emissions relating to foregone production for LW30 and LW33. By accounting for the loss of coal resources from the removal of LW33 and shortening of LW30, life of mine Scope 3 GHG emissions for the proposed modification will decrease by 1.1% relative to the MOD 8 GHG emissions inventory. Consequently, the net effect (which may be positive or negative), is unlikely to be material and will be below previous assessments based on maximum production as identified.
Subsidence (DGS Pty Ltd)	It is concluded that the assessed range of potential subsidence and far-field displacement impacts after the mining of the proposed longwall panels will be manageable for the site features, based on the analysis	Not quantitatively assessed, as effects are consistent with effects of previous approvals relating to SSD-5144.

Subsidence (cont…)	outcomes and discussions with the stakeholders to-date. The outcomes are consistent with the EIS and Mod 9 Reports. Furthermore, it is concluded that the proposed MOD 10 mining layout will not change the previous assessments of impact for any of the natural or built features by more than 10% (DGS 2021:*x*)	

Table 6: Comparison of quantitative effects valuations

Category of effect	2022	2023	Comments
Biodiversity (MSEP 2015)[5]	$199,758	$204,752	Differences relate to increase in count of households between 2011 and 2016 Censuses, and escalation of base valuation measure.
Biodiversity (Mod 10)	$252,025	$258,326	
Difference + / (-)	$52,267	$53,574	
Heritage (MSEP 2015)	$8,293	$8,541	Differences explained by smaller number of heritage items, offset by Census population increase, and escalation of base valuation measure
Heritage (Mod 10)	$8,129	$8,333	
Difference + / (-)	-$164	-$208	
Total difference by year	$52,103	$53,366	
Total difference MOD 10	**$105,469**		

2.6 Summary of quantified elements of CBA

The summary of the quantified changes associated with MOD 10 is presented in Table 7. The data are presented as 'neutral' assessments, which can be interpreted as:

- The net *benefit* should LW34 be approved;
- The net *cost* should LW34 approval not be granted.

The nominal estimates for each benefit/cost are reported for NSW, as provided for in the CBA methodology outlined in the guidelines.

Table 7: Summary of quantified estimates - NSW

Description	Nominal value ($'000)[6]
Royalties	4,236
Employee benefit	823
Supplier benefit	158,856
Environmental effects	(105)
Total	**163,810**

As noted, the aggregate effects are a potential retention of up to $164 million of economic benefit accruing to the NSW economy on approval of MOD 10, or the equivalent loss of this activity should consent be withheld.

[5] Mandalong Southern Extension Project.
[6] Values round to nearest $1,000.

3 Economic Assessment – Local Effects Analysis (LEA)

3.1 Summary of matters addressed

As is noted in Table 1, there are a number of effects that would ordinarily be considered as having particularly localised effects and which the proposed modification will not materially affect. Table 1 identifies that materially different levels of effects are not anticipated for various categories of effects, compared with those identified in SSD-5144 and previous modifications to the consent. These effects are;

- Aboriginal cultural heritage;
- Environmental heritage;
- Noise;
- Visual amenity;
- Air quality;
- Biodiversity;
- Transport impacts; and
- Greenhouse gas impacts (GHG emissions).

With respect to GHG emissions, the net effect is expected to be lower than had been previously estimated, based on the previously planned extraction of the remainder of LW30 panel and all of the LW33 panel. LW34 is not as extensive as the planned LW33 panel. As a result, the emissions-generating activity required to extract LW34 only is lower than that required for the LW30 remnant and full LW33 panels. In the context of total assessed emissions, the difference is not considered to be of sufficient materiality to justify detailed quantification.

Mining in an area of the lease that was not previously planned may expose strata and surface features above that area to the potential for effects that have not been fully contemplated previously. The two effects requiring assessment are water resources (ground and surface water), and subsidence, in the context of potential effects on surface features in the area above the proposed LW34. These are assessed in the following sections.

3.2 Water resources

As reported in Table 5, there are no downstream water users who would be affected by operations under the proposed modification. Consequently, GHD concludes that there are no expected impacts on water users.

3.3 Subsidence

The diagram in Annexure 3 identifies the privately owned property on which a building located directly above LW34 is situated. The building and dwelling are identified on the diagram. Centennial continues to engage with this landholder and the owners of four (4) other properties in the vicinity of the proposed LW34. The aim of this ongoing engagement in respect of the proposed modification is to ensure that any unanticipated effects can be appropriately addressed with relevant landholders if and as required.

3.4 Potential for locally and regionally beneficial economic effects

A socioeconomic activity profile for Mandalong Mine and its regional context, is included with this SEA, at Annexure 4. To the extent that the proposed addition of LW34 would maintain continuity of operations, the beneficial outcomes identified in the profile would be maintained. In particular, given that the significant majority of the Mandalong workforce resides in the regions including and surrounding the mine site, the economic activity involving these employees' households is concentrated in the local and neighbouring regions. The extent of local and regional benefit to relevant employees and suppliers were identified in the CBA component of this report.

3.5 Summary of local and regional effects

Approval of MOD 10 is assessed as being unlikely to impose material effects on local and regional stakeholders, with particular emphasis on land occupants in the immediate vicinity of LW34. Approval will ensure continuity of productive operations at the mine over the identified 10-month period. This will result in positive economic outcomes for the otherwise potentially affected part of the workforce, given that 32% of the workforce resides in the locality, and 89% in the broader region. Similarly, continued operations would also maintain the mine's commercial engagements with locally and regionally based suppliers, thus indirectly supporting employment and further activity for the relevant businesses.

4 Conclusions

MOD 10 is proposed to ensure continuity of production at Mandalong Mine, which would otherwise be negatively affected by the removal of part of LW30 and all of LW33 from the mine plan. This would result in a modelled 10-month suspension of productive operations, as subsequent mining requires the acquisition of new longwall equipment, which is estimated as requiring 12 to 18 months lead time.

The comparative scenarios were described in Section 2.6 and Table 7, which are reproduced below as Section 4.1 and Table 8.

4.1 Summary of quantified elements of CBA

The summary of the quantified changes associated with MOD 10 is presented in Table 7. The data are presented as 'neutral' assessments, which can be interpreted as:

- The net benefit should LW34 be approved;
- The net cost should LW34 approval not be granted.

The nominal estimates for each benefit/cost are reported for NSW, as provided for in the CBA methodology outlined in the guidelines.

Table 8: Summary of quantified estimates - NSW

Description	Nominal value ($'000)
Royalties	4,236
Employee benefit	823
Supplier benefit	158,856
Environmental effects	(105)
Total	**163,810**

As noted, the aggregate effects are a potential retention of up to $164 million of economic benefit accruing to NSW on approval of MOD 10, or the equivalent loss of this activity should consent be withheld.

As is substantiated in the LEA (Section 3), the potential for negative local effects is assessed as being not of material scale, in the context of the balance between sterilisation of part of LW30 and all of LW33, and extraction of LW34. Conversely, there is potential for substantially beneficial local and regional economic outcomes should MOD 10 be approved.

References

ABS 2021. Producer Price Indexes Australia, June 2021.
< https://www.abs.gov.au/statistics/economy/price-indexes-and-inflation/producer-price-indexes-australia/latest-release >

ABS 2021. Data by Region
< https://dbr.abs.gov.au/ >

KPMG. Coal price and FX market forecasts, June/July 2021.
< https://assets.kpmg/content/dam/kpmg/au/pdf/2021/coal-price-fx-market-forecast-june-july-2021.pdf >

Annexure 1 – Benefit transfer assumptions for quantitative assessments

ENVIRONMENTAL STUDIES RESEARCH BASELINE YEARS[7]	
Valuation Report	**Data year & base value**
Allen Consulting Group (2005): *Valuing the Priceless: The Value of Heritage Protection in Australia*, Research Report 2, Heritage Chairs and Officials of Australia and New Zealand, Sydney. <http://www.heritage.nsw.gov.au/docs/Research_ValuingthePriceless_2005.pdf >	2005 $5.53/person/1K places protected/p.a. 2021 $8.56/person
Land & Water Australia (2005): *Making Economic Valuation Work for Diversity Conservation:* Australian Government Department of Environment & Heritage <http://www.environment.gov.au/biodiversity/publications/economic-valuation/pubs/economic-valuation.pdf> *Jakobsson K. & Dragun A. (2001) The worth of a possum: valuing species with the contingent valuation method. Environmental and Resource Economics 19, 211-227.*	1996 $118/household 2021 $239/household

[7] Annual revaluations assume inflation of 2.5% per annum (midpoint of RBA long-run inflation target range).

Annexure 2 – Estimation and pricing assumptions

Table A3.1: Estimation assumptions

Description	Assumption adopted
Royalty rate	7.2% (other underground coal)
Deductions (beneficiation allowance and levies)	$4.00/tonne – export component
Prices – semi-soft coking coal (export)	Based on KPMG consensus price forecasts for June/July 2021, as per Table A3.2. The long-term prices for 2025 is the nominal long-term price and is applied to all outyears. Due to limited forecast information for the product, the KPMG low & high and mean prices were adopted. The nominated mean price is that calculated by KPMG across all 9 contributors (refer to Figure A3.1 for original USD estimates.
Prices – domestic thermal[8]	Price assumptions based on internal data provided by Centennial Mandalong. Not disclosed due to commercial confidentiality considerations.
Exchange rate (USD:AUD)	RBA long-term average exchange rate 31 January 2000 to 30 July 2021; AUD 1 = USD 0.7756 (0.78 assumed).
Discount Rate	7% (DPIE guidelines)
Sensitivity testing	By discount rates at 4% and 10% (consistent with DPIE guidelines).

Table A3.2: AUD price assumptions; semi-soft coking coal (export component of production)

	2021	2022	2023	2024	2025	Long term price assumption
KPMG Consensus (low) AUD	101.3	89.7	76.9	75.6	76.9	Long term price adopted for 2026-2035 ($69.7)
KPMG Consensus (high) AUD	141.7	131.4	153.8	102.6	100	Long term price adopted for 2026-2035 ($96.2)
Average AUD	122.0	109.1	102.3	92.0	93.3	Long term price adopted for 2026-2035 ($84.7)

8 Price assumption advised by Centennial Mandalong.

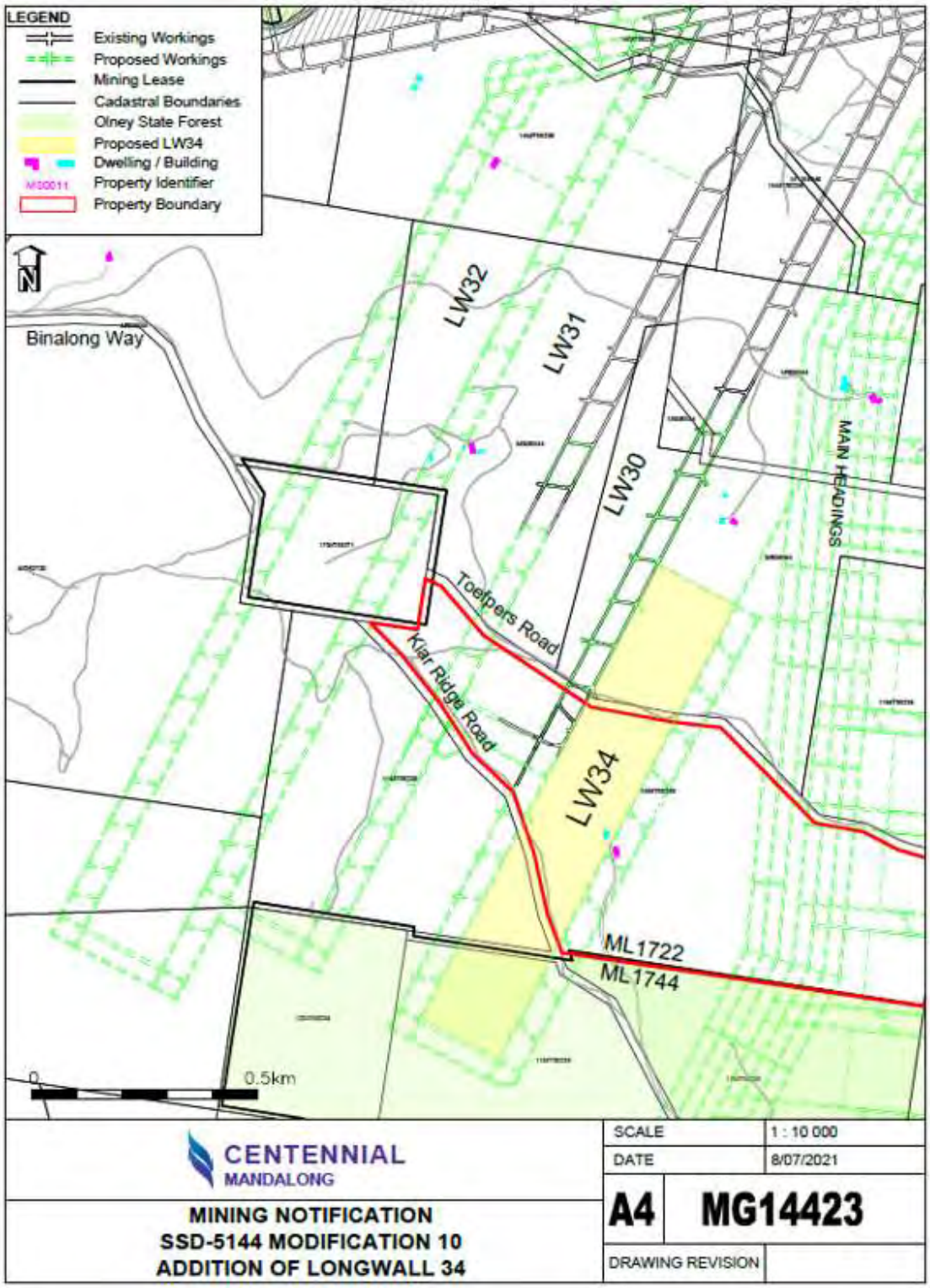
Newcastle thermal coal (USD/t Nominal)

Year ended 31 December	Reporting date	2021	2022	2023	2024	2025	LT (2021)
Contributor 2	9-Jul-21	104.0	93.0	84.0	n/a	n/a	67.0
Contributor 4	9-Jul-21	110.5	98.0	81.8	77.0	n/a	n/a
Contributor 6	8-Jul-21	101.0	80.0	n/a	n/a	n/a	65.0
Contributor 8	6-Jul-21	104.0	83.0	70.0	71.0	74.0	65.0
Contributor 9	1-Jul-21	104.0	90.0	75.0	75.0	76.0	68.1
Contributor 10	1-Jul-21	82.0	80.0	n/a	n/a	n/a	64.0
Contributor 11	30-Jun-21	109.0	100.0	90.0	80.0	75.0	70.0
Contributor 12	30-Jun-21	101.0	93.0	83.0	76.0	78.0	63.4
Contributor 13	30-Jun-21	90.0	74.0	68.0	n/a	n/a	n/a
Contributor 14	29-Jun-21	100.7	93.0	86.9	n/a	n/a	n/a
Contributor 16	25-Jun-21	91.0	74.0	60.0	59.0	60.0	54.4
Contributor 17	23-Jun-21	85.0	75.0	75.0	n/a	n/a	75.0
Contributor 18	22-Jun-21	94.5	102.5	120.0	n/a	n/a	n/a
Contributor 19	22-Jun-21	79.0	70.0	65.0	65.0	76.0	75.0
Contributor 20	22-Jun-21	90.6	90.0	85.0	75.0	75.0	65.0
Contributor 22	16-Jun-21	90.1	76.5	n/a	n/a	n/a	n/a
Contributor 23	9-Jun-21	90.1	76.5	n/a	n/a	n/a	70.0
Contributor 24	7-Jun-21	87.0	83.0	73.0	68.0	68.0	58.0
Low		**79.0**	**70.0**	**60.0**	**59.0**	**60.0**	**54.4**
High		**110.5**	**102.5**	**120.0**	**80.0**	**78.0**	**75.0**
Average		**95.2**	**85.1**	**79.8**	**71.8**	**72.8**	**66.1**
Median		**92.8**	**83.0**	**78.4**	**75.0**	**75.0**	**65.0**
Previous bulletin (Mar/Apr21)							
Average		**78.8**	**75.0**	**71.8**	**71.2**	**71.8**	**68.0**
Median		**78.0**	**73.0**	**73.0**	**72.4**	**75.0**	**70.0**

Source: Thomson Research, the Contributors, KPMG Analysis
n/a: forecast not available

Source: KPMG 2021

Annexure 3: Building on private property directly above LW34 panel[9]



9 Note that the property identifier and name of the landholder have been redacted. The property boundary is outlined in red.

Annexure 4: Mandalong Mine Socioeconomic Profile

Socioeconomic Profile
Mandalong Mine

Centennial Mandalong Pty Limited

August 2021

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Abbreviations

ABS	Australian Bureau of Statistics
DPIE	Department of Planning, Industry and Environment
EDS	Economic Development Strategy
ERP	Estimated Resident Population
FTE	Full Time Equivalent
GHG	Greenhouse gas (emissions)
GRP	Gross Regional Product
LGA	Local Government Area
LMCC	Lake Macquarie City Council
LMWSA3	Lake Macquarie West Statistical Area Level 3 (ABS)
NSWMC	NSW Minerals Council
p.a.	per annum
SA3	Statistical Area Level 3 (ABS)
SUA	Significant Urban Area (ABS)
WSA3	Wyong Statistical Area Level 3 (ABS)

INTRODUCTION

This report provides an overview of the socioeconomic impacts of Mandalong Mine, located in the Lake Macquarie City Council (LMCC) Local Government Area (LGA). Comparisons with other relevant populations, most notably the immediate area in which the operations are located, the Lake Macquarie West area, the Newcastle – Maitland region, and the contiguous Wyong area are also included. Various quantitative and qualitative measures are presented to describe these populations, communities and economies, and the role of Mandalong Mine in the context of these.

LOCAL AND REGIONAL POPULATIONS

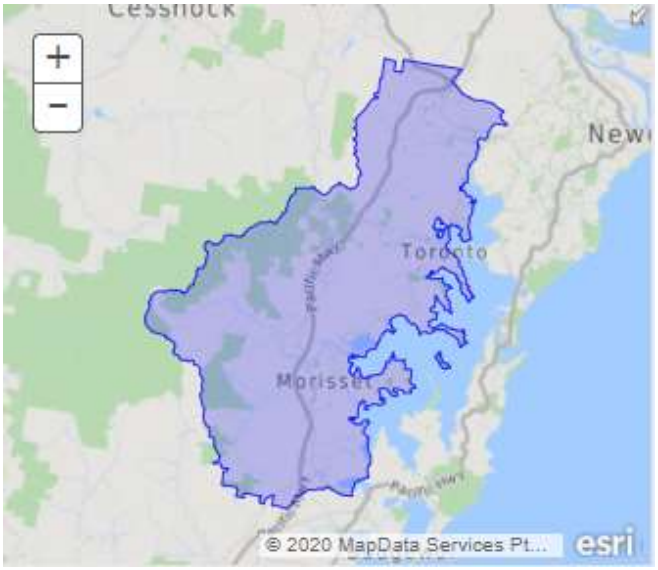
Demographic profile

Key demographic data for the following Australian Bureau of Statistics (ABS) statistical geography units in which the mine is located are examined in this section. These are:

- Lake Macquarie City Council (LMCC) LGA;
- Lake Macquarie West Statistical Area Level 3 (SA3);
- Newcastle-Maitland Significant Urban Area (SUA).

Given the proximity of Mandalong Mine to the Wyong division of the amalgamated Central Coast LGA, data for Wyong SA3 are also presented, as noted in Section 1. The SA3 corresponds to the former Wyong Council area. The geographic extents of these areas are displayed in Figures 1 through 4.

Figure 1: Lake Macquarie West SA3



Images source: ABS 2020

Figure 2: Lake Macquarie LGA

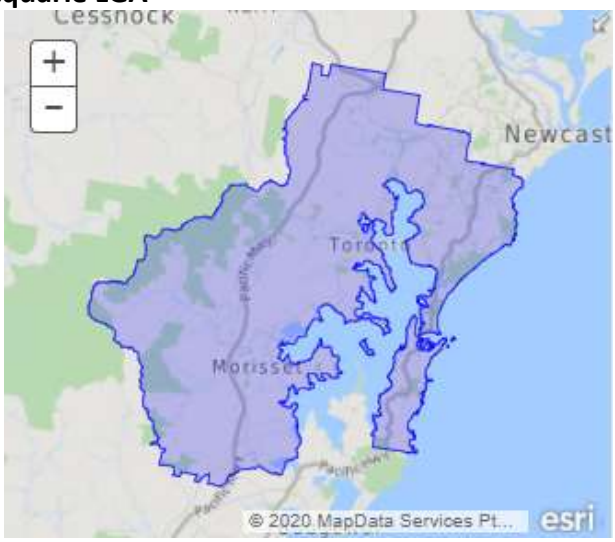


Figure 3: Newcastle – Maitland SUA

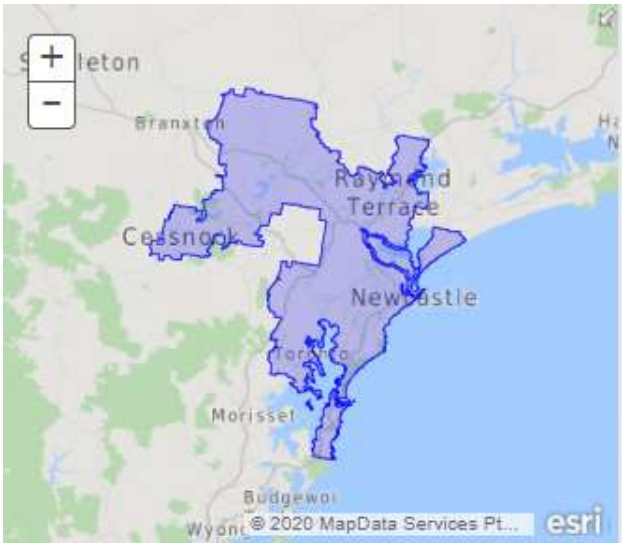
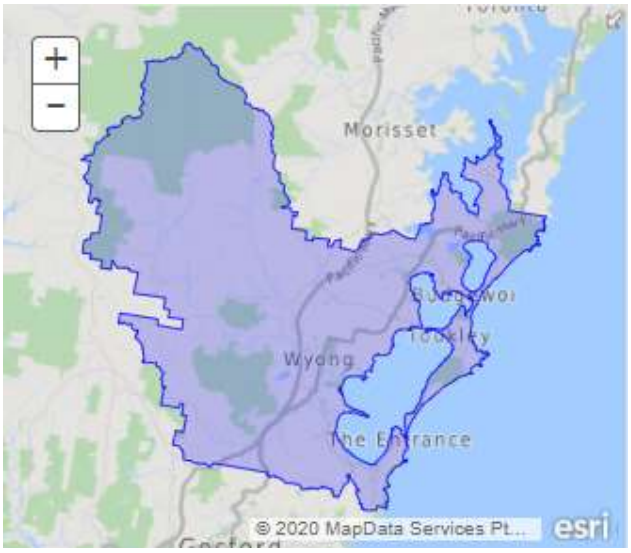


Figure 4: Wyong SA3



Personal and population characteristics

Table 1: Demographic profile; personal and population characteristics

	LMWSA3 (%[10])	LMCC (%)	WSA3 (%)	SUA (%)	NSW (%)
Population	**75,205**	**197,371**	**158,683**	**463,052**	**7,480,228**
Male	48.8	48.8	48.5	49.1	49.3
Female	51.2	51.2	51.5	50.9	50.7
ABS 2020 ERP	**80,866**	**207,775**	**167,677**	**N/A**	**8,167,532**
Median Age	**43 years**	**42 years**	**41 years**	**39 years**	**38 years**
< 15 years	18.2	18.2	19.1	18.6	18.5
15-29 years	17.0	17.0	17.4	19.6	19.5
30- 44 years	17.3	17.8	17.5	19.1	20.6
45-64 years	26.1	26.4	25.6	25.3	25
≥ 65 years	21.4	20.6	20.5	17.4	15.9
Ancestry (top responses)[11]					
Australian	32.3	31.9	32.0	31.0	22.9
English	32.2	32.0	31.5	31.0	23.3
Irish	8.0	8.3	8.9	8.8	7.5
Scottish	8.4	8.6	7.1	8.4	5.9
German	3.1	3.1	2.4	3.1	-
Chinese	-	-	-	-	5.2
Aboriginal/Torres Strait Islander	4.9	4.1	4.9	4.6	2.9
Born in Australia	84.5	85.3	81.0	84.5	65.5
Parents' country of birth					
Both parents born overseas	13.0	12.7	15.6	13.1	37.0
Father only born overseas	6.3	6.4	7.2	6.0	6.1
Mother only born overseas	4.5	4.5	4.8	4.2	4.3
Both parents born in Australia	70.3	71.1	65.5	70.5	45.5
Language					
English (only spoken at home)	91.3	91.3	89.3	88.9	68.5
Non-English language (spoken at home)	6.1	6.5	7.1	7.8	26.5
Legally registered relationship status					
Married	50.0	50.0	44.7	45.7	48.7
Separated	3.4	3.3	4.3	3.4	3.1
Divorced	9.7	9.5	11.2	9.6	8.4
Widowed	6.9	6.8	7.1	6.2	5.4
Never married	30.0	30.4	32.6	35.1	34.4
Religious affiliation					
Catholic	19.1	20.8	25.9	22.4	24.7
No religion (so described)	27.6	28.9	26.2	29.3	25.1
Anglican	22.3	21.3	24.3	21.0	15.5
Not stated	7.6	7.2	8.1	7.8	9.2
Uniting Church	5.7	5.9	2.9	5.2	-
Islam	-	-	-	-	3.6

10 Highlighted data excepted.
11 Census form included option of reporting two (2) ancestries, therefore responses do not reconcile with population counts.

Key observations – personal and population characteristics

It is noted that the ABS Estimated Resident Population (ERP) for the LGA (2018) was 204,914 (a cumulative increase of approximately 3.8% over the intervening period). However, Census data are reproduced in the table to allow accurate reporting of proportionality in respect of population characteristics.

- The SA3 population is approximately 38% of the LGA population, and approximately 16% of the regional (SUA) population.
- The balance of male and female residents is relatively consistent across all populations.
- The SA3 population is older than each of the other populations, based on median age.
- The local and regional populations are relatively less ethnically diverse than for NSW, with around 85% of people born in Australia, compared to approximately 66% for NSW. Local and regional residents are also more likely to have parents born in Australia than is the NSW population generally.
- All smaller populations have markedly larger proportions of Aboriginal and/or Torres Strait Islander residents than NSW in total.
- The larger proportions of widowed residents are consistent with the older populations for the local and regional populations.
- Generally, differences between the local and regional populations and NSW are also apparent for language and religious affiliation data. These further emphasise the relative homogeneity of the two SA3, LGA and SUA populations.

There is no apparent community or group among the observed populations that may be particularly affected by the operations of the mine on the basis of these broad demographic characteristics. Specific groups such as employees and people residing close to the mine's operations are subsequently addressed in relevant parts of this document.

Household composition characteristics

Table 2: Demographic profile: families & household composition

	LMWSA3 (%[12])	LMCC (%)	WSA3 (%)	SUA (%)	NSW (%)
Couple without children	40.6	39.5	37.5	37.9	36.6
Couple with child(ren)	41.0	42.0	40.0	41.9	45.7
One parent with child(ren)	17.3	17.4	21.1	18.6	16.0
Other family	1.2	1.2	1.4	1.6	1.7
Family households	74.7	73.5	71.0	70.2	72.0
Single/lone person households	22.9	24.1	25.9	25.8	23.8
Group households	2.4	2.4	3.1	4.0	4.2
Average people/household (count)	2.6	2.5	2.5	2.5	2.6

12 Highlighted data excepted.

Key observations – household composition

- The SA3 and LGA, have larger proportions of couple *without* children families, consistent with their older age profiles, with presumed larger proportions of 'empty-nester' households. These conclusions are also consistent with the registered relationship status data (Table 1).
- Higher proportions of single parent families and single/lone person households are also consistent with higher proportions of divorced persons (Table 1).
- Household size is relatively consistent across all populations.

Income & housing-related data

Table 3: Demographic profile: income data & housing-related data

	LMWSA3 (%)	LMCC (%)	WSA3 (%)	SUA (%)	NSW (%)
Income	**$**	**$**	**$**	**$**	**$**
Median weekly personal income	582	609	568	623	664
Median weekly household income	1,499	1,610	1,448	1,641	1,780
Median weekly family income	1,276	1,313	1,190	1,324	1,486
% households < $650 gross p.w.	21.2	21.4	23.8	21.8	19.7
% households > $3000 gross p.w.	10.9	13.1	9.4	13.2	18.7
Housing tenure	**%**	**%**	**%**	**%**	**%**
Owned outright	36.1	37.7	34.0	32.9	32.0
Owned with a mortgage	37.1	35.8	34.0	34.3	32.3
Rented	22.6	23.0	28.0	29.5	31.8
Dwelling structure	**%**	**%**	**%**	**%**	**%**
Separate house	89.8	85.4	82.6	80.6	66.4
Semi-detached, row or terrace house, townhouse etc.	6.8	9.7	10.2	11.7	12.2
Flat or apartment	2.0	3.8	5.9	6.5	19.9
Other dwelling	1.2	0.9	0.8	0.6	0.9
Housing costs	**$**	**$**	**$**	**$**	**$**
Median monthly mortgage repayment	1,733	1,733	1,733	1,733	1,986
Median weekly rent	320	320	340	320	380

Key observations – income and housing-related data

- Incomes in the SA3 and LGA are lower than for the SUA and NSW, but higher than for the neighbouring Wyong SA3. Housing costs, which represent a significant element of cost of living, are reported as being the same for the local and regional communities, and lower than for NSW. Rents in the Wyong SA3 are higher on average than for the immediate SA3, and the LGA and SUA. This is assumed to be related to the proportionally larger and thus presumably more competitive rental market in that area. Proximity to Sydney, and the Central Coast's role as an alternative to residing in the metropolitan area, are also likely to be factors.

- Home ownership (outright and under mortgage) is higher for the SA3 and LGA, and rented accommodation lower. These higher rates of home ownership are interpreted as being consistent with the older populations in these areas, and their presumed longer residential tenure.

Population growth projections

NSW Government Department of Planning, Industry and Environment (DPIE) population projections for Lake Macquarie LGA, compared with regional NSW and the entire State, are presented in Table 4. Data for Wyong is not available, as it is aggregated to Central Coast LGA.

Table 4: NSW DPIE average annual population change projections 2016-2041

Average Annual Population Growth	2016-21	2021-26	2026-31	2031-36	2036-41
Lake Macquarie	0.7%	0.4%	0.6%	0.4%	0.7%
Regional NSW	0.77%	0.64%	0.52%	0.4%	0.31%
NSW	1.8%	1.4%	1.2%	1.1%	1.0%

Projected population growth is likely to be lower for Lake Macquarie than NSW, and generally comparable to regional NSW, although displaying different projected growth patterns, particularly in the period 2036 to 2041. Considering land availability and other constraints on a particular LGA in such a comparison, these relative outcomes as compared with NSW, are to be expected to some extent.

REGIONAL ECONOMIC PROFILE DATA

Economic and employment metrics

Headline economic data

Table 5: Headline economic indicators LMCC LGA[13]

Economic metric	LMCC value
Gross Regional Product (GRP, 2020)	≈ $11.168 billion
Population (ABS ERP 2020)	207,775
Local businesses (2020)	13,516
Employed residents (2020)	85,573
Mining employment (# jobs)	1,399
Unemployment rate (Dec 2020)	7.5%

Industry structure – employment by industry

Table 6: Employment by industry: ABS Census 2016 (% of total)[14]

Industry	LMWSA3 (%)	LMCC (%)	WSA3 (%)	SUA (%)	NSW
Agriculture, forestry & fishing	0.7	0.4	0.7	0.6	2.2
Mining	3.1	2.6	0.7	3.6	0.9
Manufacturing	7.5	6.6	7.3	6.5	5.9
Electricity, gas, water & waste services	1.8	1.6	1.3	1.4	0.9
Construction	10.7	10.4	12.1	8.8	8.4
Wholesale trade	2.3	2.2	2.4	2.1	3.1
Retail trade	10.6	10.4	12.1	10.3	10.0
Accommodation & food services	6.1	6.8	7.9	7.9	7.1
Transport, postal & warehousing	4.6	4.2	4.3	4.1	4.7
Information media & telecommunications	0.9	0.9	1.5	0.9	2.2
Financial and insurance services	2.6	3.3	2.8	3.1	5.0
Rental, hiring & real estate services	1.4	1.4	1.6	1.4	1.8
Professional, scientific & technical services	4.4	5.3	4.0	5.6	8.1
Administrative & support services	3.5	3.3	3.6	3.3	3.5
Public administration & safety	5.2	5.9	6.2	6.5	5.9
Education & training	8.0	8.9	6.8	8.7	8.3
Health care & social assistance	16.6	16.8	14.6	16.4	12.5
Arts & recreation services	1.1	1.2	1.4	1.2	1.5
Other services	4.8	4.3	4.3	4.2	3.7

Key observations – economic and employment metrics

- The data demonstrate the importance of the mining industry in the Lower Hunter Region, with the SA3, LGA and SUA all having significantly greater proportions of mining employees than both Wyong and NSW.

13 REMPLAN (2020): Lake Macquarie Economic Profile (GRP, business count, employment, and unemployment rate). < https://app.remplan.com.au/lakemacquarie/economy/ >

14 ABS advises that small random adjustments are made to all cell values in source data to protect confidentiality. Classifications 'Inadequately described' and 'Industry of Employment not stated' excluded from this table.

- Electricity gas, water and waste services are also comparatively over-represented compared with NSW. This emphasises the interdependencies between the regional mining and electricity generation industries which are co-located in the Lake Macquarie/Wyong area.
- When supporting industries are considered in addition to these data, the importance of coal mining to the regional economies is further emphasised (refer to Sections 4.2 and 4.3).

Industry structure – occupation

Table 7: Comparison of mining & local/regional occupational groups 2016 Census

Occupation	LMWSA3 %	LMCC %	WSA3 %	SUA %	NSW %
Managers	9.3	9.9	10	9.7	13.5
Professionals	17.2	20.1	14.6	21.2	23.6
Technicians & Trades Workers	17.1	16.1	16.6	15.2	12.7
Community & Personal Services Workers	11.6	11.5	13	11.9	10.4
Clerical & Administrative Workers	13.7	14.3	13.1	13.4	13.8
Sales Workers	9.9	10.1	11.4	9.9	9.2
Machinery Operators & Drivers	8.3	6.8	7.7	7.3	6.1
Labourers	11.2	9.8	11.9	10	8.8

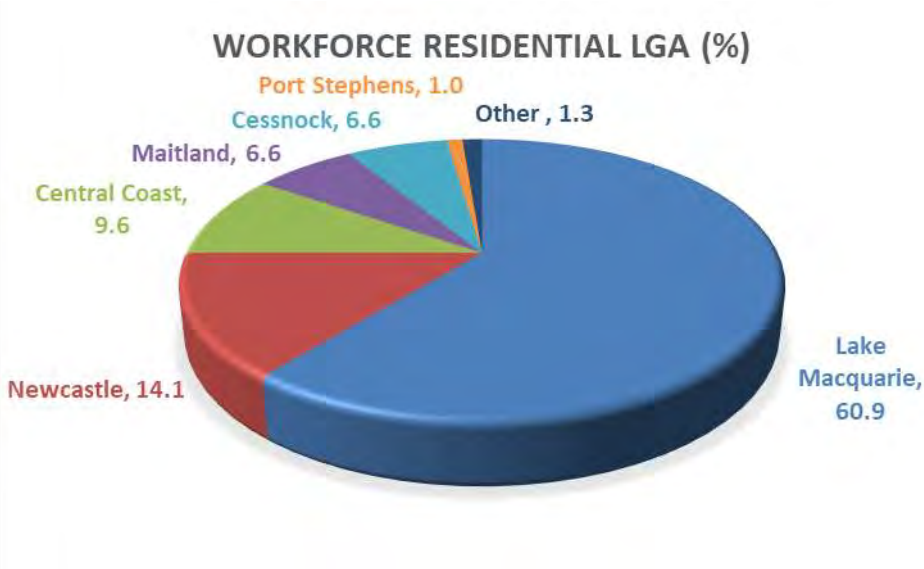
Key observations – industry structure - occupations

- There are larger representations of technicians and trades workers, and machinery operators and drivers in the SA3, when compared with general workforce data for the larger populations. These are employment categories typically associated with mining.

Residential distribution of Mandalong Mine's workforce

Figure 5 illustrates the residential distribution of the workforce, based on internal data.

Figure 5: Residential LGAs of Mandalong Mine workforce



Key observations – workforce residential distribution

Summarising Figure 5:

- Approximately 61% of the workforce resides in the Lake Macquarie LGA, in which operations are based;
- In relative terms, much lower proportions of Mandalong Mine's workforce reside in other individual LGAs. However, approximately 89% of the workforce resides in the Newcastle – Maitland SUA[15].
- Although not included in Figure 5, approximately 32% of the workforce resides in the Lake Macquarie West SA3, being the parts of the LGA most immediate to Mandalong Mine.
- The data demonstrate that the mining workforce is regionally-based. As a consequence, much of the social and economic activity of the workforce is presumed to take place in the local and regional areas, further contributing to the socioeconomic functioning of these areas.
- The retention of mining employee incomes in the region is economically beneficial, as emphasised by comparison of mining employee incomes with overall median personal and employee incomes for the LGA, SA3s and SUA (Table 8) and LMCC economic performance data (Table 9). The higher incomes in mining employment encourage increased expenditure in the local and regional economies in which these

15 As Port Stephens LGA is only partially within the SUA, some employees may reside outside the SUA, however this would be a small number of employees and would not result in a large variance on this estimate.

employees live, when compared to population medians and measures for the regional workforce.

Table 8: Weekly gross personal income data comparison

Description	Income ($/week)
Median personal income - Lake Macquarie LGA – Census 2016	$609
Median personal income - Lake Macquarie West SA3– Census 2016	$582
Median personal income - Wyong SA3 – Census 2016	$568
Median personal income – Newcastle – Maitland SUA – Census 2016	$623
Median employee income (Lake Macquarie LGA, 2018)[16]	$994
Drillers, Miners, Shotfirers (Dept. of Employment Job Outlook 2020 data)[17]	$2,500
Earthmoving Plant Operators	$1,458
Geologists, Geophysicists and Hydrogeologists	$2,192
Mining Engineers	$3,118
Safety Inspectors	$1,876

Discussion of regional economic effects

LMCC Economic Profile (Dantia)

Table 9 identifies LMCC economic performance indicators, as prepared by REMPLAN (2020). The data also include an estimate of average employee income, based on the aggregated employment and income data presented.

Table 9: Economic performance indicators – LMCC LGA

Indicator	Mining Industry	LGA Economy	% mining contribution
Employment (number)	1,399	61,601	2.3
Average income ($)	$121,438	$80,567	-
	$M	***$M***	***%***
Wages & salaries	169.9	4,963	3.4
Output	1,665.7	20,574.6	8.1
Exports	1,512.7	5,145	29.4
Imports	270.2	4,535.1	6.0
Value added	1,063.3	9,980.5	10.7

Data source: REMPLAN LMCC Economic Profile (2020)

On various measures, the mining industry makes a relatively large contribution to the regional economy, in the context of all industries. As indicated in Table 8 and demonstrated in Table 9, incomes for mining employees are comparatively large, with the associated economic on-flows that this supports. Other measures of relative productivity (output and value added) are also larger than the industry's employment measure, in terms of their proportional share of the LGA totals. As may be expected given the trade-based nature of

16 ABS Data by Region – derived as median employee income ($51,683)/ 52 weeks = $993.90.
17 Selected occupational examples for brevity.

the industry, exports are much higher. Imports are also higher, which is likely to be related to the value of capital investment associated with mining.

Lake Macquarie City Economic Development Strategy (EDS) 2018-2038

The following material from the current EDS, prepared by Dantia, the Lake Macquarie Economic Development Company, explains the city's perspective on the mining industry and its regional economic role.

Table 10: Economic Development Strategy 2018-2038.

Reference	EDS content
P.3	*LMEDC* recommends modernisation of the City's infrastructure to enable digital transformation, strengthening the tourism offering and supporting existing industry sectors including manufacturing, utilities, mining, health and retail.
P.14	Because of asset life, utilities (especially power generation) deliver secure, long-term jobs. The Eraring Power Station is expected to close in 2036 (18 years).
P.14	The quality and volume of local coal provides a solid economic foundation. New generation coal-fired plants coming online for base load power in Asia and Europe are seeking Lake Macquarie coal. Lake Macquarie's coal continues to hold its price in all markets on account of its quality thereby providing a solid employment base
P.14	Lake Macquarie has access to abundant natural coal and quarrying resources, which has driven local mining since the 1800s. Coal remains a robust and significant contributor to the state and national economies (cf. LMCC EDS 2014).

The EDS recognises the contribution of coal mining to the economic strength of the LGA and recommends continuing support of the industry by local government. The document also cites its precedent EDS with respect to contribution to the state and national economies. The reference to the remaining economic life of Eraring Power Station is also relevant to continued operation of Mandalong Mine.

ASSESSMENT OF SOCIOECONOMIC EFFECTS OF MANDALONG MINE OPERATIONS

Description of approach to assessment

The assessment presented in this section draws on internal operational data for Mandalong Mine. These data are then assessed using relevant economic assessment tools to provide a quantified profile of the economic contribution of the mine in the local and regional economies in particular, and in addition, NSW broadly. Further qualitative factors are also presented and discussed for appropriate measures of activity and their associated impacts.

Employment effects

Based on the most recent data (September 2021), Mandalong Mine employs 543 FTE employees. In order to assess the contribution of this employment to the regional economy, the most recently reported average income for Mandalong Mine employees was compared with the average incomes derived in Table 9, based on aggregate regional data. The method applied produces a 'labour surplus' metric, which may be interpreted as the additional (and

to some extent, disposable) income component of employee incomes, compared with broader employee levels. Much of this surplus is disbursed in the local and/or regional economies. An explanation of the method is included in Annexure 1. In order to ensure conservatism in the estimates however, an additional assessment of the disposable component of incomes is also formulated in Annexure 1 and presented below.

The annual labour surplus per employee resulting from employment at Mandalong Mine ranges between **$9,087** (average mining employment income in the LGA [Estimate 1]) and **$11,222** (average employment income in the broader mining industry [Estimate 2]). The estimate of the proportion of the labour surplus that may be disbursed in the regional economy each year (71.8%) ranges from **$6,524** [Estimate 1] to **$8,057** [Estimate 2].

Table 11: Estimates of labour surplus/regional employment contribution (p.a.)

	Labour surplus @ 543 employees $M	
	Total	**Local spend**
Estimate 1	4.93	3.54
Estimate 2	6.09	4.37

These estimates may be considered as the upper and lower bounds of a range which allows for differences in the behaviours of individual employees and/or their households.

In raw terms, the average Mandalong Mine employee income is approximately 75% higher than the implied average wage for all employees in the LGA, based on aggregate regional data (Table 9). The adjusted employee salary (Annexure 1) is approximately 2.5 times higher than the median wage for all LGA workers calculated therein. These estimates provide an indication of the extent of additional economic stimulus that Mandalong's employees add to the local and regional economies, when compared with working population indicators.

A further qualitative measure of these effects is the application of household size assessments to the number of positions with Mandalong Mine. This results in an estimate of the *total* number of LGA residents who may directly benefit from this employment, when employees' families and/or other household members are factored in. The estimate is based on the average household size for the LGA derived from ABS Census 2016 Census data (refer to Table 2), of 2.5 people per household. On this basis, employment at Mandalong may currently support an estimated 1,008 residents in the region. This estimate is conservative, as average household size for the LGA population includes older residents' households that typically comprise one or two people and some of which may not be in the workforce (e.g. retirees). This is likely to apply to a lesser proportion of employee households. For example, recent internal research on a Centennial operation in the Western Coalfield identified an average household size for the workforce of 3.1 persons per household, against an overall regional household size of 2.5 persons. Applied to Mandalong Mine employees as an

indicative measure, this would increase the total number of potential beneficiaries to approximately 1,250 residents.

Supply chain effects

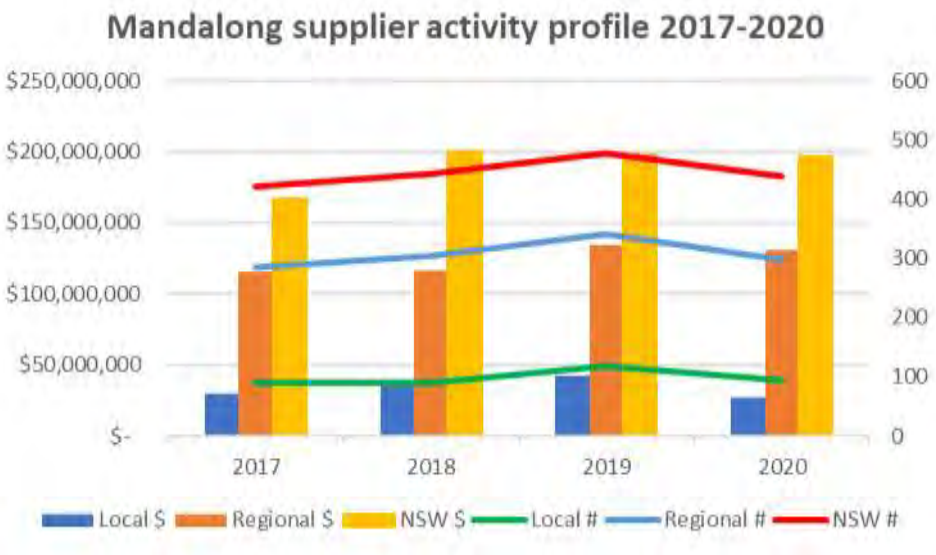
As is identified in the LMCC EDS, '*coal remains a robust and significant contributor to the state and national economies*' (2020:14, cf. LMCC EDS 2014). This finding recognises that additional economic activity among regional businesses that provide labour, goods and services, can be attributed to coal mining operations such as Mandalong Mine. Table 12 and Figure 6 provide a summary of indicators of the extent of this additional activity in the local, regional, and state economies. The assessments are based on internal data for the three most recent corporate financial years. The data also include transactions with businesses in adjacent Central Coast LGA for the regional estimate, based on proximity.

Table 12: Local (LGA), regional & NSW supplier transaction data

	2017	2018	2019	2020	Cumulative	Average
	$	$	$	$	$	$
Local $	30,140,566	38,023,396	42,522,699	27,020,132	137,706,792	34,426,698
Regional $	115,398,722	116,763,769	134,956,293	130,924,549	498,043,334	124,510,833
NSW $	166,779,609	200,697,410	198,191,618	196,839,754	762,508,392	190,627,098
	Firms	**Firms**	**Firms**	**Firms**		
Local #	90	91	119	94	-[18]	99
Regional #	285	304	342	297	-	307
NSW #	421	443	477	440	-	445

18 Not calculated. Some suppliers will be engaged across different years, therefore counts are not additive.

Figure 6



The data provide some quantitative context to the qualitative assessment in the EDS material cited, and the relative economic contributions identified in Table 9. This also emphasises the extent to which local industry is geared towards the mining sector, with around 68% of firms engaged and 65% of total transaction value, being concentrated in the regional economy.

Multiplier effects analysis of additional economic stimulus

When the downstream impacts on those regional participants in these firms' supply chains are also considered, the effects are further amplified. An indication of the scale of these effects can be estimated using input/output (I/O) multipliers. It is noted that there are limitations on the extent to which multipliers can provide an accurate assessment of the extent of economic on-flows. These limitations principally relate to the applicability of the multipliers at regional levels, given their basis in national-level economic data, and the inability of the data and multipliers to capture certain economic flows and changes. Consequently they should be considered as providing an indicative assessment of the scale of derived economic effects. Mining-specific multipliers are presented in Table 16. These are implied multipliers derived from the NSW Minerals Council (NSWMC) *Mining Expenditure Impact Survey 2019-2020* (2021). Although survey-based, these multipliers are based on regional activity, and may therefore be more representative of local effects than multipliers based on national I/O data.

Table 13: NSWMC implied multipliers – Hunter Region

Description	Multiplier value
Output	2.324
Value added	1.107
Employment	10.607
Business spend	1.735
Wages & salaries	1.667

Bearing in mind the limitations outlined, general economic effects may increase by 1.1 to 2.3 times the initial stimulus, depending on the measure adopted. Additional employment of around 11 times may also result. An alternative assessment of likely multipliers from within NSW Government (Treasury)[19] is that mining-related multiplier effects for value added are likely to be in the range of 1.1 to 1.4 times the initial stimulus, which approximates the NSWMC implied multiplier. The practical demonstration of these effects is provided by the summary internal data on contractor and supplier engagement, and the further employment this supports. As such, given the scale of Mandalong Mine's activities, particularly at regional level, these remain a positive additional source of economic benefit.

Direct community contributions & community participation

Based on the most recent reported internal financial year data, Mandalong Mine provided financial support in excess of $50,000 to local community service, volunteer, schools and sports organisations.

In addition to these corporate contributions, it is considered likely that individual employees also make financial and in-kind contributions to the community, particularly through activities such as volunteering with organisations in the region. Although equivalent internal workforce data has not been generated at this point for Mandalong Mine, workforce research at one of Centennial's Western Operations provides an indication of these community contributions. The research found that 161 respondents (approximately 62 percent of respondents) reported a total 288 involvements with various service, community, school, sports, social and cultural organisations in the areas in which they reside.

Considered together, these company and employee contributions contribute positively to the local and regional communities, in both economic and social terms. Although a quantified assessment is possible for donations, labour surplus etc., these other qualitative contributions are also important in contributing to community welfare and cohesion.

Royalties, taxes, rates and other government charges

Mandalong Mine also returns a range of payments to various levels of government. For example, corporate income taxes are paid at federal level, royalties and payroll taxes at state level, and rates and other charges to local government. In the 2019-2020 corporate financial year, State royalties paid amounted to approximately **$30.55 million**. Payroll tax remitted to the state was approximately **$4.51 million.** Rates and charges paid to Lake

19 Verbal advice provided by Treasury representatives January 2015.

Macquarie City Council were approximately **$1.82 million**. Centennial Coal assesses its income tax liabilities at total group level (including all of Centennial's Northern and Western, and corporate operations). Therefore, a separate estimate for Mandalong Mine cannot be practically presented. In each instance, the sums returned to government contribute to the provision of public goods and services that benefit communities locally, regionally and more broadly.

As is the case with the local and regional economic stimulus provided by employment at the various operations, Mandalong Mine's employees also remit personal income taxes to the federal government, which fund further public goods and services.

OPERATIONAL IMPACTS

There are a range of impacts associated with Mandalong Mine that may affect a relatively limited number of households and residents located in the near vicinity of the mine, particularly in areas where longwall mining activity is being undertaken. The impacts are not quantified in this profile, as they may vary from time to time due to operational factors. These impacts include:

- Air quality (dust etc.);
- Noise;
- Visual impacts;
- Water resources;
- Subsidence.

It is acknowledged that some impacts are generated as a result of operations at Mandalong Mine. However, Centennial has in place an appropriate balance of avoidance, management and mitigation strategies, and rehabilitation plans, which are continuously deployed to address such impacts. This includes ongoing strategy development in relation to reducing GHG emissions. The potential for localised or regional effects of GHG emissions produced through mining at Mandalong is unlikely to be realised by, or be apparent to, these communities. However, it is the cumulative effect of emissions in the context of existing conditions that may contribute to impacts on those communities, and at the broader state and national scales. It is acknowledged that there is a general awareness and acceptance of the negative effects of GHG emissions. However, in the current societal and political environment, it is not feasible to immediately discontinue the coal-fired electricity generation supported by Mandalong Mine, without major disruption to the social and economic fabric of NSW.

Centennial also has structures in place for ongoing stakeholder engagement, with a particular focus on residents and/or community representatives residing within areas immediate to the mine. These are a key element in managing the impacts discussed above.

CONCLUSION

The material presented in this socioeconomic profile focuses on the contribution of Centennial Coal's Mandalong Mine to the local, regional and state economies and communities. The two key elements of socioeconomic contribution are those related to the mine's commercial activities, and those resulting from the economic and social involvements of the mine and its employees. These must be considered in the context of qualitative acknowledgements of operational impacts.

The mine's operations entail both commercial/economic elements and associated social impacts. Commercial engagement of locally and regionally-based suppliers and contractors supports those businesses and the consequent employment and extended economic benefit such transactions produce. This also has positive social impacts, through increasing the number of residents and households that have the resources to engage in the community on a variety of levels.

The role of employees as local and regional economic actors is also beneficial. This is perhaps best illustrated by the estimates of the number of household members who directly benefit from a household member's employment with Mandalong Mine. This has short and longer term benefits for these households in terms of immediate and continuing financial security, and wealth creation. As is the case with Mandalong Mine's commercial partners, these households also have greater resources, permitting them to engage in the community and to form part of and/or contribute to the social fabric, functioning and cohesion of their communities.

Section 5 of the profile identified that a small number of households are situated close to the mine and its operational footprint. The occupants of these households may experience some negative impacts, along with the broader impact of GHG emissions, which are more difficult to quantify in terms of affected parties. As stated, the effects on these third parties are managed directly by Centennial, through appropriate avoidance, management and mitigation activities, to the extent practicable, and consultation with these parties is ongoing.

A number of different measures of socioeconomic impact are examined in this profile. On balance, the contribution to the local, regional and state economies is strongly likely to be positive.

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Annexure 1

Estimation of net economic benefit to workers

Internal data on the residential status of Mandalong Mine employees and FTE contractors indicates that the workforce is largely resident in the immediate region (refer to Figure 5). As a result, mobility in terms of alternative employment may be somewhat constrained, as transaction costs associated with relocation may be a barrier (e.g. Coulson and Fisher 2009). A further outcome of local/regional workforce residency is that there is a range of significant personal, family and social ties to the region, based on the long time in residence that is typical for that workforce. This further detracts from any simplified expectation that employees can leave the area and find alternative work without incurring significant financial/economic and social costs.

This being the case, attempts to apply more generalised assumptions to a regional area in relation to which access to suitable alternative employment may be highly competitive are problematic and may not effectively capture the full range and scale of the effects of these factors. The assessment method presented below permits calculation of the residual or surplus economic contribution (labour surplus) of employees of Mandalong Mine, taking into account alternative employment outcomes. The approach taken is to adopt a 'reservation wage' and compare this to the assumed wage level for ongoing employment, producing an estimate of 'labour surplus'. The reservation wage is derived as:

$$RW = (1 - p)AW + pB$$

Where:
RW = reservation wage;
p = probability of a worker remaining unemployed and thus claiming unemployment (Jobseeker Allowance) benefit. The Australian Government Job Outlook website[20] was referenced to obtain information to inform an assumption on this probability. Findings for relevant occupations are included in Table A2.

Table A2: Job outlook information[21]

Identifier	Occupation	Future growth	$/week (median)	$ annualised
1	Drillers, Miners & Shot Firers	strong	2,500	130,000
2	Mine Deputies[22]	strong	2,812	146,224
3	Mining Engineers	strong	3,118	162,136
4	Other Construction and Mining Labourers	stable	1,683	87,516
5	Geologists, Geophysicists & Hydrogeologists	moderate	2,192	113,984
6	Production Managers	stable	2,258	117,416
7	Earthmoving Plant Operators	moderate	1,458	75,816

20 Information current at August 2020.
21 Previous versions of this information included an assessment of unemployment for each occupation, however this is noted as 'not available' for the current material.
22 Included in the occupational group 'Other Building and Engineering Technicians'.

Based on internal information, for each operation the workforce comprises ≈90% operations (mining) personnel and ≈10% staff/management personnel. Category 1 was assumed as the median wage for operations (mining) personnel ($130,000). The average of categories 2,3 and 5 were assumed for staff ($141,000). These estimates were then used as a basis for assessing the assumed alternative wage, which is calculated as $131,100. Incidence of unemployment is assumed as average, therefore, the unemployment rate for NSW may be considered as reflecting the likelihood of a displaced employee being unable to find work. As of February 2020, the unemployment rate for NSW was 5.1%. Adopting the NSW rate can be considered as conservative, as it does not recognise the inherently low labour mobility in the black coal industry reported by the Productivity Commission (1998), which found that voluntary labour turnover rates were less than half the average for all industries, thus indicating scarcity of alternative employment positions. For the purposes of recognising the higher level of unemployment in the immediate area, an estimate is also provided based on the unemployment rate for the Newcastle - Lake Macquarie SA4, reported as of May 2021, of 7.2%.

AW = assumed alternate wage. In this instance the alternate wage is assumed as the median wage for the mining sector, adjusted for the structure of the workforce as determined in the preceding material ($131,100 annualised).
B = Jobseeker Allowance. The benefit is assumed at partnered level, $565.40 per fortnight (each)[23] annualised ($29,401). Therefore, the reservation wage would be alternatively:

(0.949 x $131,100) + (0.051 x $29,401) ∴
$124,414 + $1,499 = **$125,913**
OR
(0.928 x $131,100) + (0.072 x $29,401) ∴
$121,661 + $2,117 = **$123,778**

The assumed wage rate at the time of preparation of the economic impact assessment was the budgeted 2020 forecast (average) employee income for Centennial's regional operations, which is approximately **$135,000**[24]. Consequently, the difference, and the labour surplus value assumed for estimation of the employment effects in the Lake Macquarie LGA and/or the Newcastle – Lake Macquarie SA4 is **$9,087 (Estimate 1)** and **$11,222 (Estimate 2)**.

23 Australian Government Department of Human Services website (2021). Partnered rate assumed as this is consistent with internally generated workforce demographic data, applied for one partner. Allowance updated March 2021. Excludes supplementary payments in relation to COVID19.
24 Estimate based on information as of August 2020.

Method of local expenditure adjustment

ABS data for gross and disposable income (2015/2016, released 2017) are presented in Figure A1. With gross income of approximately $2,600 per week[25], Mandalong employees fall within the fourth (i.e. second highest) quintile, for which 46.1% or $1,231 per week is disposable income.

Figure A1

Mean income per week NSW	2015/16	Disposable	Gross	%
Lowest quintile	$	397	454	87.4
Second quintile	$	641	986	65.0
Third quintile	$	878	1,690	52.0
Fourth quintile	$	1,231	2,668	46.1
Highest quintile	$	2,206	5,713	38.6
All persons	$	***1,070***	***2,306***	***46.4***
Adjusted lowest income quintile(c)	$	429	503	85.3

Further related ABS data (2017) are presented in Figure A2. Nominal disposable income equates to mean gross income less income tax. Total other expenditure ('average weekly expenditure') plus selected other income (excluding income tax) totals approximately $1,698.

In order to assess local expenditure, the following items were subtracted from expenditure on the basis that the majority of the value is unlikely to be spent in the local/regional economy:

- Current housing costs;
- Communication;
- Mortgage repayments[26];
- Superannuation and life insurance.

25 $135,000/52 weeks ≈ $2,596 per week.
26 It is assumed that this figure is supplementary to 'current housing costs', which is interpreted as the proportion of weekly housing costs that equates to equivalent rental cost.

Figure A2

Average weekly expenditure (AWE)	Value $
Goods and services	
Current housing costs (selected dwelling)	279.12
Domestic fuel and power	40.92
Food and non-alcoholic beverages	236.97
Alcoholic beverages	31.95
Tobacco products	12.84
Clothing and footwear	43.75
Household furnishings and equipment	57.87
Household services and operation	44.90
Medical care and health expenses	82.38
Transport	206.69
Communication	46.62
Recreation	171.85
Education	43.86
Personal care	28.64
Miscellaneous goods and services	97.08
Total goods and services expenditure	***1,425.44***
Selected other payments	
Income tax	383.26
Mortgage repayments – principal (selected dwelling)	70.77
Other capital housing costs	124.18
Superannuation and life insurance	77.14
Gross income per week	
Mean gross income (MGI)	**2,086.00**
Nominal mean gross disposable income	**1,706.00**
Total % AWE/MGI	**68.3**

The total spending likely to occur in the local/regional economy, excluding these items is approximately $1,224, therefore 71.8% of disposable income (equated to 'take home pay'). Applying this proportion to the two estimates of total residual (disposable) income calculated above, produces: **Estimate 1: $6,524; Estimate 2: $8,057.**

Comparison with regional median income

To permit comparison of the relative effect of these mining wages in the local and regional economy, the corresponding calculation was made for the median employee income for the Lake Macquarie LGA[27]. This was $49,945. This has been progressively adjusted in successive reports, based on the annual Wage Price Index (WPI)[28]. The 2020 income estimate was $53,158. Adjusted for 2021 WPI (1.5%), the current adopted income is $53,955.

(0.949 x $53,955) + (0.051 x $29,401) ∴
$51,203 + $1,499 = **$52,702**

OR

(0.928 x $53,955) + (0.072 x $29,401) ∴
$50,070 + $2,117 **= $52,187**

The estimate results in a mean of approximately **$52,445.**

27 ABS Data by Region. Most recent estimate published (2017).
28 ABS Cat No. 6345.0 - Wage Price Index, Australia 2021.

Appendix G

Greenhouse gas emissions assessment









Memorandum

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30 September 2021

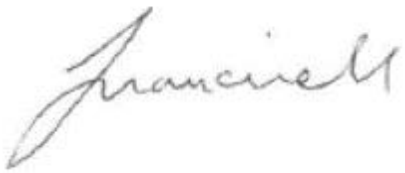
To: James Wearne
From: Francine Manansala
Subject: J210436 - Mandalong Mine - MOD 10 - Greenhouse gas assessment

Dear James,

Centennial Mandalong Pty Limited (Centennial Mandalong) has engaged EMM Consulting Pty Ltd (EMM) to prepare a greenhouse gas assessment (GHG) related to proposed changes at Mandalong Mine under Modification 10 (MOD 10). This memorandum provides a summary of the assessment.

We hope that this meets your requirements. Please don't hesitate to contact me should you have any comments or require clarification on the information presented.

Yours sincerely



Francine Manansala
Associate - Air Quality
fmanansala@emmconsulting.com.au

1 Introduction

Mandalong Mine (Mandalong) is an existing underground coal mine near Morisset, approximately 35 kilometres (km) south-west of Newcastle in the Lake Macquarie local government area (LGA). Mandalong is operated by Centennial Mandalong Pty Limited (Centennial Mandalong).

Centennial Mandalong has approval to extract run-of-mine (ROM) coal from the West Wallarah and Wallarah-Great Northern seams using a combination of longwall and continuous mining methods. Mandalong operates under State significant development (SSD) consent SSD-5144.

2 Background

In April 2021, a modification to SSD-5144 was approved (herein referred to as MOD 9). Since this time, Centennial Mandalong has continued to review the progression of underground mining within the Mandalong Southern Extension Area. As a result of these investigations, the decision has been made to shorten LW30 and remove LW33 from the mine plan.

The length of LW30 was reduced through the Extraction Plan process to avoid mining through a high strength igneous dyke. The amendment to LW30 reduces the extent of potential subsidence impacts on rock-face features, a tributary to Mannering Creek, Kiar Ridge Road and identified Aboriginal cultural heritage sites.

LW33 has been removed from the mine plan due to the extent of an igneous sill intrusion and resultant impacts on panel length, tonnages available for extraction and financial viability of mining in this area. The removal of LW33 will reduce the extent of potential subsidence impacts on surface features, including TransGrid's TL25/26 330 kV electricity transmission line and identified Aboriginal cultural heritage sites.

The shortening of LW30 and removal of LW33 are estimated to result in the sterilisation of approximately 0.4 million tonnes (Mt) and 1.6 Mt of coal, respectively. Consequently, Centennial Mandalong has explored options to optimise the mine plan to access additional coal resources.

The proposed modification will seek approval for the addition of LW34, which will maximise resource extraction within the West Wallarah Seam and Mandalong's development consent boundary. The addition of LW34 will also improve the continuity of coal extraction and employment at Mandalong. The additional coal resource within LW34 can be extracted efficiently using existing infrastructure.

3 Proposed modification

Centennial Mandalong is seeking to modify SSD-5144, pursuant to Section 4.55(2) of the EP&A Act, to include LW34. It is anticipated that LW34 will result in the extraction of approximately 1.3 Mt of coal.

As noted in Section 2, the shortening of LW30 and removal of LW33 has resulted in a loss of approximately 0.4 Mt and 1.6 Mt of ROM coal from each longwall, respectively. Therefore, total ROM coal available to be extracted at Mandalong will decrease by approximately 0.6 Mt when compared to the amount of ROM coal approved for extraction under MOD 9 (ie 60.5 Mt). This represents a decrease in ROM coal of approximately 1%.

The proposed modification will not result in an increase of the currently approved annual mining rate of 6.5 Mt per annum (Mtpa) nor will it increase the total mine life.

The most recent greenhouse gas (GHG) assessment prepared for Mandalong was completed by EMM (2019) to account for the proposed changes under Modification 8 (MOD 8).

4 Emission estimates

Table 4.1 shows the sources of emissions relevant to the operation of Mandalong, which have been included in previous GHG assessments.

Table 4.1 Emissions sources and relevance to the proposed modification

Scope	Emission source
Scope 1	Mine ventilation air
	Pre-drainage gas (residual after flaring)
	On-site diesel combustion (underground mining)
Scope 2	Electricity usage
Scope 3	Energy production from product coal
	Product transportation
	Employee travel
	SF_6 leakage

Source: EMM 2019

The only emission source anticipated to change as a result of MOD 10 is downstream energy production from product coal (ie Scope 3 - end-user combustion of the coal).

All other sources listed in Table 4.1 are not anticipated to change as GHG assessments completed to date have been based on the annual maximum coal production rate of 6.5 Mtpa, which will not change as part of MOD 10.

Mandalong does not produce the maximum rate of coal every year but rather, it fluctuates year-on-year dependent on the mining process in addition to externalities such as geology. Therefore, the GHG assessments completed to date (which are based on the annual maximum coal production rate) represent an upper level estimate.

As noted in Section 2, the shortening of LW30 and removal of LW33 has resulted in a loss of approximately 0.4 Mt and 1.6 Mt of ROM coal from each longwall, respectively. Therefore, total ROM coal extracted at Mandalong will decrease by approximately 645,186 t when compared to the amount of ROM coal approved for extraction under MOD 9 (ie 60,515,116 t). This represents a decrease in ROM coal of 1.1%.

By accounting for the loss of coal resources from the removal of LW33 and shortening of LW30, life of mine (LOM) Scope 3 GHG emissions for the proposed modification will decrease from 147,443,870 t CO_2-e (MOD 8) to 145,871,887 t CO_2-e (MOD 10) (Table 4.2). This represents an approximately 1.1% decrease in LOM Scope 3 emissions relative to the MOD 8 GHG emissions inventory (EMM 2019).

Table 4.2 Scope 3 emissions – combustion of product coal (MOD 8 and MOD 10 - including changes to LW30 and LW33)

Emission source	LOM emissions (t CO_2-e) – MOD 8	LOM emissions (t CO_2-e) – MOD 10 including losses	Percentage difference
Combustion of product coal	147,443,870	150,720,935	+2.2%

For consistency, LOM emissions from MOD 8 have also been compared directly with the addition of LW34. In this scenario, a 2.2% increase in LOM Scope 3 emissions (relative to the MOD 8 GHG emissions inventory) would occur. However, this scenario does not take into account the reduced coal resource available due to the shortening of LW30 and removal of LW33. As noted above, despite the addition of LW34, the proposed modification will overall contribute to a 1.1% reduction in LOM Scope 3 emissions.

References

EMM 2019, *Mandalong Mine - Greenhouse Gas Assessment*. Prepared by EMM Consulting Pty Ltd for Centennial Mandalong Pty Limited.

Appendix H

Stakeholder correspondence









Planning and Assessment
Energy, Industry and Compliance
Contact: Melissa Anderson
Phone: 8275 1392
Email: melissa.anderson@planning.nsw.gov.au

Iain Hornshaw
Approvals Manager
Centennial Mandalong Pty Limited
PO Box 1000
TORONTO NSW 2283

08/07/2021

Dear Mr Hornshaw

Mandalong Southern Extension Project (SSD-5144)
Proposed Modification 10 – Approval Pathway

I refer to your letter, dated 10 June 2021, seeking confirmation of the approval pathway and environmental assessment requirements for a proposed modification 10 to the development consent for the Mandalong Southern Extension Project (SSD-5144). The Department understands that the proposed modification involves modification of the mine plan to include Longwall 34. The proposal also seeks minor amendments to exploration activities and the distribution of annual community fund contributions.

Based on the information contained within your letter, the Department would be willing to consider a modification application under section 4.55(2) of the *Environmental Planning and Assessment Act 1979*.

With respect to the supporting Modification Report (MR), the Department is satisfied with your preliminary identification of key issues and supports the key areas of focus in the proposed assessment approach, which includes the following detailed impact assessment studies:

- subsidence;
- surface water;
- groundwater;
- Aboriginal cultural heritage and historic heritage;
- biodiversity;
- socio-economic; and
- greenhouse gas.

Notwithstanding the above, I remind you that all potential impacts of the modification must be assessed.

Please contact the Department at least two weeks before you plan to submit the modification application and supporting MR. This will enable the Department to provide lodgment instructions, confirm the applicable fee and discuss exhibition periods. Please note that the Department will require the development application fee to be paid in full prior to formal acceptance and exhibition of the application.

Should you have any questions please contact Melissa Anderson on the details above.

Yours sincerely,

Director
Resource Assessments

16 August 2021

Ms. Morvan Cameron
Chief Executive Officer
Lake Macquarie City Council
PO Box 1906
Hunter Regional Mail Centre NSW 2310
Via email: council@lakemac.nsw.gov.au

Dear Ms. Cameron,

RE: Centennial Mandalong SSD-5144 Modification 10

Mandalong Mine is an existing underground coal mine near Morisset, approximately 35 kilometres south-west of Newcastle in the Lake Macquarie and Central Coast local government areas. The mine is operated by Centennial Mandalong Pty Limited (Centennial Mandalong) and is approved to operate an underground longwall mine in addition to supporting surface infrastructure.

In 2010, an exploration drilling program over an area referred to as the Mandalong Southern Extension Area identified additional economic coal reserves ideally suited for electricity generation. Subsequently, Centennial Mandalong sought consent for the Mandalong Southern Extension Project to extract these reserves. This project was approved under State significant development (SSD) consent SSD-5144 in October 2015 by the NSW Planning Assessment Commission.

The progression of underground mining is regularly reviewed and is dependent on ongoing monitoring and geological conditions. Since the approval of MOD 9 in April 2021, Centennial Mandalong has continued to review the progression of underground mining within the Mandalong Southern Extension Area. As a result of these investigations, the decision has been made to shorten LW30 and remove LW33 from the mine plan. The shortening of LW30 and removal of LW33 are estimated to result in the sterilisation of approximately 0.4 million tonnes (Mt) and 1.6 Mt of coal, respectively. Consequently, Centennial Mandalong has explored options to optimise the mine plan to access additional coal resources within existing lease and approval boundaries.

Centennial Mandalong is seeking to modify (Mod 10) SSD-5144, pursuant to Section 4.55(2) of the *Environmental Planning & Assessment Act 1979* (EP&A Act), to change Mandalong's approved mine plan to include LW34 (refer attached figure). The addition of LW34 will maximise resource extraction within the West Wallarah Seam and Mandalong's development consent boundary and improve the continuity of coal extraction and employment at Mandalong. Two updates to Appendix 8 of SSD-5144 are also proposed to:

- Allow for greater flexibility when exploration drilling activities are undertaken on total fire ban days.
- Change the way Mandalong's annual contributions are distributed to the local community.

This letter has been prepared to inform Lake Macquarie City Council (Council) of the proposed modification to Mandalong Mine's development consent (SSD-5144).

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The revised mine design has been developed to ensure no greater impacts will occur than those presently approved under SSD-5144 as a result of mine subsidence and subsequent impacts on the built and natural surface environment.

A preliminary subsidence assessment undertaken as part of Mandalong Mine's redesign process has determined that predicted subsidence effects for the proposed longwall layout are similar to the predicted subsidence effects that were approved as part of the original Mandalong Southern Extension Project.

A Modification Report, including relevant technical specialist assessments, will be prepared to support Centennial Mandalong's application to modify SSD-5144 for these changes to the approved mine plan. The technical specialist assessments will assess the impacts associated with the revised design and contrast them against those currently approved for review and assessment by the Department of Planning, Industry and Environment (DPIE) in consultation with key government agencies including Council.

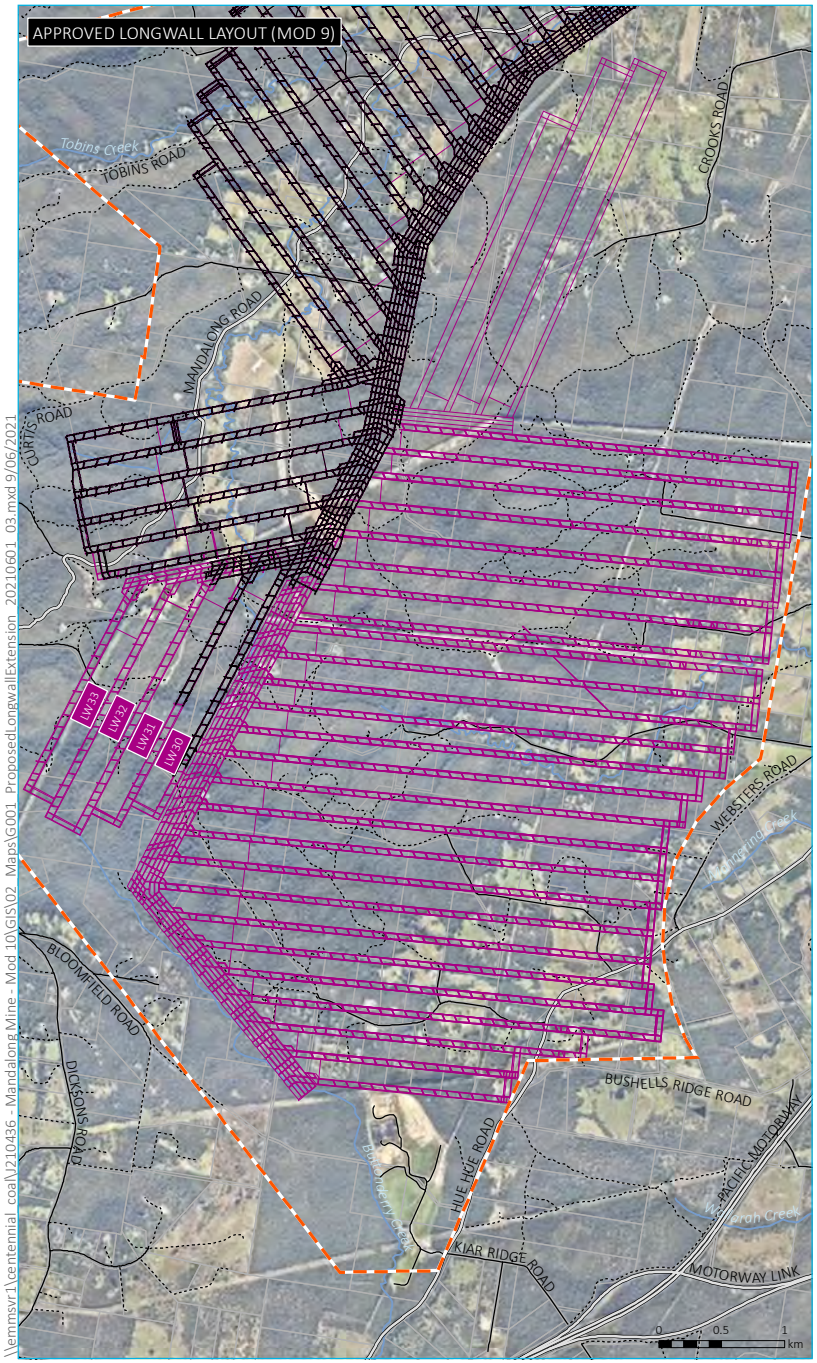
In summary, Mandalong Mine is seeking approval for a revised mine design to include LW34 and optimise the current mining area due to resource areas lost due to poor geological conditions. The revised mine design will remain within the currently assessed and approved footprint and is expected to have negligible impacts beyond those currently approved. This letter aims to provide Council with an overview of the modification prior to lodgment of the Modification Report with DPIE. It is anticipated that DPIE will engage with Council as part of the public exhibition and assessment process once the Modification Report is lodged.

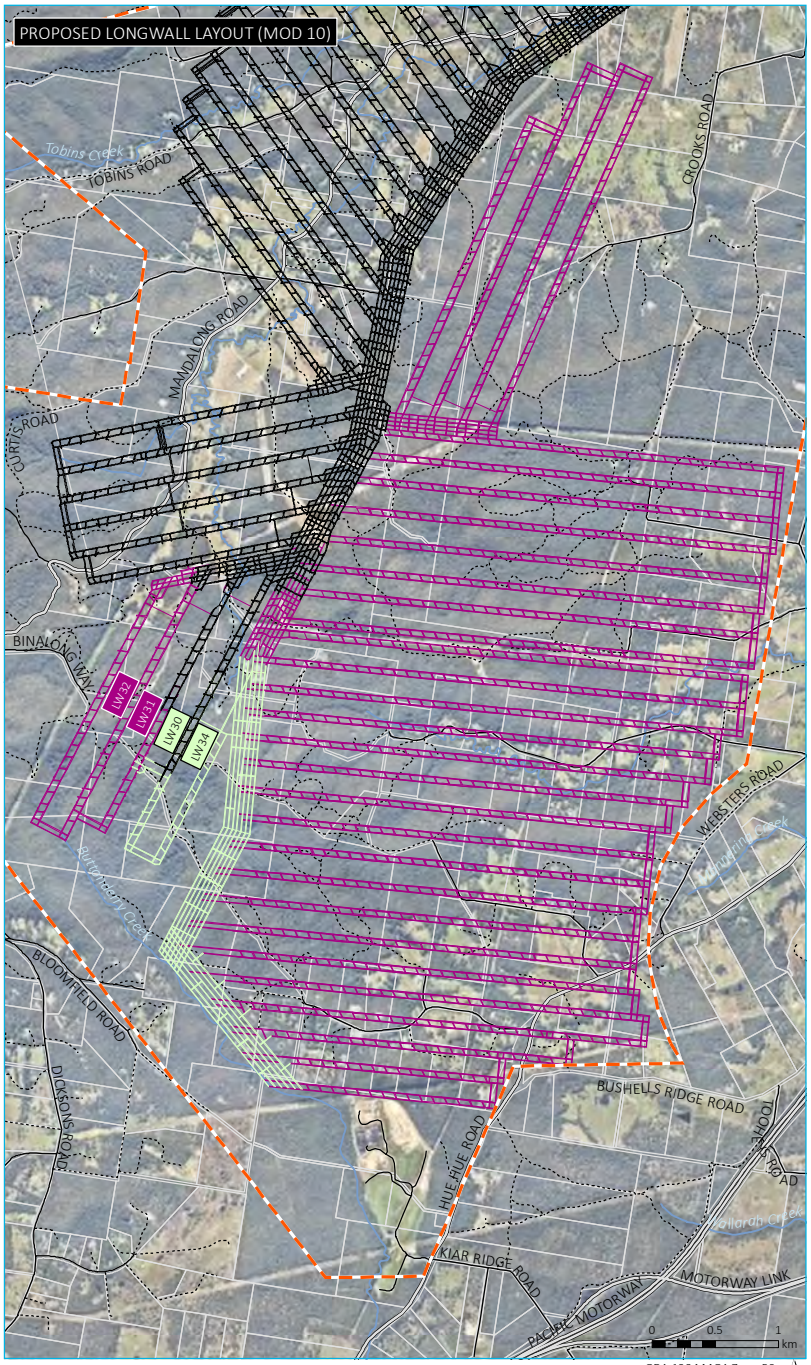
Should you have any queries or require any further information regarding this modification please contact me by phone on 0407 207 530 or email james.wearne@centennialcoal.com.au.

Yours sincerely



James Wearne
Group Manager Approvals/Environment







KEY

- Development consent boundary
- Proposed amendments
- Approved workings
- Completed mine workings
- Main road
- Minor road
- Vehicular track
- Named watercourse
- Cadastral boundary

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Source: EMM (2021); NearMap (2021): Centennial (2021); DFSI (2017); GA (2011)

GDA 1994 MGA Zone 56

N

Proposed amendments to the underground mine layout at Mandalong Mine

Mandalong Mine Modification 10
Figure 3.1

EMM
creating opportunities

16 August 2021

Mr. Scott Cox
Director – Environment and Planning
Central Coast Council
2 Hely Street
Wyong NSW 2259
Via email: ask@centralcoast.nsw.gov.au

Dear Mr. Cox,

RE: Centennial Mandalong SSD-5144 Modification 10

Mandalong Mine is an existing underground coal mine near Morisset, approximately 35 kilometres south-west of Newcastle in the Lake Macquarie and Central Coast local government areas. The mine is operated by Centennial Mandalong Pty Limited (Centennial Mandalong) and is approved to operate an underground longwall mine in addition to supporting surface infrastructure.

In 2010, an exploration drilling program over an area referred to as the Mandalong Southern Extension Area identified additional economic coal reserves ideally suited for electricity generation. Subsequently, Centennial Mandalong sought consent for the Mandalong Southern Extension Project to extract these reserves. This project was approved under State significant development (SSD) consent SSD-5144 in October 2015 by the NSW Planning Assessment Commission.

The progression of underground mining is regularly reviewed and is dependent on ongoing monitoring and geological conditions. Since the approval of MOD 9 in April 2021, Centennial Mandalong has continued to review the progression of underground mining within the Mandalong Southern Extension Area. As a result of these investigations, the decision has been made to shorten LW30 and remove LW33 from the mine plan. The shortening of LW30 and removal of LW33 are estimated to result in the sterilisation of approximately 0.4 million tonnes (Mt) and 1.6 Mt of coal, respectively. Consequently, Centennial Mandalong has explored options to optimise the mine plan to access additional coal resources within existing lease and approval boundaries.

Centennial Mandalong is seeking to modify (Mod 10) SSD-5144, pursuant to Section 4.55(2) of the *Environmental Planning & Assessment Act 1979* (EP&A Act), to change Mandalong's approved mine plan to include LW34 (refer attached figure). The addition of LW34 will maximise resource extraction within the West Wallarah Seam and Mandalong's development consent boundary and improve the continuity of coal extraction and employment at Mandalong. Two updates to Appendix 8 of SSD-5144 are also proposed to:

- Allow for greater flexibility when exploration drilling activities are undertaken on total fire ban days.
- Change the way Mandalong's annual contributions are distributed to the local community.

This letter has been prepared to inform Central Coast Council (Council) of the proposed modification to Mandalong Mine's development consent (SSD-5144).

Centennial Mandalong Pty Limited
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www.centennialcoal.com.au

The revised mine design has been developed to ensure no greater impacts will occur than those presently approved under SSD-5144 as a result of mine subsidence and subsequent impacts on the built and natural surface environment.

A preliminary subsidence assessment undertaken as part of Mandalong Mine's redesign process has determined that predicted subsidence effects for the proposed longwall layout are similar to the predicted subsidence effects that were approved as part of the original Mandalong Southern Extension Project.

A Modification Report, including relevant technical specialist assessments, will be prepared to support Centennial Mandalong's application to modify SSD-5144 for these changes to the approved mine plan. The technical specialist assessments will assess the impacts associated with the revised design and contrast them against those currently approved for review and assessment by the Department of Planning, Industry and Environment (DPIE) in consultation with key government agencies including Council.

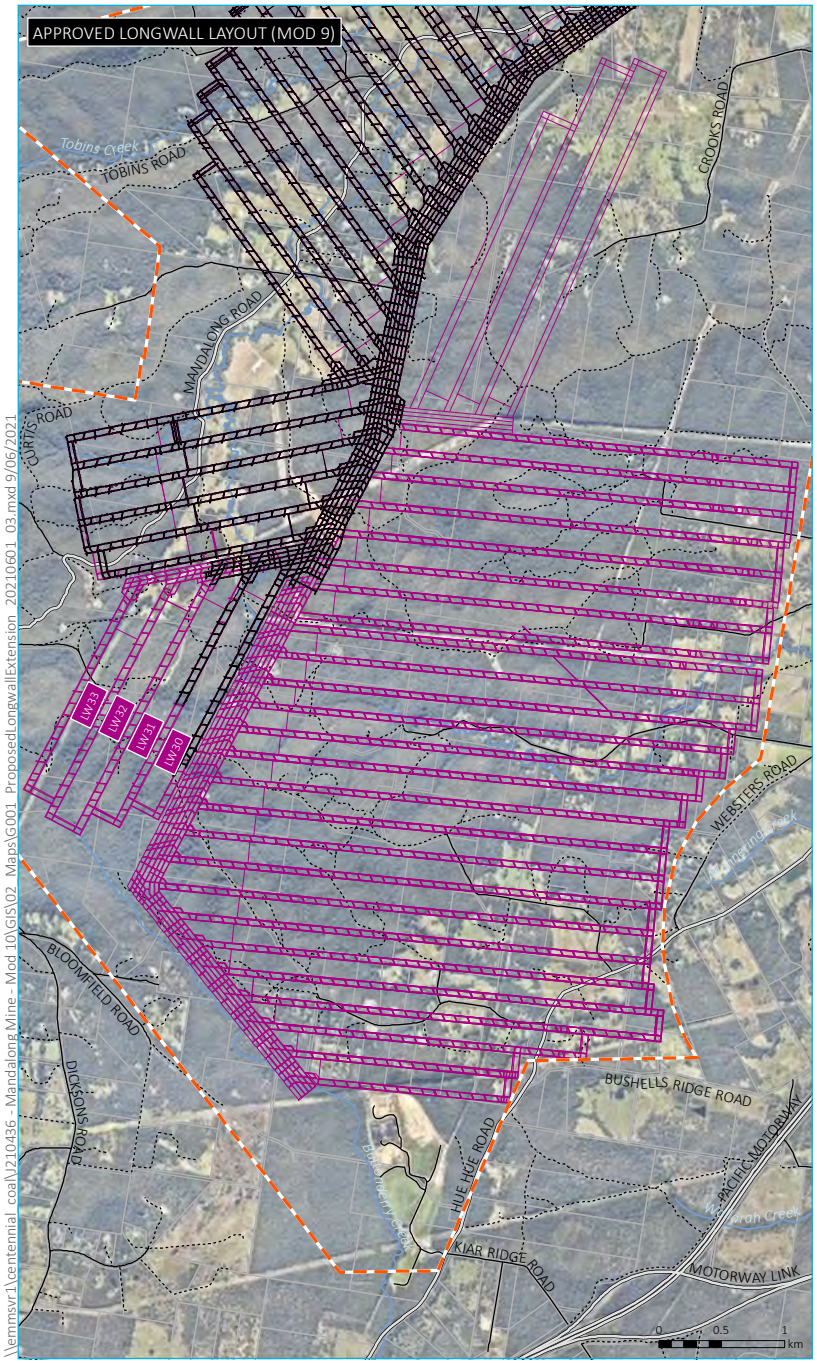
In summary, Mandalong Mine is seeking approval for a revised mine design to include LW34 and optimise the current mining area due to resource areas lost due to poor geological conditions. The revised mine design will remain within the currently assessed and approved footprint and is expected to have negligible impacts beyond those currently approved. This letter aims to provide Council with an overview of the modification prior to lodgment of the Modification Report with DPIE. It is anticipated that DPIE will engage with Council as part of the public exhibition and assessment process once the Modification Report is lodged.

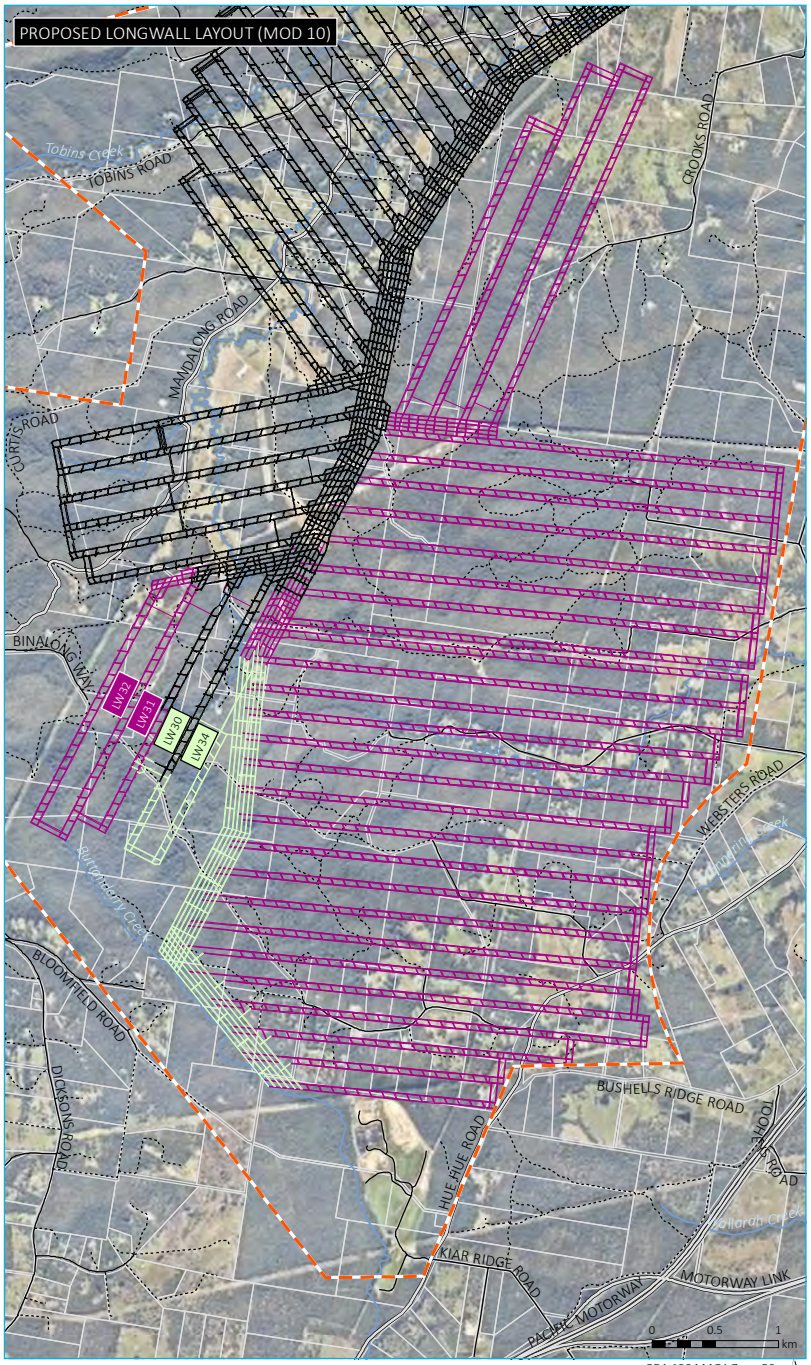
Should you have any queries or require any further information regarding this modification please contact me by phone on 0407 207 530 or email james.wearne@centennialcoal.com.au.

Yours sincerely



James Wearne
Group Manager Approvals/Environment







KEY

- Development consent boundary
- Proposed amendments
- Approved workings
- Completed mine workings
- Main road
- Minor road
- Vehicular track
- Named watercourse
- Cadastral boundary

\\emmsvr1\centennial coal\21\0436 - Mandalong Mine - Mod 10\GIS\02 Maps\G001 ProposedLongwallExtension 20210601 03.mxd 9/06/2021

Source: EMM (2021); NearMap (2021): Centennial (2021); DFSI (2017); GA (2011)

GDA 1994 MGA Zone 56

N

Proposed amendments to the underground mine layout at Mandalong Mine

Mandalong Mine Modification 10
Figure 3.1

EMM
creating opportunities

16 August 2021

Crown Land – Department of Planning, Industry and Environment
PO Box 2155
Dangar NSW 2309
Via email: cl.enquiries@crownland.nsw.gov.au

RE: Centennial Mandalong SSD-5144 Modification 10

Mandalong Mine is an existing underground coal mine near Morisset, approximately 35 kilometres south-west of Newcastle in the Lake Macquarie and Central Coast local government areas. The mine is operated by Centennial Mandalong Pty Limited (Centennial Mandalong) and is approved to operate an underground longwall mine in addition to supporting surface infrastructure.

In 2010, an exploration drilling program over an area referred to as the Mandalong Southern Extension Area identified additional economic coal reserves ideally suited for electricity generation. Subsequently, Centennial Mandalong sought consent for the Mandalong Southern Extension Project to extract these reserves. This project was approved under State significant development (SSD) consent SSD-5144 in October 2015 by the NSW Planning Assessment Commission.

The progression of underground mining is regularly reviewed and is dependent on ongoing monitoring and geological conditions. Since the approval of MOD 9 in April 2021, Centennial Mandalong has continued to review the progression of underground mining within the Mandalong Southern Extension Area. As a result of these investigations, the decision has been made to shorten LW30 and remove LW33 from the mine plan. The shortening of LW30 and removal of LW33 are estimated to result in the sterilisation of approximately 0.4 million tonnes (Mt) and 1.6 Mt of coal, respectively. Consequently, Centennial Mandalong has explored options to optimise the mine plan to access additional coal resources within existing lease and approval boundaries.

Centennial Mandalong is seeking to modify (Mod 10) SSD-5144, pursuant to Section 4.55(2) of the *Environmental Planning & Assessment Act 1979* (EP&A Act), to change Mandalong's approved mine plan to include LW34 (refer attached figure). The addition of LW34 will maximise resource extraction within the West Wallarah Seam and Mandalong's development consent boundary and improve the continuity of coal extraction and employment at Mandalong. Two updates to Appendix 8 of SSD-5144 are also proposed to:

- Allow for greater flexibility when exploration drilling activities are undertaken on total fire ban days.
- Change the way Mandalong's annual contributions are distributed to the local community.

This letter has been prepared to inform Crown Land of the proposed modification to Mandalong Mine's development consent (SSD-5144).

The revised mine design has been developed to ensure no greater impacts will occur than those presently approved under SSD-5144 as a result of mine subsidence and subsequent impacts on the built and natural surface environment.

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A preliminary subsidence assessment undertaken as part of Mandalong Mine's redesign process has determined that predicted subsidence effects for the proposed longwall layout are similar to the predicted subsidence effects that were approved as part of the original Mandalong Southern Extension Project. There are two public unsealed Crown roads (Toepfers Road and Kiar Ridge Road) present within the LW34 area. The roads are unsealed with reinforced concrete pipe culverts at watercourse crossings. The predicted subsidence effects and impacts due to the proposed LW34 are consistent with previous assessments. Current impact management strategies will remain unchanged.

A Modification Report, including relevant technical specialist assessments, will be prepared to support Centennial Mandalong's application to modify SSD-5144 for these changes to the approved mine plan. The technical specialist assessments will assess the impacts associated with the revised design and contrast them against those currently approved for review and assessment by the Department of Planning, Industry and Environment (DPIE) in consultation with key government agencies and stakeholders.

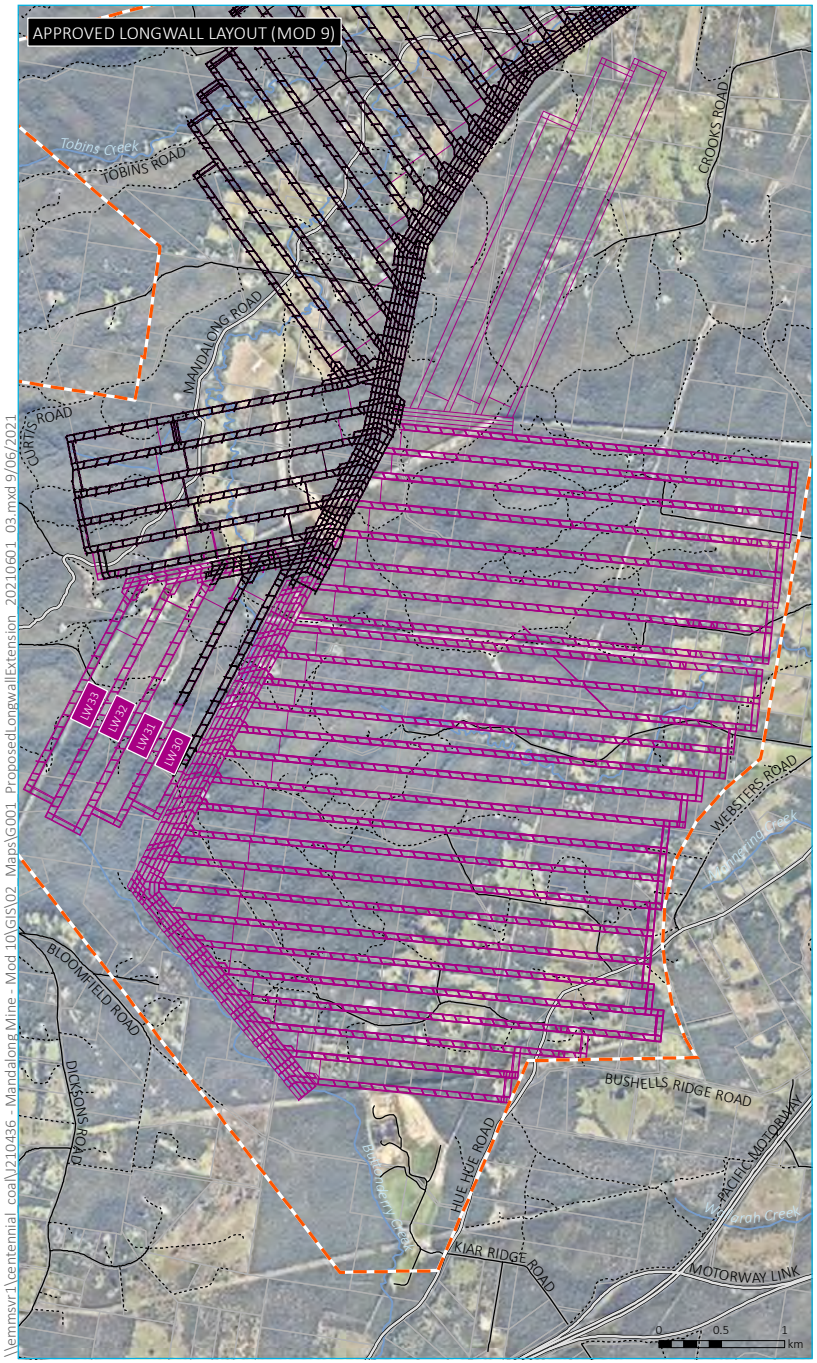
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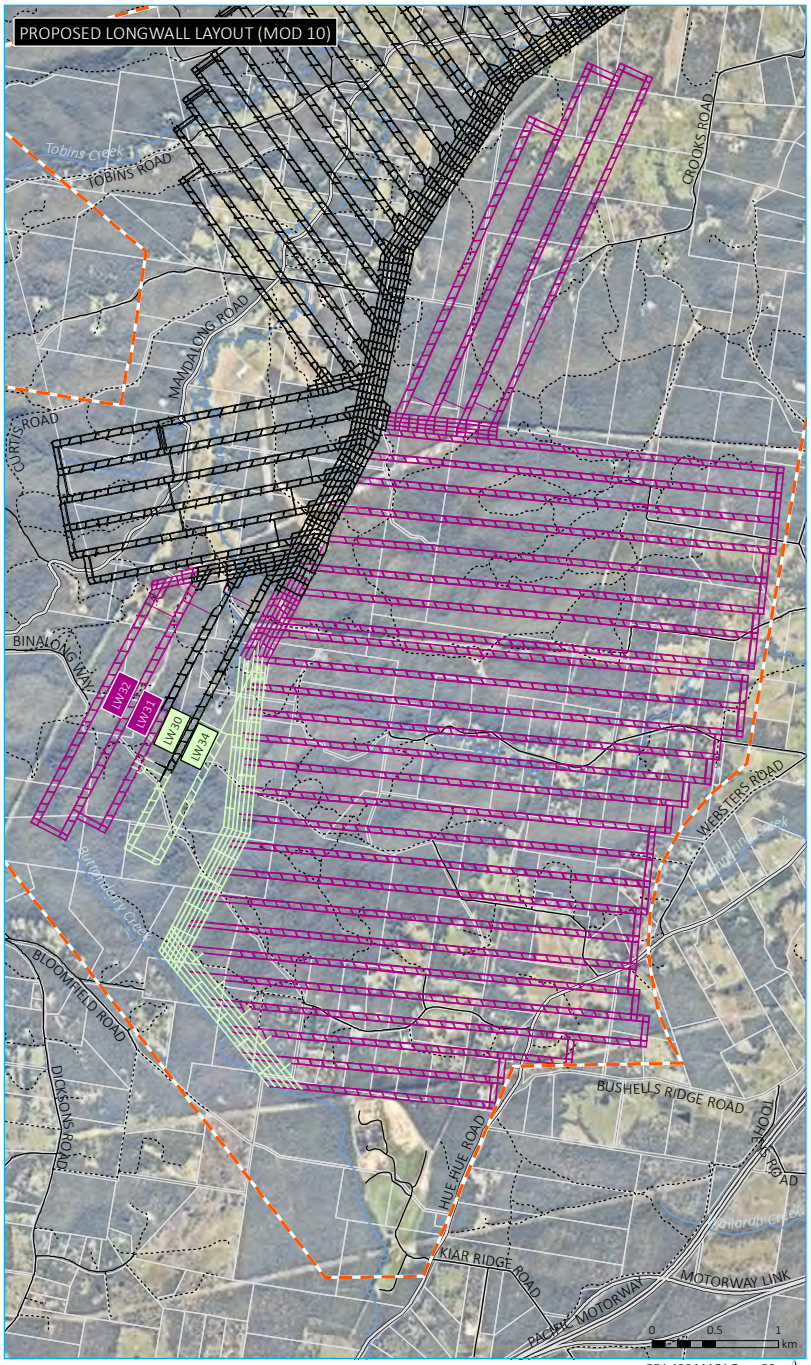
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Yours sincerely



James Wearne
Group Manager Approvals/Environment







KEY

- Development consent boundary
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\\emmsvr1\centennial coal\21\0436 - Mandalong Mine - Mod 10\GIS\02 Maps\G001 ProposedLongwallExtension 20210601 03.mxd 9/06/2021

Source: EMM (2021); NearMap (2021): Centennial (2021); DFSI (2017); GA (2011)

GDA 1994 MGA Zone 56

N

Proposed amendments to the underground mine layout at Mandalong Mine

Mandalong Mine Modification 10
Figure 3.1

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16 August 2021

NSW Rural Fire Service
Via email: central.coast@rfs.nsw.gov.au

RE: Centennial Mandalong SSD-5144 Modification 10

Mandalong Mine is an existing underground coal mine near Morisset, approximately 35 kilometres south-west of Newcastle in the Lake Macquarie and Central Coast local government areas. The mine is operated by Centennial Mandalong Pty Limited (Centennial Mandalong) and is approved to operate an underground longwall mine in addition to supporting surface infrastructure.

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The progression of underground mining is regularly reviewed and is dependent on ongoing monitoring and geological conditions. Since the approval of MOD 9 in April 2021, Centennial Mandalong has continued to review the progression of underground mining within the Mandalong Southern Extension Area. As a result of these investigations, the decision has been made to shorten LW30 and remove LW33 from the mine plan. The shortening of LW30 and removal of LW33 are estimated to result in the sterilisation of approximately 0.4 million tonnes (Mt) and 1.6 Mt of coal, respectively. Consequently, Centennial Mandalong has explored options to optimise the mine plan to access additional coal resources within existing lease and approval boundaries.

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- Allow for greater flexibility when exploration drilling activities are undertaken on total fire ban days. On Total fire ban days, a structured assessment of the risk of either igniting or becoming impacted by a fire will be completed by all exploration workers prior to commencing work on that day. The findings of the risk assessment will identify the risk of working along with the required additional controls and mitigation actions.

- Change the way Mandalong's annual contributions are distributed to the local community.

This letter has been prepared to inform the NSW Rural Fire Service (RFS) of the proposed modification to Mandalong Mine's development consent (SSD-5144).

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The revised mine design has been developed to ensure no greater impacts will occur than those presently approved under SSD-5144 as a result of mine subsidence and subsequent impacts on the built and natural surface environment.

A preliminary subsidence assessment undertaken as part of Mandalong Mine's redesign process has determined that predicted subsidence effects for the proposed longwall layout are similar to the predicted subsidence effects that were approved as part of the original Mandalong Southern Extension Project.

A Modification Report, including relevant technical specialist assessments, will be prepared to support Centennial Mandalong's application to modify SSD-5144 for these changes to the approved mine plan. The technical specialist assessments will assess the impacts associated with the revised design and contrast them against those currently approved for review and assessment by the Department of Planning, Industry and Environment (DPIE) in consultation with key government agencies.

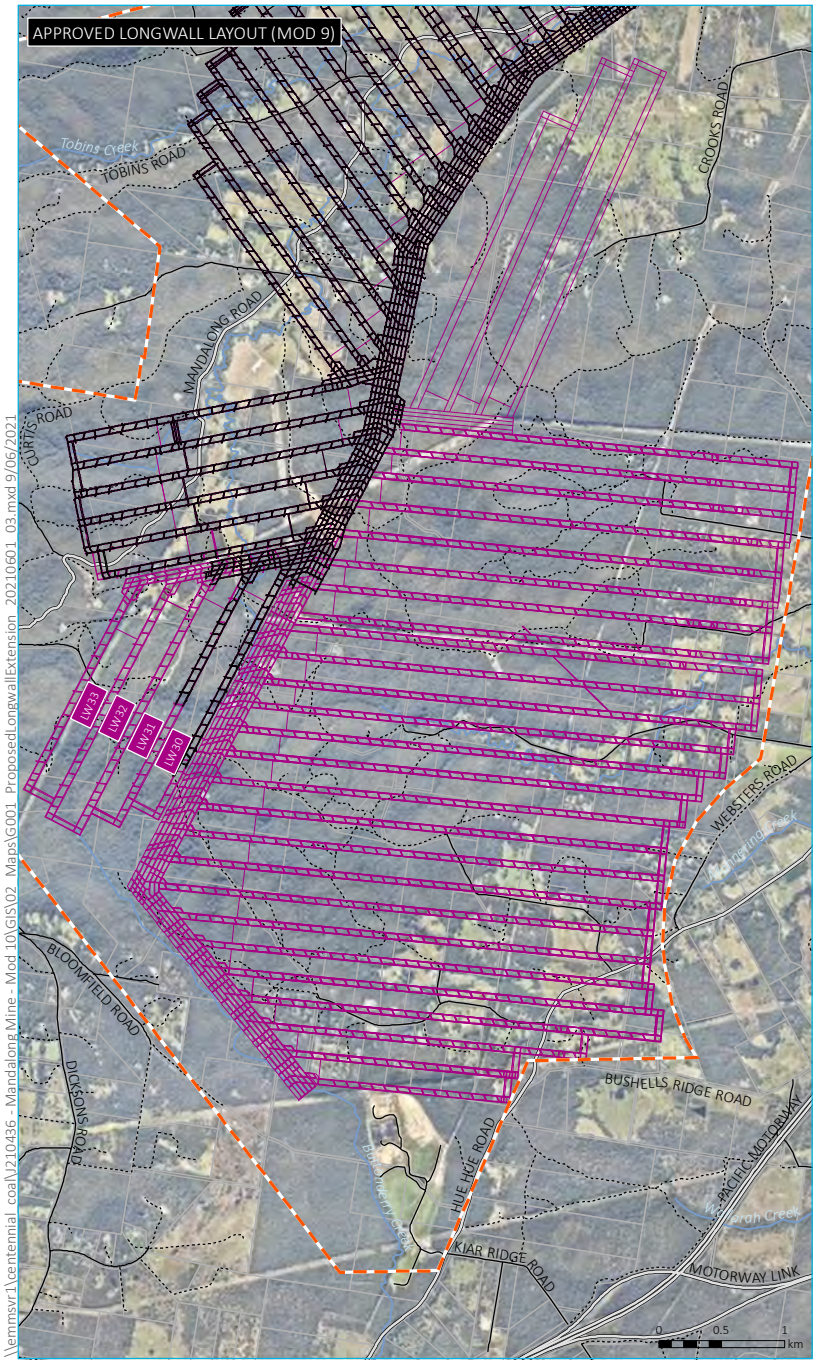
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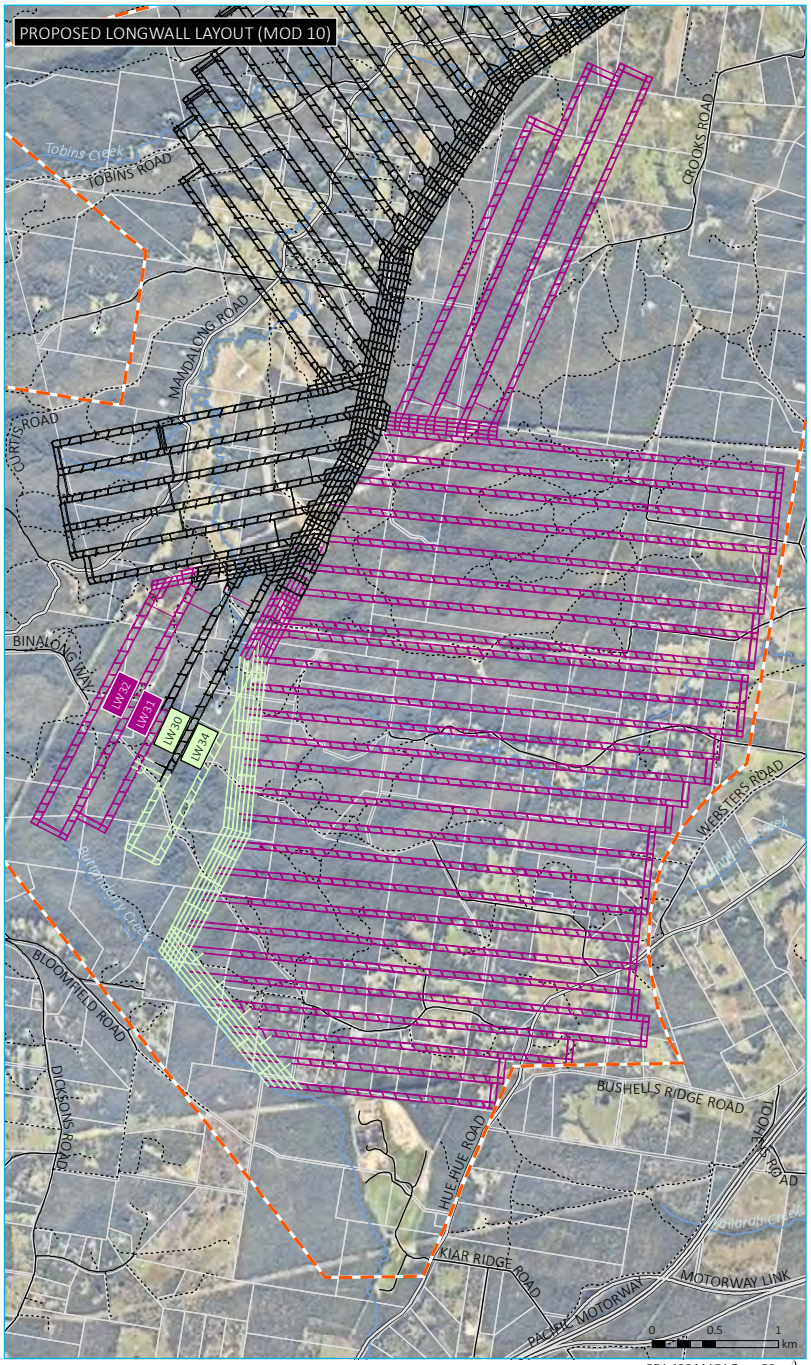
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Yours sincerely



James Wearne
Group Manager Approvals/Environment







KEY

- Development consent boundary
- Proposed amendments
- Approved workings
- Completed mine workings
- Main road
- Minor road
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\\emmsvr1\centennial coal\21\0436 - Mandalong Mine - Mod 10\GIS\02 Maps\G001 ProposedLongwallExtension 20210601 03.mxd 9/06/2021

Source: EMM (2021); NearMap (2021): Centennial (2021); DFSI (2017); GA (2011)

GDA 1994 MGA Zone 56

N

Proposed amendments to the underground mine layout at Mandalong Mine

Mandalong Mine Modification 10
Figure 3.1

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creating opportunities

16 August 2021

Subsidence Advisory NSW
PO Box 488G
Newcastle NSW 2300
Via email: subsidenceadvisory@customerservice.nsw.gov.au

RE: Centennial Mandalong SSD-5144 Modification 10

Mandalong Mine is an existing underground coal mine near Morisset, approximately 35 kilometres south-west of Newcastle in the Lake Macquarie and Central Coast local government areas. The mine is operated by Centennial Mandalong Pty Limited (Centennial Mandalong) and is approved to operate an underground longwall mine in addition to supporting surface infrastructure.

In 2010, an exploration drilling program over an area referred to as the Mandalong Southern Extension Area identified additional economic coal reserves ideally suited for electricity generation. Subsequently, Centennial Mandalong sought consent for the Mandalong Southern Extension Project to extract these reserves. This project was approved under State significant development (SSD) consent SSD-5144 in October 2015 by the NSW Planning Assessment Commission.

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- Allow for greater flexibility when exploration drilling activities are undertaken on total fire ban days.
- Change the way Mandalong's annual contributions are distributed to the local community.

This letter has been prepared to inform Subsidence Advisory NSW (SA NSW) of the proposed modification to Mandalong Mine's development consent (SSD-5144).

The revised mine design has been developed to ensure no greater impacts will occur than those presently approved under SSD-5144 as a result of mine subsidence and subsequent impacts on the built and natural surface environment.

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A preliminary subsidence assessment undertaken as part of Mandalong Mine's redesign process has determined that predicted subsidence effects for the proposed longwall layout are similar to the predicted subsidence effects that were approved as part of the original Mandalong Southern Extension Project.

A Modification Report, including relevant technical specialist assessments, will be prepared to support Centennial Mandalong's application to modify SSD-5144 for these changes to the approved mine plan. The technical specialist assessments will assess the impacts associated with the revised design and contrast them against those currently approved for review and assessment by the Department of Planning, Industry and Environment (DPIE) in consultation with key government agencies.

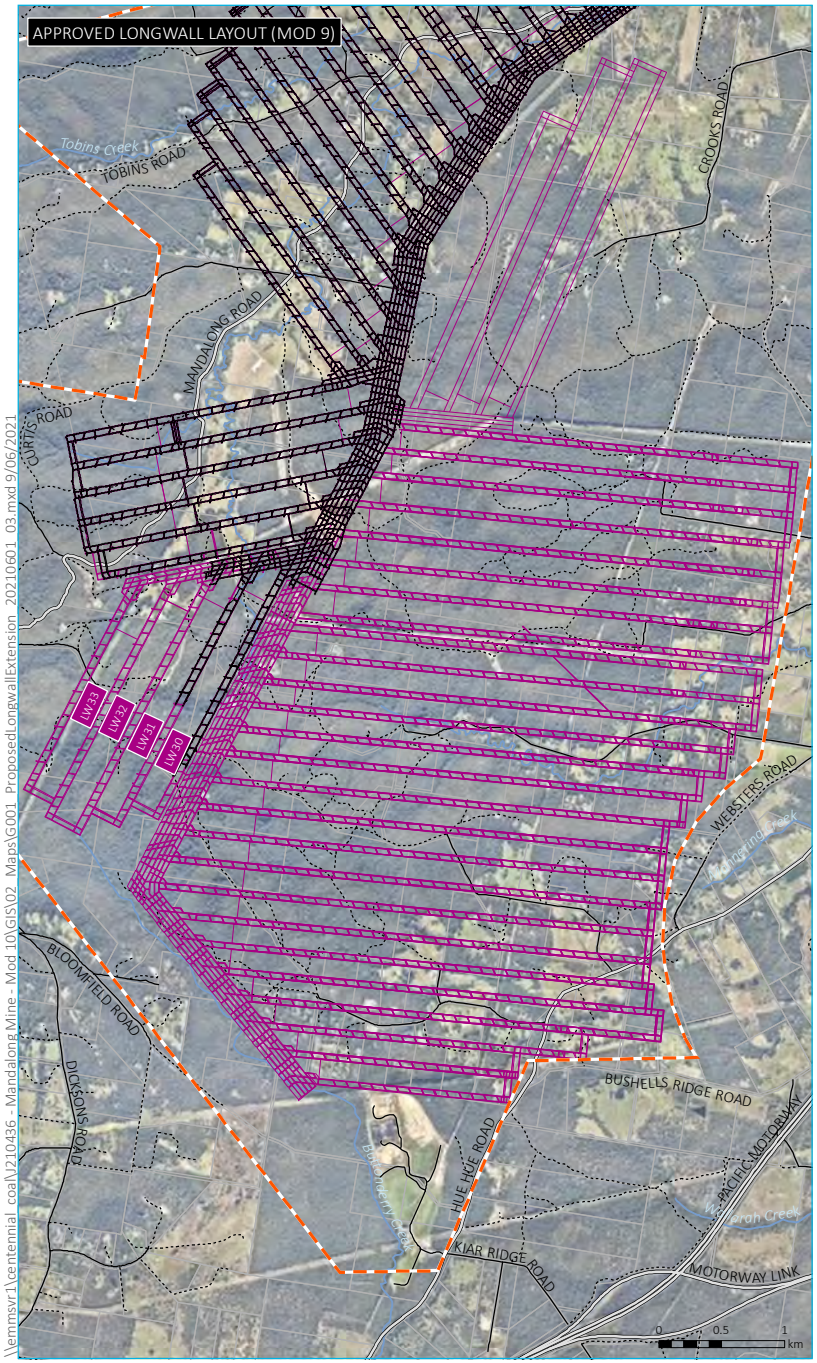
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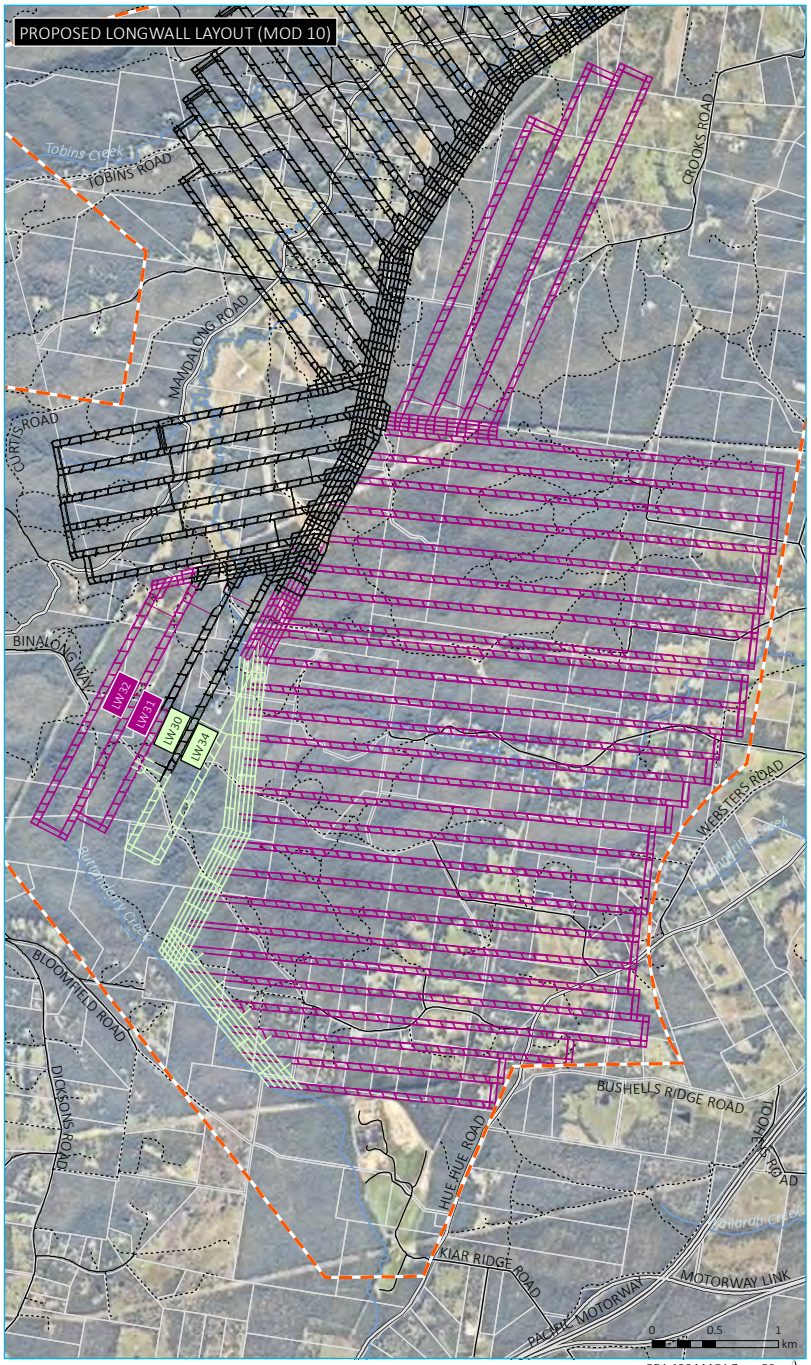
Should you have any queries or require any further information regarding this modification please contact me by phone on 0407 207 530 or email james.wearne@centennialcoal.com.au.

Yours sincerely



James Wearne
Group Manager Approvals/Environment







KEY

- Development consent boundary
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\\emmsvr1\centennial coal\21\0436 - Mandalong Mine - Mod 10\GIS\02 Maps\G001 ProposedLongwallExtension 20210601 03.mxd 9/06/2021

Source: EMM (2021); NearMap (2021): Centennial (2021); DFSI (2017); GA (2011)

GDA 1994 MGA Zone 56

N

Proposed amendments to the underground mine layout at Mandalong Mine

Mandalong Mine Modification 10
Figure 3.1

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16 August 2021

Scott Mallyon
Manager, Forest Occupancy and Materials
Forestry Corporation of NSW
PO Box 168
Wauchope NSW 2446
Via email: scott.mallyon@fcnsw.com.au

RE: Centennial Mandalong SSD-5144 Modification 10

Mandalong Mine is an existing underground coal mine near Morisset, approximately 35 kilometres south-west of Newcastle in the Lake Macquarie and Central Coast local government areas. The mine is operated by Centennial Mandalong Pty Limited (Centennial Mandalong) and is approved to operate an underground longwall mine in addition to supporting surface infrastructure.

In 2010, an exploration drilling program over an area referred to as the Mandalong Southern Extension Area identified additional economic coal reserves ideally suited for electricity generation. Subsequently, Centennial Mandalong sought consent for the Mandalong Southern Extension Project to extract these reserves. This project was approved under State significant development (SSD) consent SSD-5144 in October 2015 by the NSW Planning Assessment Commission.

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- Allow for greater flexibility when exploration drilling activities are undertaken on total fire ban days.
- Change the way Mandalong's annual contributions are distributed to the local community.

This letter has been prepared to inform Forestry Corporation of NSW (FCNSW) of the proposed modification to Mandalong Mine's development consent (SSD-5144).

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The revised mine design has been developed to ensure no greater impacts will occur than those presently approved under SSD-5144 as a result of mine subsidence and subsequent impacts on the built and natural surface environment.

A preliminary subsidence assessment undertaken as part of Mandalong Mine's redesign process has determined that predicted subsidence effects for the proposed longwall layout are similar to the predicted subsidence effects that were approved as part of the original Mandalong Southern Extension Project.

A Modification Report, including relevant technical specialist assessments, will be prepared to support Centennial Mandalong's application to modify SSD-5144 for these changes to the approved mine plan. The technical specialist assessments will assess the impacts associated with the revised design and contrast them against those currently approved for review and assessment by the Department of Planning, Industry and Environment (DPIE) in consultation with key government agencies.

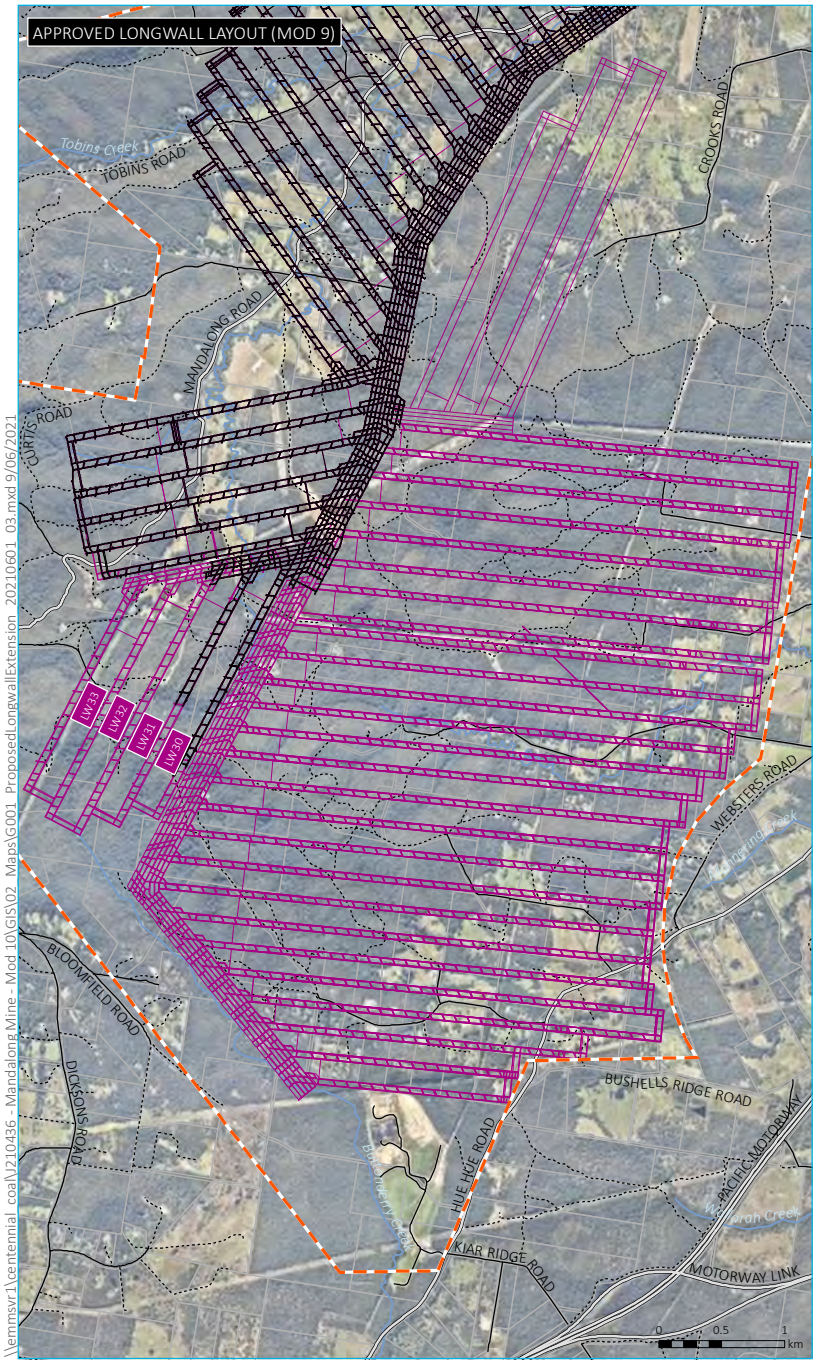
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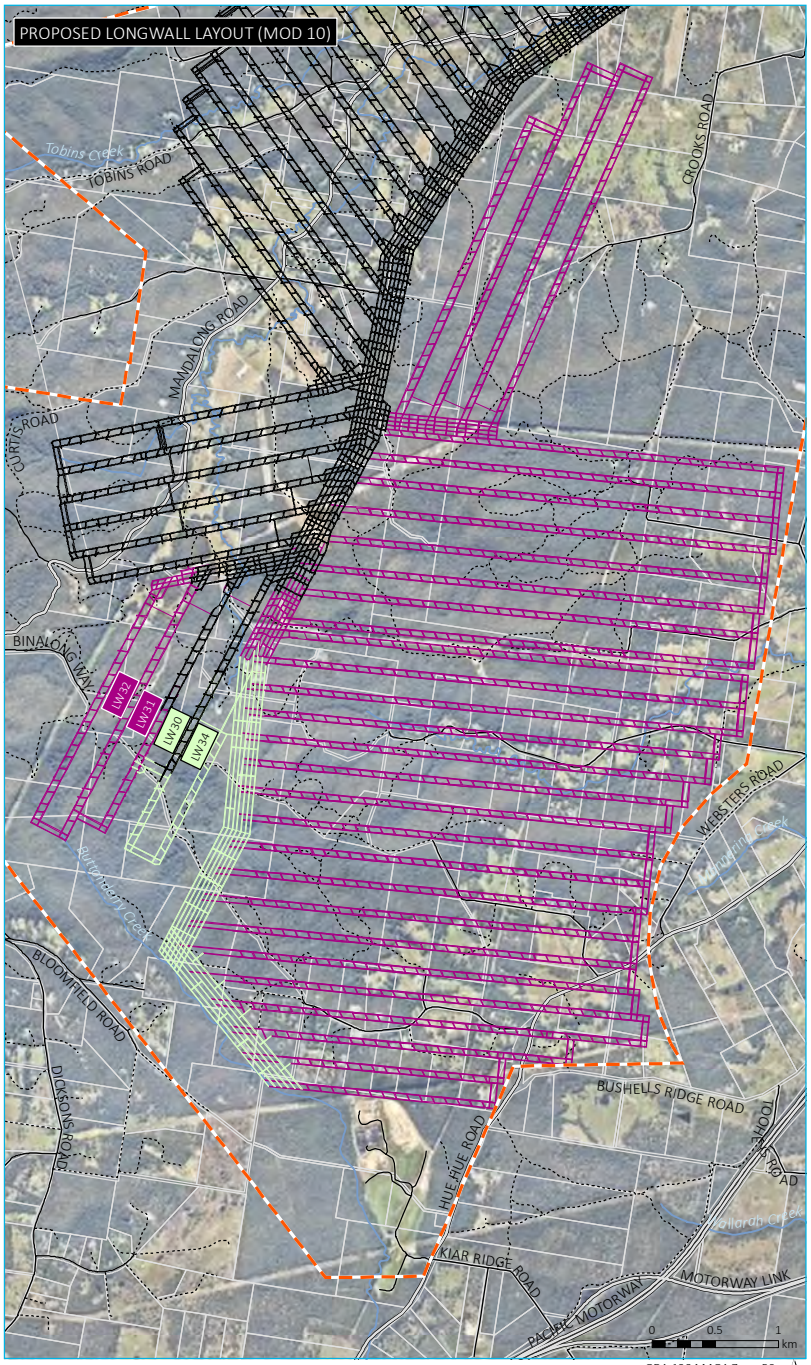
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Yours sincerely



James Wearne
Group Manager Approvals/Environment







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Source: EMM (2021); NearMap (2021): Centennial (2021); DFSI (2017); GA (2011)

GDA 1994 MGA Zone 56

N

Proposed amendments to the underground mine layout at Mandalong Mine

Mandalong Mine Modification 10
Figure 3.1

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16 August 2021

Mark Schneider
Network Integrity – Project Specialist
Telstra
Via email: mark.p.schneider@team.telstra.com

Dear Mark,

RE: Centennial Mandalong SSD-5144 Modification 10

Mandalong Mine is an existing underground coal mine near Morisset, approximately 35 kilometres south-west of Newcastle in the Lake Macquarie and Central Coast local government areas. The mine is operated by Centennial Mandalong Pty Limited (Centennial Mandalong) and is approved to operate an underground longwall mine in addition to supporting surface infrastructure.

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- Change the way Mandalong's annual contributions are distributed to the local community.

This letter has been prepared to inform Telstra of the proposed modification to Mandalong Mine's development consent (SSD-5144).

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The revised mine design has been developed to ensure no greater impacts will occur than those presently approved under SSD-5144 as a result of mine subsidence and subsequent impacts on the built and natural surface environment.

A preliminary subsidence assessment undertaken as part of Mandalong Mine's redesign process has determined that predicted subsidence effects for the proposed longwall layout are similar to the predicted subsidence effects that were approved as part of the original Mandalong Southern Extension Project.

Telstra have infrastructure throughout the Project Area and are likely to tolerate the predicted subsidence effects without remediation works. Mandalong Mine currently has an effective Communications Management Plan, which is revised for each Extraction Plan. This plan outlines the expected impacts, inspection regimes and potential or proposed mitigation measures.

A Modification Report, including relevant technical specialist assessments, will be prepared to support Centennial Mandalong's application to modify SSD-5144 for these changes to the approved mine plan. The technical specialist assessments will assess the impacts associated with the revised design and contrast them against those currently approved for review and assessment by the Department of Planning, Industry and Environment (DPIE) in consultation with key government agencies.

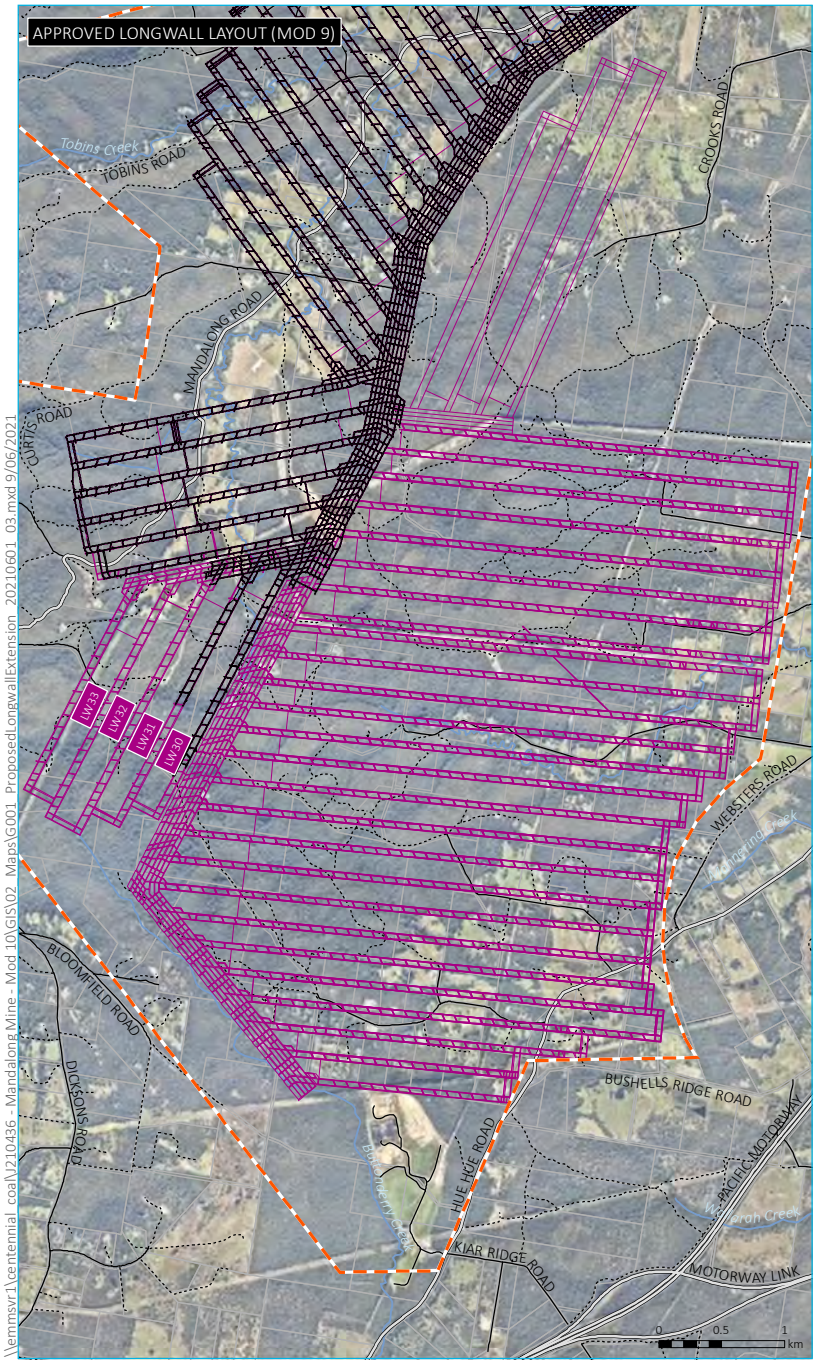
In summary, Mandalong Mine is seeking approval for a revised mine design to include LW34 and optimise the current mining area due to resource areas lost due to poor geological conditions. The revised mine design will remain within the currently assessed and approved footprint and is expected to have negligible impacts beyond those currently approved. This letter aims to provide Telstra with an overview of the modification prior to lodgment of the Modification Report with DPIE. It is anticipated that DPIE will engage with Telstra as part of the public exhibition and assessment process once the Modification Report is lodged.

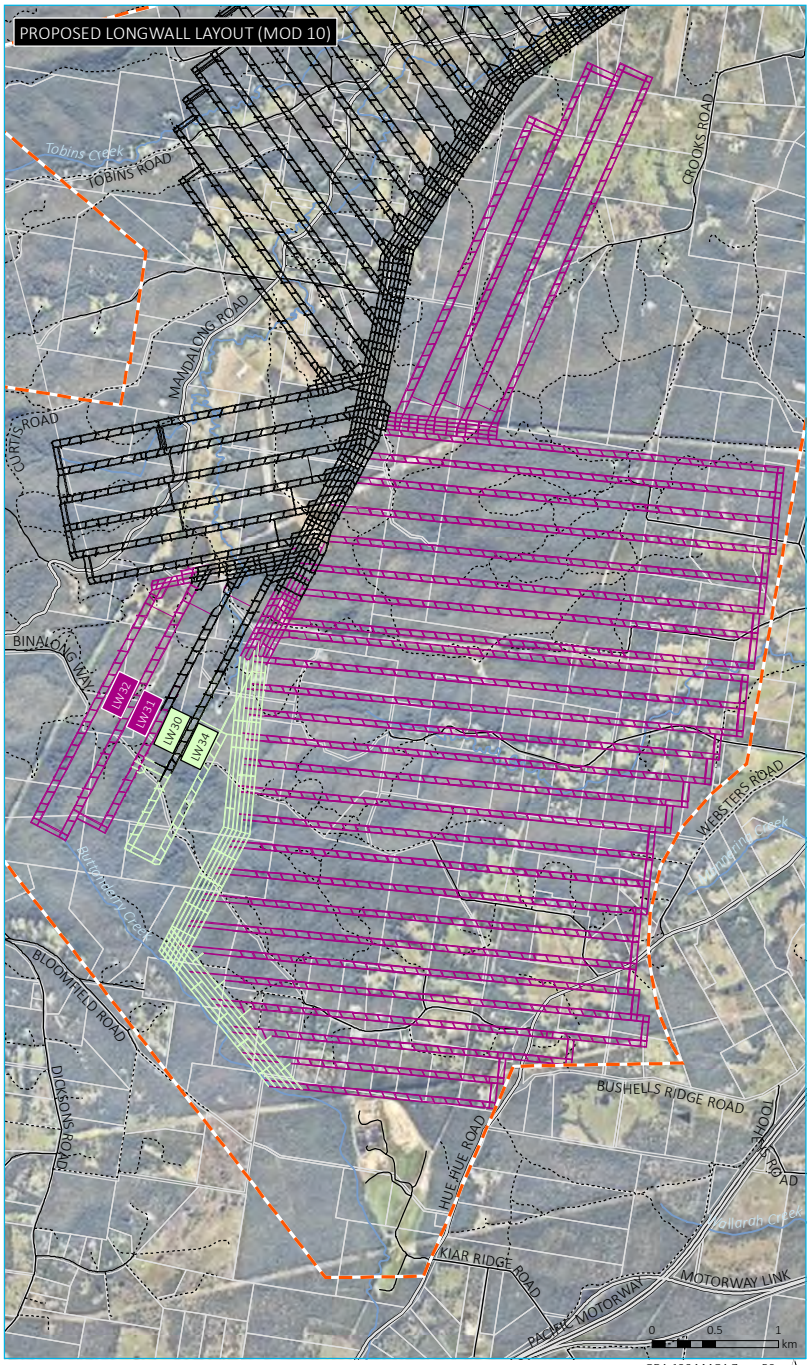
Should you have any queries or require any further information regarding this modification please contact me by phone on 0407 207 530 or email james.wearne@centennialcoal.com.au.

Yours sincerely



James Wearne
Group Manager Approvals/Environment







KEY

- Development consent boundary
- Proposed amendments
- Approved workings
- Completed mine workings
- Main road
- Minor road
- Vehicular track
- Named watercourse
- Cadastral boundary

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Source: EMM (2021); NearMap (2021): Centennial (2021); DFSI (2017); GA (2011)

GDA 1994 MGA Zone 56

N

Proposed amendments to the underground mine layout at Mandalong Mine

Mandalong Mine Modification 10
Figure 3.1

EMM
creating opportunities







