Appendix H Groundwater Dependent Ecosystem Assessment

Xenith Consulting Pty Ltd on behalf of
Boggabri Coal Operations Pty Ltd

May 2025

Boggabri Coal Mine Modification 10

Groundwater Dependent Ecosystem Assessment



Question today
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Boggabri Coal Mine Modification 10
Groundwater Dependent Ecosystem Assessment

Xenith Consulting Pty Ltd on behalf of Boggabri Coal Operations Pty Ltd

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WSP acknowledges that every project we work on takes place on First Peoples lands.
We recognise Aboriginal and Torres Strait Islander Peoples as the first scientists and engineers and pay our respects to Elders past and present.

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Appendix A EPBC Act Assessment of Significance

Glossary

Avoid	Measures taken by a proponent such as careful site selection or actions taken through the design, planning, construction, and operational phases of the development to completely avoid impacts on biodiversity values, or certain areas of biodiversity.
Biodiversity offsets	Management actions that are undertaken to achieve a gain in biodiversity values on areas of land to compensate for losses to biodiversity values from the impacts of development.
Biodiversity value	Are the following values: — vegetation integrity – being the degree to which the composition, structure, and function of vegetation at a particular site and the surrounding landscape has been altered from a near natural state. — habitat suitability – being the degree to which the habitat needs of threatened species are present at a particular site. — biodiversity values, or biodiversity-related values, prescribed by the regulations.
Groundwater	Water found in the subsurface in the saturated zone below the water table or piezometric surface, i.e., the water table marks the upper surface of groundwater systems.
Hollow bearing tree	A living or dead tree that has at least one hollow. A tree is considered to contain a hollow if: (a) the entrance can be seen; (b) the entrance width is at least 5 cm; (c) the hollow appears to have depth (i.e., you cannot see solid wood beyond the entrance); (d) the hollow is at least 1 m above the ground. Trees must be examined from all angles.
IBRA region	A bioregion identified under the Interim Biogeographic Regionalisation for Australia (IBRA) system, which divides Australia into bioregions based on their dominant landscape-scale attributes.
IBRA subregion	A subregion of a bioregion identified under the IBRA system.
Indirect impact	An impact on biodiversity values that occurs when development related activities affect threatened species, threatened species habitat, or ecological communities in a manner other than direct impact. Compared to direct impacts, indirect impacts often: — occur over a wider area than just the site of the development — have a lower intensity of impact in the extent to which they occur compared to direct impacts — occur off site — have a lower predictability of when the impact occurs — have unclear boundaries of responsibility.
Minimise	A process applied throughout the development planning and design life cycle which seeks to reduce the residual impacts of the proposal on biodiversity values.
Mitchell landscape	Landscapes with relatively homogeneous geomorphology, soils, and broad vegetation types, mapped at a scale of 1:250,000.
Mitigation	Action to reduce the severity of an impact.
Mitigation measure	Any measure that facilitates the safe movement of wildlife and/or prevents wildlife mortality.

Native vegetation	Means any of the following types of plants native to NSW: — trees (including any sapling or shrub or any scrub) — understorey plants — groundcover (being any type of herbaceous vegetation) — plants occurring in a wetland
PCT classification system	The system of classifying native vegetation approved by the NSW Plant Community Type Control Panel and described in the BioNet Vegetation Classification.
Plant community type	A NSW Plant Community Type (PCT) identified using the BioNet Vegetation Classification system.
Population	A group of organisms, all the same species, occupying a particular area.
Threatened ecological community	Means a critically endangered ecological community, an endangered ecological community or a vulnerable ecological community listed in Schedule 2 of the BC Act.
Threatened species	Critically endangered, endangered, or vulnerable threatened species as defined by Schedule 1 of the BC Act, or any additional threatened species listed under Part 13 of the EPBC Act as critically endangered, endangered, or vulnerable.
Vegetation class	A level of classification of vegetation communities defined in Keith (2004). There are 99 vegetation classes in NSW.
Vegetation formation	A broad level of vegetation classification as defined in Keith (2004). There are 16 vegetation formations and sub-formations in NSW.
Vegetation integrity	The condition of native vegetation assessed for each vegetation zone against the benchmark for the PCT.
Vegetation type	A NSW PCT
Vegetation zone	A relatively homogenous area of native vegetation that is the same PCT and broad condition state.

Abbreviations

AGE	Australasian Groundwater & Environmental Consultants Pty Ltd
AWS	Automatic Weather Station
BAM	Biodiversity Assessment Methodology
BC Regulation	Biodiversity Conservation Regulation 2017 (NSW)
BC Act	*Biodiversity Conservation Act 2016* (NSW)
BCM	Boggabri Coal Mine
BCOPL	Boggabri Coal Operations Pty Ltd
BDAR	Biodiversity Development Assessment Report
BGL	Below Ground Level
BOA	Biodiversity Offset Area
BTM Complex	Boggabri, Tarrawonga, Maules Creek Complex
DCCEEW	Commonwealth Department of Climate Change, Energy, the Environment and Water
DPHI	NSW Department of Planning, Housing and Infrastructure
DPIE	The former NSW Department of Planning, Industry and Environment
EEC	Endangered Ecological Community
EP&A Act	*Environmental Planning and Assessment Act 1979* (NSW)
EP&A Regulation	Environmental Planning and Assessment Regulation 2021 (NSW)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
GDE	Groundwater Dependent Ecosystem
GMP	Boggabri Coal Mine Groundwater Management Plan
IA	Idemitsu Australia
IBRA	Interim Biogeographic Regionalisation for Australia
IESC	Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development
LGA	Local Government Area
MBGL	Metres below ground level
MCCM	Maules Creek Coal Mine
MNES	Matters of National Significance
MOD	Modification
Mtpa	Million tonnes per annum

NDVI	Normalised Difference Vegetation Index
OWS	Office of Water and Science
PA	Project Approval granted under the former Part 3A of the EP&A Act
PBGW	Poplar Box Grassy Woodland on Alluvial Plains
PCT	Plant Community Type
ROM	Run of Mine
SAVI	Soil-Adjusted Vegetation Index
SEARs	Secretary's Environmental Assessment Requirements
SSD	State Significant Development
SWMP	Boggabri Coal Mine Surface Water Management Plan
TCM	Tarrawonga Coal Mine
TEC	Threatened Ecological Community
WA Act	*Water Act 2007*
WMP	Boggabri Coal Mine Water Management Plan
WMS	Boggabri–Tarrawonga–Maules Creek Complex Water Management Strategy

1 Introduction

1.1 Project background

Boggabri Coal Operations Pty Ltd (BCOPL) operates the Boggabri Coal Mine (BCM) on behalf of the joint venture participants. The BCM is an open cut mine located approximately 15 kilometres (km) north-east of the township of Boggabri in the North West Region of NSW, wholly within the Narrabri Local Government Area. BCM operates within the Leard Forest Mining Precinct and is immediately adjacent to the Tarrawonga Coal Mine (TCM) in the south and Maules Creek Coal Mine (MCCM) to the north. This mining precinct is referred to as the Boggabri, Tarrawonga, Maules Creek Complex (BTM Complex).

The BCM has operated since 2006 and currently operates in accordance with Project Approval PA 09_0182 (now known as State Significant Development (SSD) 09_0182), which was originally granted for the continuation of operations at the BCM on 18 July 2012 under the former Part 3A of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). The BCM operations are also undertaken pursuant to the approvals under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act); EPBC 2009/5256 and EPBC 2021/8875, granted on 11 February 2013 and 19 December 2024 respectively. SSD 09_0182 has been modified on nine occasions to date.

1.2 Modification description

BCM (on behalf of the joint venture participants) is seeking to modify its approved mining operations at BCM to recover known coal resources within the approved BCM Project Boundary and to extend mining to the northwest beyond the approved Mine Disturbance Boundary. This will entail the recovery of an additional 30 Million tonnes (Mt) of Run of Mine (ROM) coal down to the base of the Templemore Coal Seam (MOD 10). If approved this will extend the approved life of the BCM from 2036 to 2040.

1.3 Secretary's environmental assessment requirements

The Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW) has determined that referred aspects of MOD 10 (subject to EPBC Referral 2024/9887) would be a controlled action under section 75 of the EPBC Act. The EPBC Act controlling provision for MOD 10 are:

- Listed threatened species and communities (sections 18 and 18A); and
- A water resource, in relation to unconventional gas development and large coal mining development (sections 24D and 24E).

As MOD 10 is being assessed by the NSW Government, the assessment will be undertaken in accordance with the bilateral agreement between the Commonwealth Government and NSW Government. On 27 September 2024, Secretary's Environmental Assessment Requirements (SEARs) were issued by the NSW Department of Planning, Housing and Infrastructure (DPHI) to ensure that Commonwealth matters are appropriately addressed within the MOD 10 application. DPHI has requested the Modification Report address SEARs and provide suitable information to be presented to the Independent Expert Scientific Committee (IESC).

Table 1.1 outlines the SEARs for Matters of National Environmental Significance (MNES) listed under the EPBC Act.

Table 1.1 MOD 10 Environmental assessment requirements (EPBC 2024/9887)

Requested Information	Section within this report
Listed threatened species and communities — Regent Honeyeater — Swift Parrot — Corben's Long-eared Bat — Koala	Biodiversity Development Assessment Report (Appendix G of the Modification Report)
An assessment of changes to groundwater and surface water	Groundwater Impact Assessment (Appendix I of the Modification Report) Surface Water Impact Assessment (Appendix J of the Modification Report) Section 3 to Section 6 of this report, specifically in relation to terrestrial Groundwater Dependent Ecosystems (GDE)

In anticipation of the IESC review of the MOD 10 Groundwater Impact Assessment (Australasian Groundwater & Environmental Consultants Pty Ltd, 2025), this report specifically assesses the portion of the alluvial aquifer area which was expected to be impacted by incremental groundwater drawdown in as a result of the mine plan changes proposed by MOD 10. The area of interest for understanding the potential for groundwater usage of the remnant vegetation growing on alluvial areas occurs between the existing coal handling infrastructure associated with BCM and Bald Hill to the southwest (Figure 1.2).

1.4 MOD 10 Biodiversity development assessment report

The potential impacts of MOD 10 on biodiversity values within the Modification Disturbance Footprint (otherwise known as the MOD 10 subject land) were considered in the Boggabri Coal Mine Modification 10 Biodiversity Development Assessment Report (BDAR) (WSP, 2025b). The BDAR was prepared in accordance with the Biodiversity Assessment Methodology (BAM) (Department of Planning Industry and Environment, 2020a) and supplementary BAM Operational Manuals – Stage 1 and Stage 2 (Department of Planning Industry and Environment, 2020b) (Department of Planning and Environment, 2023a) and included an assessment of GDEs in the MOD 10 subject land, which is defined as the area of land subject to development or clearing. This Terrestrial GDE Assessment Report was prepared to provide further information regarding potential indirect impacts of MOD 10 to GDEs.

1.5 Regional study area

An approximate 10 km radius from the MOD 10 subject land that incorporates drainage features such as Back Creek, Goonbri Creek and Bollol Creek and the high potential GDEs that they may support (Figure 1.1).

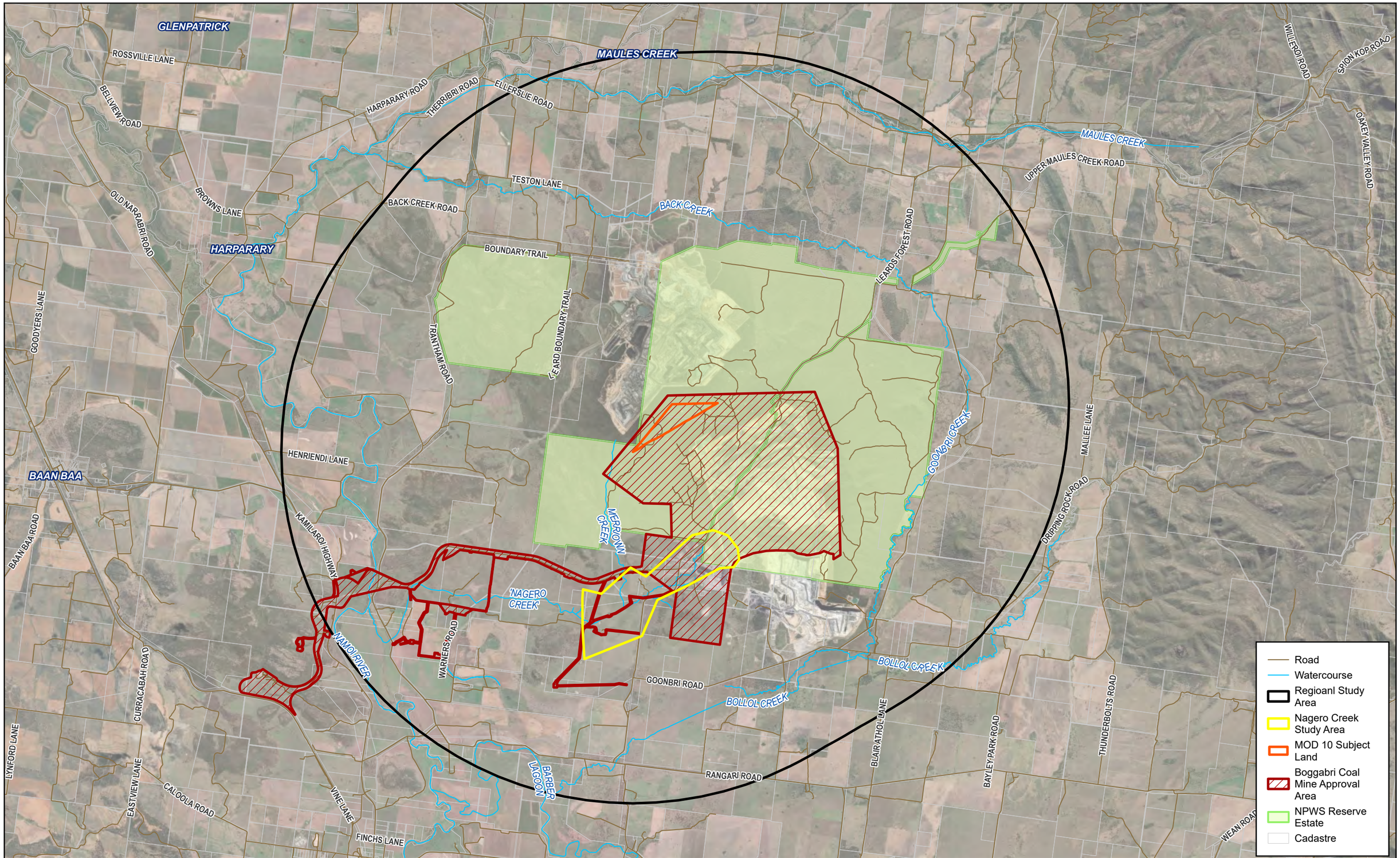
1.6 Nagero Creek study area

An area of interest for understanding the potential for groundwater usage of the remnant vegetation growing on alluvial areas occurring between the existing coal handling infrastructure associated with BCM and Bald Hill to the south-west. The Nagero Creek study area is shown in Figure 1.2.

1.7 Definitions

For this report the following definitions apply:

- **Regional study area** – an approximate 10 km radius from the MOD 10 subject land, incorporating Boggabri, Maules Creek and Tarrawonga Coal Mines, and Back Creek, Goonbri Creek and Bollol Creek (Figure 1.1).
- **Nagero Creek study area** – an area of alluvium to the south-west of and immediately adjacent to BCM where potential groundwater drawdown may be experienced as a result of MOD 10 activities (Figure 1.2).
- **MOD 10 subject land** – the area of additional vegetation disturbance for MOD 10 beyond the approved Mine Disturbance Boundary which was assessed in the BDAR for MOD 10 (Figure 1.1)
- **Project Boundary** – Project Approval (SSD 09_0182) area, which includes the approved activities for the BCM (Figure 1.1).



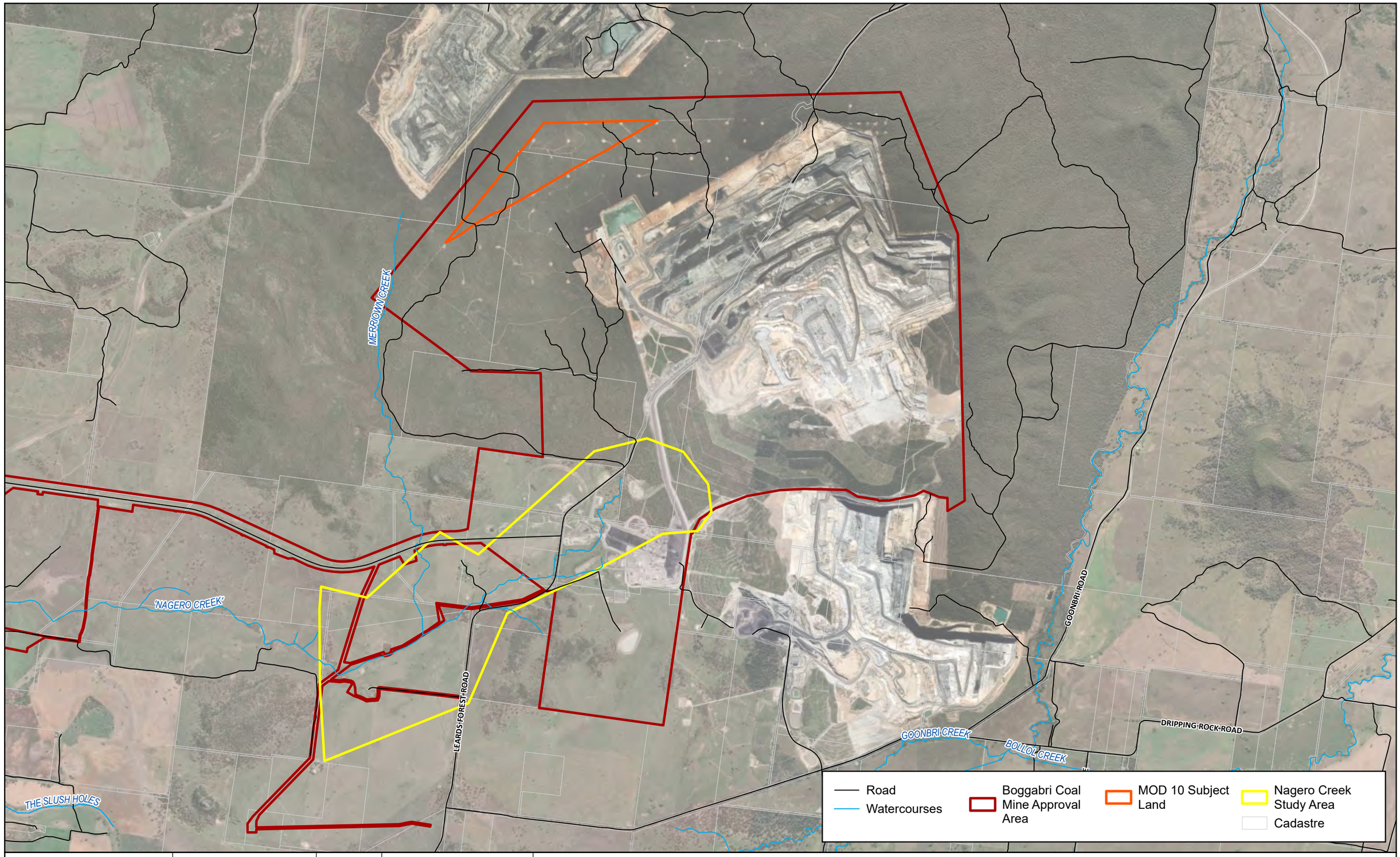
Map: BC2025_F001_1_RegionalStudyArea_r1v3	Author: A.Carrillo		0 1 2 Kilometers 1:100,000 Coordinate system: GDA 1994 MGA Zone 56 Scale ratio correct when printed at A3
Date: 10/04/2025	Approved by: N.Cooper		

Data source: Atlass-Aerometrex Pty Ltd via BCOPL (2017), World_Street_Map: Esri, HERE, Garmin, NGA, USGS
World Imagery: Earthstar Geographics

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Figure 1.1
Regional Study Area



Map: BC2025_F001_2_NageroCkStudyArea_r1v3	Author: A.Carrillo		0 0.5 1 Kilometers 1:40,000 Coordinate system: GDA 1994 MGA Zone 56 Scale ratio correct when printed at A3
Date: 10/04/2025	Approved by: N.Cooper		

Data source: Atlass-Aerometrex Pty Ltd via BCOPL (2017),
World_Street_Map: Esri, HERE, Garmin, NGA, USGS
World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

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BOGGABRI COAL MINE MOD 10 GROUNDWATER DEPENDENT ECOSYSTEM ASSESSMENT

Figure 1.2
Nagero Creek Study Area

2 Methodology

2.1 Personnel

The contributors to the preparation of this report, their qualifications and roles are listed in Table 2.1.

Table 2.1 Personnel

Name	Qualifications	Position and role
Nathan Cooper	Bachelor of Environmental Science, Graduate Diploma Ornithology	Principal Ecologist – project manager, report author
Tanya Bangel	Bachelor of Environmental Management and Science (Hons), Diploma of Conservation and Land Management	Senior Associate Ecologist – technical review
Angelica Corrillo Osorio	Bachelor of Environmental Management	GIS Consultant – data management and figure preparation

2.2 Desktop assessment

2.2.1 Spatial and regional specific data

The following desktop assessments have been completed:

- Commonwealth Protected Matters Search Tool (Department of Climate Change Energy the Environment and Water, 2023).
- Commonwealth Groundwater Dependent Ecosystem Atlas (Bureau of Meteorology, 2025).
- Water Sharing Plan for the Namoi Alluvial Groundwater Source 2020 – High Priority Groundwater-Dependent Ecosystem Map (GDE017_Version 1) (NSW Government, 2020a).
- Regional soil and geology maps.
- BCOPL vegetation mapping (project site and biodiversity offsets).
- The following broad-scale mapping projects:
  - State Vegetation Type Map: Border Rivers – Gwydir and Namoi Region Version 2 VIS ID 4467 (Office of Environment & Heritage, 2016).
  - State Vegetation Type Map NSW Extant PCT Version C2.0.M2.1 (November 2024) (NSW Department of Climate Change Energy the Environment and Water, 2024).
  - A Vegetation Map for the Namoi Catchment Management Authority, an unpublished report for the Namoi Catchment Management Authority (Eco Logical Australia, 2008).

2.3 Literature review

The following literature has been reviewed to inform the assessment of the potential for GDEs within the Nagero Creek study area and regional study area:

- Australian Groundwater-dependent ecosystem toolbox part 2: Assessment Tools (Richardson et al., 2011).

- A Review of Groundwater Dependent Terrestrial Vegetation and Groundwater Depth for the Namoi Catchment Management Authority (Stygoecologia, 2013).
- Maules Creek Coal Mine Biodiversity Impact Assessment (Cumberland Ecology, 2011).
- Tarrawonga Coal Project Environmental Assessment – Appendix E (Fauna Assessment (Resource Strategies and Cenwest Environmental Services, 2011)) and Appendix F (Flora Assessment) (FloraSearch, 2011).
- Boggabri Coal Mine references:
  - Boggabri Coal, Groundwater Management Plan (Boggabri Coal Operations Pty Ltd, 2017a).
  - Groundwater Impact Assessment Boggabri Coal Mine Modification 10 (Australasian Groundwater & Environmental Consultants Pty Ltd, 2025).
  - 2024 Groundwater Dependent Ecosystems and Stream and Riparian Vegetation Health Monitoring (WSP, 2025a).
  - Groundwater Impact Assessment Boggabri Coal Mine MOD 8 to SSD 09_0182 (Australian Groundwater & Environmental Consultants Pty Ltd, 2021).
  - Boggabri Coal Mine Modification 8 Response to Independent Expert Scientific Committee (WSP, 2022).
  - Boggabri Coal Mine Modification 8 Biodiversity Development Assessment Report (WSP, 2021b).
  - Modification 5 MNES Assessment of the Borefield Development Approved by Modification 5 to project approval No. 09_0182 (Parsons Brinckerhoff, 2015).
  - Continuation of Boggabri Coal Mine – Groundwater Assessment (Australian Groundwater & Environmental Consultants Pty Ltd, 2010).

The following guidelines were reviewed to assess the impact to GDEs as part of this report:

- Information guidelines Explanatory Note, Assessing Groundwater-dependent Ecosystems. Report prepared for the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining (Doody, 2019).
- Information guidelines for proponents preparing coal seam gas and large coal mining develop proposals (IESC, 2024).

2.4 Vegetation mapping

Vegetation mapping used in this assessment incorporates the following:

- Field verified vegetation mapping within the Project Boundary and Biodiversity Offset Areas (BOAs).
- Field verified vegetation mapping of the Nagero Creek study area (WSP, 2022).
- Regional state-based broad-scale vegetation mapping in areas that have not been field verified (Office of Environment & Heritage, 2016).

A detailed description of the different vegetation mapping datasets used for this assessment is provided below.

2.4.1 Field-verified vegetation mapping

Vegetation within and immediately surrounding the Project Boundary have been subjected to numerous previous surveys and assessments as part of the establishment and ongoing operation of the BCM. Specifically, these surveys have mapped the vegetation in the Project Boundary, BOAs and areas of Leard State Forest as part of the following investigations.

- Continuation of Boggabri Coal Mine – Biodiversity Impact Assessment (Parsons Brinckerhoff, 2010) which involved mapping of the Project Boundary and Leard State Forest.

- Boggabri Coal Mine Biodiversity Offset Strategy (WSP, 2019), which included vegetation mapping completed across the biodiversity offset properties of the BCM completed by Parsons Brinckerhoff (now WSP) and Niche Environment and Heritage (Niche Environment and Heritage, 2014).
- Boggabri Coal Mine Modification 8 Biodiversity Development Assessment Report (WSP, 2021b), which involved vegetation mapping within the 'MOD 8 study area'.
- Boggabri Coal Mine Modification 8 Response to Independent Expert Scientific Committee (WSP, 2022), which included field validation of vegetation patches in the Nagero Creek study area and a comparison and updated baseline assessment for potential terrestrial GDEs along Bollol Creek and Goonbri Creek.
- Other ad hoc vegetation surveys completed as part of the ongoing operation of the BCM including, project modifications, ecological monitoring, tree clearing et cetera.

Where available, the field verified mapping completed as part of the above has been relied upon for this assessment.

2.4.2 Regional state-based vegetation mapping

Vegetation within the Nagero Creek and regional study areas have also been mapped at a regional scale by the following broad-scale vegetation mapping projects:

- State Vegetation Type Map: Border Rivers Gwydir/Namoi Region Version 2.0_ID4467 (Office of Environment & Heritage, 2016).
- State Vegetation Type Map NSW Extant PCT Version C2.0.M2.1 (November 2024) (NSW Department of Climate Change Energy the Environment and Water, 2024).
- Refinement of Vegetation Mapping in the Namoi Catchment: Extant and pre-European (Eco Logical Australia, 2008).
- Report on the botany, wildlife and ecology of the Leard State Forest (James B. Croft and Associates, 1983).

For the purposes of this assessment, the State Vegetation Type Map: Border Rivers Gwydir/Namoi Region (Office of Environment & Heritage, 2016) was used to determine vegetation in areas where no field verified vegetation mapping has occurred.

2.4.3 MNES threatened ecological communities mapping

Where field verified vegetation mapping occurred, the information collected during survey was used to determine the PCT for each vegetation type recorded as described in the BioNet Vegetation Classification System (NSW Environment and Heritage, 2025) and whether the vegetation aligned to any State or Commonwealth listed Threatened Ecological Communities (TEC).

One Commonwealth listed TEC, being Poplar Box Grassy Woodland on Alluvial Plains, was listed under the EPBC Act on the 4 July 2019. As all field validated vegetation mapping within the BCM Project Boundary and BOAs was conducted prior to 2019, areas of native vegetation in the regional study area with potential to meet the EPBC Act listing have not been assessed against the TECs key diagnostic characteristics or condition thresholds. As such, a precautionary approach has been applied and it is assumed for the purposes of this investigation that all remnant patches previously mapped as PCT 101 and areas of PCT 88 on the Namoi alluvial floodplain (not including the Nagero Creek study area) meet the EPBC Act listing. The only exception to this is areas of derived native grasslands, which do not meet the specific condition thresholds required to form part of the Poplar Box Grassy Woodland on Alluvial Plains EPBC Act listing, unless they form part of a patch.

Where the State Vegetation Type Map: Border Rivers Gwydir/Namoi Region (Office of Environment & Heritage, 2016) was relied upon (i.e., in areas where no field verification has occurred), PCT alignment to Commonwealth listed TECs was determined using the associated TECs listed for each PCT within the BioNet Vegetation Classification System (NSW Environment and Heritage, 2025).

3 Existing environment

An overview of landscape features associated with the MOD 10 regional study area and regional assessment of GDEs are presented in Table 3.1.

Table 3.1 Summary of the regional study area landscape features

Landscape feature	Occurrence in MOD 10 regional study area
IBRA bioregion	Brigalow Belt South
IBRA subregion	Liverpool Plains
NSW landscape regions (Mitchell landscapes)	Bugaldie Uplands and Liverpool Alluvial Plains
Local Government Area (LGA)	Narrabri Shire Council
Rivers, streams and estuaries	Namoi River, Nagero Creek, Goonbri Creek, Bollol Creek, and Back Creek
Important and local wetlands	No important wetlands have been recorded in the MOD 10 regional study area
Geology	Permian geology (Maules Creek Formation) overlain by Quaternary alluvial deposits
Soils	Predominantly consisting of conglomerate and sandstone with minor siltstone, claystones and intercalated coal seams (Australian Groundwater & Environmental Consultants Pty Ltd, 2010)
Aquifers	Alluvium aquifers

3.1 Groundwater dependent ecosystems

3.1.1 Terrestrial and aquatic GDEs

A review of the GDE Atlas (Bureau of Meteorology, 2025) identified one known and one high potential aquatic GDE and 10 high potential terrestrial GDEs mapped in the regional study area (Table 3.2). The location of known and high potential aquatic and terrestrial GDEs is illustrated on Figure 3.1. A review of the Water Sharing Plan for the Namoi Alluvial Groundwater Sources 2020 High Priority Groundwater-Dependent Ecosystem Map (GDE017_Version 1) (NSW Government, 2020a) illustrates the same high potential terrestrial GDEs in association with the lower reaches of Goonbri Creek and Bollol Creek (Figure 3.1).

Table 3.2 Known and high potential terrestrial and aquatic GDEs mapped in the regional study area

Name	Groundwater Dependent Ecosystem potential	Level of assessment
Aquatic GDEs		
Namoi River	High potential	National assessment
Maules Creek	Known GDE	Regional studies
Terrestrial GDEs		
PCT 112 Black Tea-tree – River Oak – Wilga riparian low forest/shrubland wetland of rich soil depressions	High potential	Regional studies
PCT 599 Blakely's Red Gum – Yellow Box grassy tall woodland on flats and hills in the Brigalow Belt South Bioregion		

Name	Groundwater Dependent Ecosystem potential	Level of assessment
PCT 78 River Red Gum tall woodland/open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion		
PCT 53 Shallow freshwater wetland sedgeland in depressions on floodplains on inland alluvial plains		
PCT 55 Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains		
PCT 433 White Box grassy woodland to open woodland on basalt flats and rises in the Liverpool Plains sub-region		
PCT 241 River Coobah swamp wetland on the floodplains of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion		
PCT 101 Poplar Box – Yellow Box – Western Grey Box grassy woodland on cracking clay soils mainly in the Liverpool Plains		
PCT 244 Poplar Box grassy woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate		
PCT 516 Grey Box grassy woodland or open forest of the Nandewar Bioregion and New England Tableland Bioregion		

3.2 Regional groundwater aquifers

The types of groundwater aquifers present in the region consist of:

- Alluvial aquifer (incorporating the Narrabri formation and Gunnedah formation), which comprises alluvial deposits associated with the Namoi River and its tributaries. Mapped as Qx Quaternary Alluvium (Pratt, 1998).
- Maules Creek Formation Aquifer: the major transmissive units are within the coal seams. Mapped as Pmx Maules Creek and Goonbri formations (Pratt, 1998).
- Minor colluvium associated with the weathered Boggabri volcanics. Mapped as Pbr – Boggabri Volcanics.

3.2.1 Alluvial aquifer

The Nagero Creek study area is located on the alluvial plain associated with tributaries of the Namoi River. Nagero Creek is an ephemeral tributary of the Namoi River and captures runoff from the southern portion of the Leard State Forest (where the BCM is situated) and surrounding areas. Tributaries of Nagero Creek occur within the MOD 10 subject land, and to the south-east of Bald Hill, Merrygowen Creek flows into Nagero Creek. These areas are mapped as Quaternary sediments (Qx) (Pratt, 1998) and the lower lying portion of Nagero Creek and Merrygowen Creek is likely to be the extent of the alluvial aquifer to the south and west of BCM (Boggabri Coal Operations Pty Ltd, 2017a). The alluvial aquifer extends from south and north along the Namoi River and covers wide areas around Boggabri. It forms part of the Upper Namoi groundwater source and is used extensively for irrigation, town water supply and stock and domestic purposes. The groundwater levels are typically within 10 m of the ground surface and there is an established hydraulic connection with the surface water system (Australasian Groundwater & Environmental Consultants Pty Ltd, 2025).

GLENPATRICK
ROSSVILLE LANE
BELLVIEW ROAD
HARPARARY ROAD
THERRIBRI ROAD
ELLERSLIE ROAD
MAULES CREEK
WILLEROI ROAD
SPION KOP ROAD
OAKEY VALLEY ROAD
MAULES CREEK
UPPER MAULES CREEK ROAD
BACK CREEK
TESTON LANE
BACK CREEK ROAD
OLD NARRABRI ROAD
BROWNS LANE
HARPARARY
BOUNDARY TRAIL
LEARDS FOREST ROAD
GOODYERS LANE
TRANTHAM ROAD
YEARD BOUNDARY TRAIL
HENRIENDI LANE
BAAN BAA
MERRIOWN CREEK
GOONBRI CREEK
MALLEE LANE
DRIPPING ROCK ROAD
KAMILAROI HIGHWAY
NAGERO CREEK
NAMOI RIVER
WARNERS ROAD
GOONBRI ROAD
BOLLOL CREEK
BOLLOL CREEK
CURRACABAH ROAD
BLAIR ATHOL LANE
THUNDERBOLTS ROAD
BAYLEY PARK ROAD
RANGARI ROAD
EASTVIEW LANE
CALOOLA ROAD
VINE LANE
FINCHS LANE

Road
Drainage
Regional Study Area
Nagero Creek Study Area
Cadastre
MOD 10 Subject Land
Boggabri Coal Mine Approval Area
Maules Creek Coal Mine Approval Area
Tarrawonga Coal Mine Project Approval Area
NPWS Reserve

Aquatic GDE

High potential GDE - from national assessment
Known GDE - from regional studies

Terrestrial GDE

High potential GDE - from regional studies

Map: BC2025_F003_1_PotentialGDE_r1v3	Author: A.Carrillo
Date: 10/04/2025	Approved by: N.Cooper

0 1.5 3 Kilometers

1:100,000

Coordinate system: GDA 1994 MGA Zone 56
Scale ratio correct when printed at A3

Data source: Atlass-Aerometrex Pty Ltd via BCOPL (2017), World_Street_Map: Esri, HERE, Garmin, NGA, USGS
World Imagery: Earthstar Geographics

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BOGGABRI COAL MINE MOD 10 GROUNDWATER DEPENDENT ECOSYSTEM ASSESSMENT

Figure 3.1
Known and High Potential Terrestrial and Aquatic GDEs

Groundwater movement within the alluvium is via intergranular flow, where sandy lenses are interconnected and in hydraulic continuity with the creeks and drainage channels. The regional groundwater flow direction within the alluvium is generally to the north north-west. South of the BCM, groundwater in the alluvium associated with Bollol Creek flows south-west towards the Namoi River. The alluvial aquifer in the vicinity of the BCM is limited within thin valley infill deposits of generally low to variable permeability. The thin alluvium associated with Nagero Creek and Bollol Creek are downgradient of the mine lease. These creeks are ephemeral and flow only after high rainfall events. Groundwater in these sections of the alluvium is minor compared to the areas in the west and south (Boggabri Coal Operations Pty Ltd, 2017a). Detailed studies indicate that groundwater levels are typically 7 mbgl to 10 mbgl on the alluvial plain but can be deeper in places upslope towards the outcropping Boggabri Volcanics (11.2 m at Victoria Park monitoring bore) (Parsons Brinckerhoff, 2010, Parsons Brinckerhoff, 2015, Australian Groundwater & Environmental Consultants Pty Ltd, 2010). The thickness of the alluvial aquifer ranges from 25 m to 75 m (Australian Groundwater & Environmental Consultants Pty Ltd, 2010). Groundwater levels are shallower in the vicinity of drainage depressions and creeks, particularly during wetter months when they contain surface water.

A pilot survey of stygofauna within and adjacent to BCM was undertaken in 2018 and 2019, including sampling of the alluvial aquifer. Despite eight bores being sampled during the pilot survey, only one bore (MW6) yielded stygofauna typical of the aquifers being investigated in this report (Austral Research and Consulting, 2020). Following the pilot survey, BCOPL has completed annual stygofauna sampling exclusively within the alluvium to the south-west of BCM operations. Subsequent sampling events have confirmed four stygofauna species from the alluvial aquifer, including Notobathynella (Parabathynellidae), Harpacticoid, Syncarida and one unidentified species (Austral Research and Consulting, 2024). These stygofauna were recorded from several monitoring bores, including MW6, MWP07, Victoria Park bore, Cooboobindi House bore, and Belleview bore, expanding the local distribution of stygofauna in the alluvium between BCM and the Namoi River.

In Australia, stygofauna are known from alluvial, limestone karst, fractured rock, and calcrete aquifers (Hancock, 2005) (Humphreys, 2008). To be suitable for stygofauna, aquifers must have sufficient porosity or fractionation (connectivity) for adequate living space and have a sufficient flux of organic matter (DOC) and dissolved oxygen (Humphreys, 2008). A wider range of stygofaunal species have been identified in the Gunnedah Coal Basin, which encompasses the Namoi River catchment and the BCM site. Korbel *et. al.* (2013) found 21 taxa, which were dominated by copepods, amphipods and syncarids. Findings from these and other reports suggest that there is a diverse range of stygofauna present.

3.3 Plant Community Types

3.3.1 Nagero Creek study area

Five native PCTs and one non-native vegetation community have been recorded in the Nagero Creek study area as part of previous field surveys completed for the BCM. A summary of these PCTs is provided in Table 3.3 and illustrated in Figure 3.2.

There are portions of the Nagero Creek study area which have not been field verified as part of previous field surveys completed for the BCM. The regional State Vegetation Type Map: Border Rivers Gwydir/Namoi Region (Office of Environment & Heritage, 2016) was used to determine vegetation likely to occur within these areas. The regional broad-scale vegetation mapping did not identify any additional PCTs as occurring in the Nagero Creek study area. All remaining vegetation types identified are equivalent to other vegetation types previously identified within the Nagero Creek study area; namely non-native vegetation in grassland areas previously cleared for agriculture and PCT 592, which is considered equivalent to vegetation mapped as PCT 1313 (Figure 3.2).

Table 3.3 PCTs identified in the Nagero Creek study area

Vegetation type	Condition	BC Act status	EPBC Act status
Field verified (WSP, 2021)			
PCT 88 – Pilliga Box – White Cypress Pine – Buloke shrubby woodland in the Brigalow Belt South Bioregion	Intact	Not listed	Not listed
	Modified		
	Shrubby regrowth		
	Derived Native Grassland		
PCT 101 – Poplar Box – Yellow Box – Western Grey Box grassy woodland on cracking clay soils mainly in the Liverpool Plains, Brigalow Belt South Bioregion	Intact	Not listed	Endangered[1]
	Derived Native Grassland		
PCT 599 – Blakely's Red Gum – Yellow Box grassy tall woodland on flats and hills in the Brigalow Belt South Bioregion and Nandewar Bioregion	Intact	Critically Endangered[2]	Critically Endangered[3]
PCT 1313 – White Cypress Pine – Narrow – leaved Ironbark shrub/grass open forest of the western Nandewar Bioregion	Intact	Not listed	Not listed
PCT 1383 – White Box Grassy Woodland of the Nandewar and Brigalow Belt South Bioregions	Intact	Critically Endangered[2]	Critically Endangered[3]
Miscellaneous Ecosystem: Highly disturbed areas with no or limited native vegetation	Not applicable	Not listed	Not listed
Regional state-based vegetation mapping			
PCT 1 – Candidate Native Grasslands	Not applicable	Not listed	Not listed
PCT 592 – Narrow-leaved Ironbark – Cypress Pine – White Box shrubby open forest in the Brigalow Belt South Bioregion and Nandewar Bioregion	Not applicable	Not listed	Not listed
Not Native (equivalent to Miscellaneous Ecosystem)	Not applicable	Not listed	Not listed

(1) Listed as Endangered under the EPBC Act listing for Poplar Box Grassy Woodland on Alluvial Plains. This listing did not include areas of derived native grassland, unless it forms part of a patch.

(2) Listed as Critically Endangered under BC Act listing for White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grassland in the NSW North Coast, New England Tableland, Nandewar, Brigalow Belt South, Sydney Basin, South Eastern Highlands, NSW South Western Slopes, South East Corner and Riverina Bioregions.

(3) Listed as Critically Endangered under EPBC Act listing for White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grassland.

3.3.2 Regional study area

A review of the GDE Atlas (Bureau of Meteorology, 2025) identified 10 PCTs as having high potential to be GDEs within the regional study area. A summary of these PCTs is provided in Table 3.4 and illustrated on Figure 3.3. Figure 3.3 also includes PCTs previously field verified by WSP.

Table 3.4 PCTs identified in association with regional high potential GDEs

Vegetation type	BC Act status	EPBC Act status
PCT 112 Black Tea-tree – River Oak – Wilga riparian low forest/shrubland wetland of rich soil depressions in the Brigalow Belt South Bioregion	Not listed	Not listed
PCT 599 Blakely's Red Gum – Yellow Box grassy tall woodland on flats and hills in the Brigalow Belt South Bioregion	Critically Endangered[1]	Critically Endangered[2]
PCT 78 River Red Gum tall woodland/open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion	Not listed	Not listed
PCT 101 Poplar Box – Yellow Box – Western Grey Box grassy woodland on cracking clay soils mainly in the Liverpool Plains	Not listed	Endangered[3]
PCT 53 Shallow freshwater wetland sedgeland in depressions on floodplains on inland alluvial plains	Not listed[4]	Not listed
PCT 55 Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains	Not listed[5]	Not listed
PCT 516 Grey Box grassy woodland or open forest of the Nandewar Bioregion and New England Tableland Bioregion	Not listed	Not listed
PCT 433 White Box grassy woodland to open woodland on basalt flats and rises in the Liverpool Plains sub-region	Critically Endangered[1]	Critically Endangered[2]
PCT 241 River Coobah swamp wetland on the floodplains of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion	Not listed[4]	Not listed
PCT 244 Poplar Box grassy woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate	Not listed	Endangered[3]

(1) Listed as Critically Endangered under BC Act listing for White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grassland in the NSW North Coast, New England Tableland, Nandewar, Brigalow Belt South, Sydney Basin, South Eastern Highlands, NSW South Western Slopes, South East Corner and Riverina Bioregions.

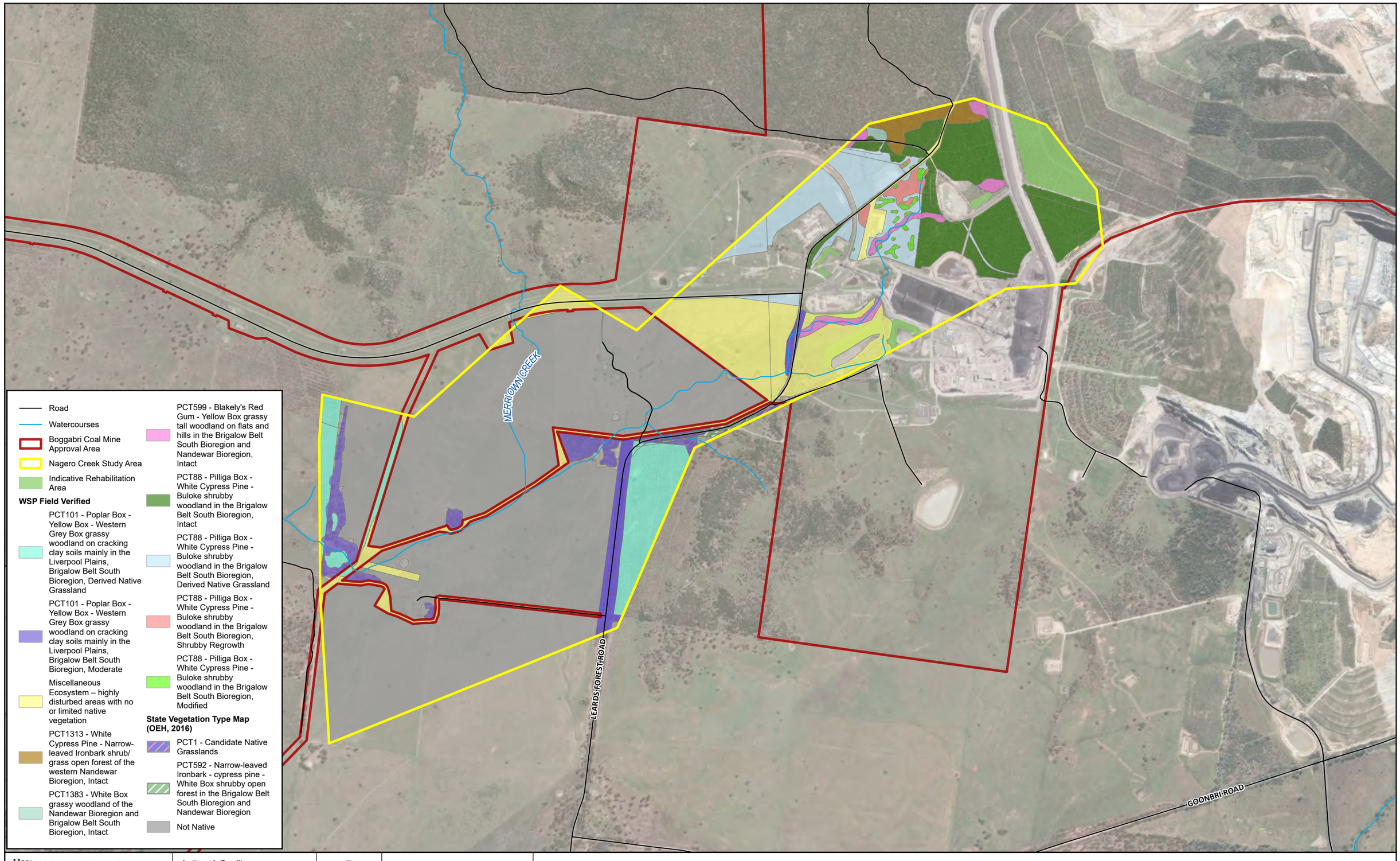
(2) Listed as Critically Endangered under EPBC Act listing for White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grassland.

(3) Listed as Endangered under the EPBC Act listing for Poplar Box Grassy Woodland on Alluvial Plains.

(4) Artesian Springs Ecological Community in the Great Artesian Basin is an associated threatened ecological community of PCT 53 in BioNet (NSW Environment and Heritage, 2025). Despite this, PCT 53 is not considered likely to align to the TEC for the purpose of this assessment as the regional study area does not occur within the Great Artesian Basin.

(5) There are multiple BC Act listed TECs in BioNet (NSW Environment and Heritage, 2025) which are associated with PCT 55. PCT 55 within the regional study area is not considered likely to align to any of the TECs based on surveys completed on PCT 55 within the locality.

Source: (Bureau of Meteorology, 2025)



Map: BC2025_F003_2_PCTNageroCreek_r1v5	Author: A.Carrillo	
Date: 10/04/2025	Approved by: N.Cooper	

0 250 500 Meters

1:20,000

Coordinate system: GDA 1994 MGA Zone 56
Scale ratio correct when printed at A3

Data source: Atlass-Aerometrex Pty Ltd via BCOPL (2017), World_Street_Map: Esri, HERE, Garmin, NGA, USGS
World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

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BOGGABRI COAL MINE MOD 10 GROUNDWATER DEPENDENT ECOSYSTEM ASSESSMENT

Figure 3.2
Plant Community Types identified in the Nagero Creek study area

ROSSVILLE LANE
BELLVIEW ROAD
BROWNS LANE
HARPARARY ROAD
ELLERSLIE ROAD
GLENCOE ROAD
THORNFIELD CROSSING ROAD
MAULES CREEK
UPPER MAULES CREEK ROA
WILLEROI ROAD
SPION KOP ROAD
OAKEY VA
TESTON LANE
BACK CREEK ROAD
BOUNDARY TRAIL
BACK CREEK
THERRIBRI ROAD
LEARD BOUNDARY TRAIL
TRANTHAM ROAD
LEARDS FOREST ROAD
MALLEE LANE
OLD NARRABRI ROAD
HENRIENDI LANE
KAMILAROI HIGHWAY
MERRIOWN CREEK
GOONBRI CREEK
DRIPPING ROCK ROAD
THUNDERBOLTS ROAD
WAGERO CREEK
NAMOI RIVER
THE SLUSH HOLES
GOONBRI ROAD
BOLLOL CREEK
BLAIR ATHOL LANE
BAYLEY PARK ROAD
CURRACABAH ROAD
BARBERS LAGOON ROAD
BARBER LAGOON
RANGARI ROAD
CALOOLA ROAD
VINE LANE
FINCHS LANE

- Road
- Watercourses
- Regional Study Area
- Boggabri Coal Mine Approval Area
- MOD 10 Subject Land
- Nagero Creek Study Area
- Indicative Rehabilitation Area

WSP Surveyed

- PCT102 - Liverpool Plains grassland mainly on basaltic black earth soils, Brigalow Belt South Bi0oregion [PCT102/ NA181], Moderate
- PCT1307 - White Cypress Pine - Silver-leaved Ironbark shrubby open forest of the Nandewar Bioregion [PCT1307_NA224], Moderate
- PCT1329 - Yellow Box - Blakely's Red Gum grassy woodland of the Nandewar Bioregion [PCT1329/NA237], Good
- PCT1329 - Yellow Box - Blakely's Red Gum grassy woodland of the Nandewar Bioregion [PCT1329/NA237]. Moderate
- PCT1329 - Yellow Box - Blakely's Red Gum grassy woodland of the Nandewar Bioregion [PCT1329/NA237], Low
- PCT1381 - Narrow-leaved Ironbark shrubby woodland of the Brigalow Belt South Bioregion [PCT1381/NA165], Good
- PCT1383 - White Box grassy woodland of the Nandewar Bioregion and Brigalow Belt South Bioregion [PCT1383/ NA226], Good
- PCT1383 - White Box grassy woodland of the Nandewar Bioregion and Brigalow Belt South Bioregion [PCT1383/ NA226], Low
- PCT438 - River Red Gum riparian tall woodland wetland on basaltic alluvial soils mainly in the Liverpool Plains sub-region, Brigalow Belt South Bioregion [PCT438/ NA336], Good
- PCT438 - River Red Gum riparian tall woodland wetland on basaltic alluvial soils mainly in the Liverpool Plains sub-region, Brigalow Belt South Bioregion [PCT438/ NA336], Moderate
- PCT438 - River Red Gum riparian tall woodland wetland on basaltic alluvial soils mainly in the Liverpool Plains sub-region, Brigalow Belt South Bioregion [PCT438/ NA336], Low
- PCT78 - River Red Gum riparian tall woodland/ open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion [PCT78/ NA193], Good
- PCT78 - River Red Gum riparian tall woodland/ open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion [PCT78/ NA193], Moderate
- PCT78 - River Red Gum riparian tall woodland/ open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion [PCT78/ NA193], Low
- PCT84 - River Oak riparian woodland of the Brigalow Belt South and Nandewar Bioregions [PCT84/NA191], Moderate
- PCT88 - Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion [PCT88/NA179], Good
- PCT88 - Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion [PCT88/NA179], Moderate
- PCT88 - Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion [PCT88/NA179], Low
- Miscellaneous Ecosystem – highly disturbed areas with no or limited native vegetation, Undefined
- Miscellaneous Ecosystem – highly disturbed areas with no or limited native vegetation, Not applicable (crop land)
- PCT not defined, Moderate

Groundwater Dependent Ecosystems Atlas - Terrestrial GDE

- PCT 53 - Shallow freshwater wetland sedgeland in depressions on floodplains on inland alluvial plains and floodplains
- PCT 55 - Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions
- PCT 78 - River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion
- PCT 101 - Poplar Box - Yellow Box - Western Grey Box grassy woodland on cracking clay soils mainly in the Liverpool Plains, Brigalow Belt South Bioregion
- PCT 112 - Black Tea-tree - River Oak - Wilga riparian low forest/ shrubland wetland of rich soil depressions in the Brigalow Belt South Bioregion
- PCT 241 - River Coobah swamp wetland on the floodplains of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion
- PCT 244 - Poplar Box grassy woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt)
- PCT 433 - White Box grassy woodland to open woodland on basalt flats and rises in the Liverpool Plains sub-region, Brigalow Belt South Bioregion
- PCT 516 - Grey Box grassy woodland or open forest of the Nandewar Bioregion and New England Tableland Bioregion
- PCT 599 - Blakely's Red Gum - Yellow Box grassy tall woodland on flats and hills in the Brigalow Belt South Bioregion and Nandewar Bioregion

Map: BC2025_F003_3_PCTRegStudyArea_r1v6	Author: A.Carrillo
Date: 14/04/2025	Approved by: N.Cooper

0 1 2 Kilometers

1:100,000

Coordinate system: GDA 1994 MGA Zone 56
Scale ratio correct when printed at A3

Data source: World_Street_Map: Esri, HERE, Garmin, NGA, USGS
World Imagery: Earthstar Geographics

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BOGGABRI COAL MINE MOD 10 GROUNDWATER DEPENDENT ECOSYSTEM ASSESSMENT

Figure 3.3
Plant Community Types identified in the Regional Study Area

3.4 Matters of National Environmental Significance

3.4.1 Threatened ecological communities

Eight TECs listed under the EPBC Act were predicted to occur in the regional study area (~10 km radius of the MOD 10 subject land) based on the Commonwealth's Protected Matter Search Tool (Department of Climate Change Energy the Environment and Water, 2025). Of these TECs, four are known to occur in the regional study area based on the following vegetation mapping:

- Field verification mapping surveys undertaken for the Boggabri Coal Mine – Modification 10 BDAR (WSP, 2025b).
- Field verification mapping surveys undertaken for the Boggabri Coal Mine Modification 8 Response to IESC (WSP, 2022).
- Field verification mapping surveys undertaken for the Boggabri Coal Mine – Modification 8 BDAR (WSP, 2021b).
- Field verification mapping surveys completed for the Continuation of Boggabri Coal Mine – Biodiversity Impact Assessment (Parsons Brinckerhoff, 2010), which involved mapping of the Project Boundary and Leard State Forest.
- Boggabri Coal Mine Biodiversity Offset Strategy (WSP, 2019) which included vegetation mapping completed across the biodiversity offset properties of the BCM completed by Parsons Brinckerhoff (now WSP) and Niche Environment and Heritage (Niche Environment and Heritage, 2015).
- Other ad hoc vegetation completed as part of the ongoing operation of the BCM, including project modifications, ecological monitoring, tree clearing etcetera.
- Regional broad-scale vegetation mapping i.e., State Vegetation Type Map: Border Rivers Gwydir/Namoi Region Version 2.0_ID4467 (Office of Environment & Heritage, 2016).

A description of each of the four TECs listed under the EPBC Act in regard to the regional study area (and therefore the Nagero Creek study area) are provided below in Section 3.4.1.1 to Section 3.4.1.4.

Table 3.5 Threatened ecological communities predicted to occur in the regional study area

Threatened ecological community	EPBC Act status	Recorded in the study area?[1]
Coolibah – Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions	Endangered	Not known to occur in the regional study area
Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and Derived Native Grasslands of South-eastern Australia	Endangered	Not known to occur in the regional study area
Mount Kaputar land snail and slug community	Endangered	Not known to occur in the regional study area
Natural grasslands on basalt and fine-textured alluvial plains of northern New South Wales and southern Queensland	Critically Endangered	Yes – recorded in the regional study area
New England Peppermint (*Eucalyptus nova-anglica*) Grassy Woodlands	Critically Endangered	Not known to occur in the regional study area
Poplar Box Grassy Woodland on Alluvial Plains	Endangered	Yes – recorded in Nagero Creek study area and regional study area
Weeping Myall Woodlands	Endangered	Yes – recorded in the regional study area

Threatened ecological community	EPBC Act status	Recorded in the study area?[1]
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	Critically Endangered	Yes – recorded in Nagero Creek study area and regional study area

3.4.1.1 Natural grasslands on basalt and fine-textured alluvial plains of northern NSW and southern Queensland

Natural grasslands on basalt and fine textured alluvial plains of northern NSW and southern Queensland (Plains Grassland) are listed as a Critically Endangered Ecological Community under the EPBC Act. Plains Grassland is a grassland dominated by native tussock grasses which is highly variable across its range. The community is influenced by soil, rainfall, geology and land use which vary the community's composition and structure (Threatened Species Scientific Committee, 2009).

Plains Grassland has been mapped within the regional study area by Niche Environment and Heritage (Niche Environment and Heritage, 2015) (refer to areas mapped as PCT 102 in Figure 3.3). Plains Grassland was not identified as occurring in the MOD 10 subject land or the Nagero Creek study area.

As no field verification has been undertaken as part of this assessment, it is conservatively assumed that all patches of Plains Grassland mapped in Figure 3.5 are consistent within the Plains Grassland condition criteria outlined in the community's Commonwealth Listing Advice (Threatened Species Scientific Committee, 2009) as the vegetation is located within the Liverpool Plains, occurs on flats (<5%) and is likely to contain a projected crown cover of <10% and contain characteristic species.

3.4.1.2 Poplar Box Grassy Woodland on Alluvial Plains

Poplar Box Grassy Woodland on Alluvial Plains (PBGW) was listed as an Endangered Ecological Community under the EPBC Act on 4 July 2019. Although this community was not recorded in the MOD 10 subject land, it is known to occur in the Nagero Creek study area (Figure 3.4) (WSP, 2022).

PCT 101 Poplar Box – Yellow Box – Western Grey Box Grassy Woodland recorded in the Nagero Creek study area was previously identified as being a candidate to meet the EPBC Act listing for the PBGW TEC (WSP, 2021c). The EPBC Act Conservation Advice (Department of Environment and Energy, 2019) for PBGW requires that vegetation must meet both the key diagnostic criteria and the minimum condition thresholds presented in the Conservation Advice to meet the EPBC Act listing.

Field validation to determine whether patches of PCT 101 Poplar Box – Yellow Box – Western Grey Box grassy woodland in the Nagero Creek study area met the key diagnostic criteria and minimum condition thresholds presented in the EPBC Act Conservation Advice for PBGW was completed in December 2021. Field validation confirmed that four patches met the key diagnostic criteria (Table 3.6); however, assessment against the Conservation Advice minimum condition thresholds identified that only two patches met all condition thresholds and therefore met the EPBC Act listing whilst the other two patches failed to meet the minimum patch size and therefore do not meet the EPBC Act listing (Table 3.7) (WSP, 2022).

One additional PCT in the Nagero Creek study area was considered a candidate to form part of the PBGW TEC; being PCT 88 Pilliga Box – White Cypress Pine – Buloke shrubby woodland in the Brigalow Belt South Bioregion. This PCT has been mapped in the north-east of the Nagero Creek study area in proximity to existing mine infrastructure (Figure 3.2). However, PCT 88 in this location was assessed as not meeting the key diagnostic characteristics (Department of Environment and Energy, 2019) of the PBGW TEC, as it typically occurred as a dry sclerophyll forest with a canopy dominated largely by *Eucalyptus pilligaensis* (Narrow-leaved Grey Box) and a midstorey usually greater than 30% in cover dominated by *Allocasuarina luehmannii* (Bulloak). Given this, PCT 88 in the Nagero Creek study area was considered not to form part of the PBGW TEC.

Table 3.6 Poplar Box Grassy Woodland on Alluvial Plains key diagnostic criteria assessment

Key diagnostic criteria	PCT 101 patches in the Nagero Creek study area
Does the PCT occur in the Brigalow Belt South, Southeast Queensland, Cobar Peneplains, Darling Riverine Plains, NSW South Western Slopes, Riverina and Murray Darling Depression IBRA bioregion	Yes Occurs in the Brigalow Belt South IBRA Bioregion
Is associated with ancient and recent depositional alluvial plains with clay, clay-loam, load and sandy loam, typically duplex soils or sodsoils	Yes Occurs on the alluvial plains of the Namoi River and its tributaries (Nagero Creek)
A grassy woodland to grassy open woodland with a tree crown cover of 10% or more at the patch scale	Yes Grassy woodland with a tree crown cover of 20% or more
A tree canopy must be present that shows the following features: — Canopy tree species are capable of reaching 10 m or more in height — *Eucalyptus populnea* (Poplar Box) must be present in the canopy and is the dominant tree species — Where hybrids of Poplar Box with other Eucalypt spp. are present, they should be counted as part of the *Eucalyptus populnea* component of the tree canopy when assessing the previous criterion	Yes Tree height ranges from 15 m to 20 m in all patches All patches are dominated by *Eucalyptus populnea* subsp. *bimbil* (Poplar Box)
Mid layer (1-10 m) crown cover of shrubs to small trees is low, about 30% or less	Yes Mid-layer crown cover is <10%
A ground layer (<1 m) mostly dominated by native grasses, other herbs and occasionally chenopods (during extended dry periods) ranging from sparse to thick (in response to canopy development soil moisture, disturbance and/or management history).	Yes Ground layer <1 m is dominated by native grasses, herbs and occasionally chenopods
Comprises of diagnostic native plant species and some of the key native fauna that make up the ecological community.	Yes 41 of the diagnostic flora species were recorded in the patches
Does PCT 101 within the study area meet the EPBC Act key diagnostic criteria?	**Yes**

Table 3.7 Assessment of PCT 101 against the Poplar Box Grassy Woodland on Alluvial Plains EPBC Act Conservation Advice minimum condition thresholds

Poplar Box Grassy Woodland and Alluvial Plains EPBC Act Conservation Advice minimum condition thresholds	**Patch 1**	**Patch 2**	**Patch 3**	**Patch 4**
Class A – Highest Quality				
Category A1 Minimum Patch threshold ≥1 ha The crown cover of canopy trees in the patch is ≥10% **AND** ≥90% of perennial vegetation cover in the ground layer is native **AND** ≥ 30 native plant species per patch in the ground layer	Patch is 2.71 ha in size Crown cover is 30% **AND** 99% native perennial vegetation cover **AND** 30 native plant species present in the ground layer **Meets Criteria for Category A1**	Patch size is 0.92 ha **Does not meet Criteria for Category A1**	Patch is 5.8 ha Crown cover is 20% **AND** 97% native perennial vegetation cover **AND** 38 native plant species present in the ground layer **Meets Criteria for Category A1**	Patch size is 0.43 ha **Does not meet Criteria for Category A1**
Category A2 Is the patch size ≥5 ha The crown cover canopy trees in the patch is ≥10% **AND** ≥70% of perennial vegetation cover in the ground layer is native **AND** ≥ 30 native plant species per patch in the ground layer	N/A	Patch size is 0.92 ha **Does not meet Criteria for Category A2**	N/A	Patch size is 0.43 ha **Does not meet Criteria for Category A2**

Poplar Box Grassy Woodland and Alluvial Plains EPBC Act Conservation Advice minimum condition thresholds	Patch 1	Patch 2	Patch 3	Patch 4
Class B – Good Quality				
Is the patch size ≥5 ha The crown cover canopy trees in the patch is ≥10% **AND** ≥50% of perennial vegetation cover in the ground layer is native **AND EITHER** ≥ 20 Perennial native plant species per patch in the ground layer **OR** ≥ 10 mature trees *Eucalyptus populnea* per ha with ≥30 cm diameter at breast height (and/or hollows)	N/A	Patch size is 0.92 ha **Does not meet Criteria for Class B**	N/A	Patch size is 0.43 ha **Does not meet Criteria for Class B**
Class C – Moderate Quality				
Is the patch size ≥5 ha The crown cover canopy trees in the patch is ≥10% **AND** If <50% of perennial vegetation cover in the ground layer is native then the patch must have: ≥ 20 Perennial native plant species per patch in the ground layer **AND** ≥ 10 mature trees *Eucalyptus populnea* per ha with ≥30 cm diameter at breast height (and/or hollows) **AND** smaller trees *Eucalyptus populnea*, saplings or seedlings suggestive of periodic recruitment	N/A	Patch size is 0.92 ha **Does not meet Criteria for Class C**	N/A	Patch size is 0.43 ha **Does not meet Criteria for Class C**
Does the patch meet the criteria for PBGW?	**Yes – Highest Quality Category A1**	**No does not meet criteria for PBGW**	**Yes – Highest Quality Category A1**	**No does not meet criteria for PBGW**

3.4.1.3 Weeping Myall Woodlands

Weeping Myall Woodlands is listed as an Endangered Ecological Community under the EPBC Act. This community occurs on inland alluvial plains as a low open to sparse woodland which reaches up to 12 m in height with a canopy dominated by *Acacia pendula* (Weeping Myall).

Weeping Myall Woodland occurs as scattered patches within the regional study area along the Namoi floodplain (Figure 3.5). Within the Project Boundary and BOAs, where this TEC has been field verified, the community occurs as scattered remnants within a fragmented agricultural landscape and as roadside vegetation along Therribri Road, Boggabri NSW (Parsons Brinckerhoff, 2015). Weeping Myall Woodlands has not been identified as occurring within the MOD 10 subject land or the Nagero Creek study area.

To be considered part of the EPBC Act listing of Weeping Myall Woodlands, remnant areas must meet the Commonwealth condition criteria as outlined in the listing advice (Department of Environment Water Heritage and the Arts, 2009). A comparison of the Weeping Myall Woodlands within the Project Boundary and BOAs against the Commonwealth condition criteria is provided in Table 3.8. All patches previously assessed in the Project Boundary and BOAs met all condition criteria for the Commonwealth listing of Weeping Myall Woodland.

Table 3.8 Weeping Myall Woodland Commonwealth condition criteria comparison (Parsons Brinckerhoff, 2015)

Criteria number	Condition criteria	Weeping Myall Woodland in the regional study area
1	Tree canopy is dominated (at least 50% of trees present) by living, dead or defoliated Weeping Myall trees.	Yes. The Weeping Myall Woodland contained a canopy cover dominated by Weeping Myall.
2	Overstorey must have at least 5% tree canopy cover or at least 25 dead or defoliated mature Weeping Myall trees/ha.	Yes. The Weeping Myall Woodland contained a tree canopy cover with over 5% mature and semi-mature Weeping Myall trees.
3	Area is at least 0.5 ha in size.	Yes. The patch of Weeping Myall Woodland is greater than 0.5 ha in size.
4	The patch has either: — more than two layers of regeneration of Weeping Myall present; or — tallest layer of living, dead or defoliated Weeping Myall trees is at least 4 m tall and of the vegetation cover present, 50% is comprised of native species.	Yes. The Weeping Myall Woodland contained two layers of regeneration. In addition, the canopy is greater than 4 m high and contains greater than 50% native species.
End	**Does the patch meet the Commonwealth condition criteria?**	**Yes. The patch meets all condition criteria for the Commonwealth listing of Weeping Myall Woodland.**

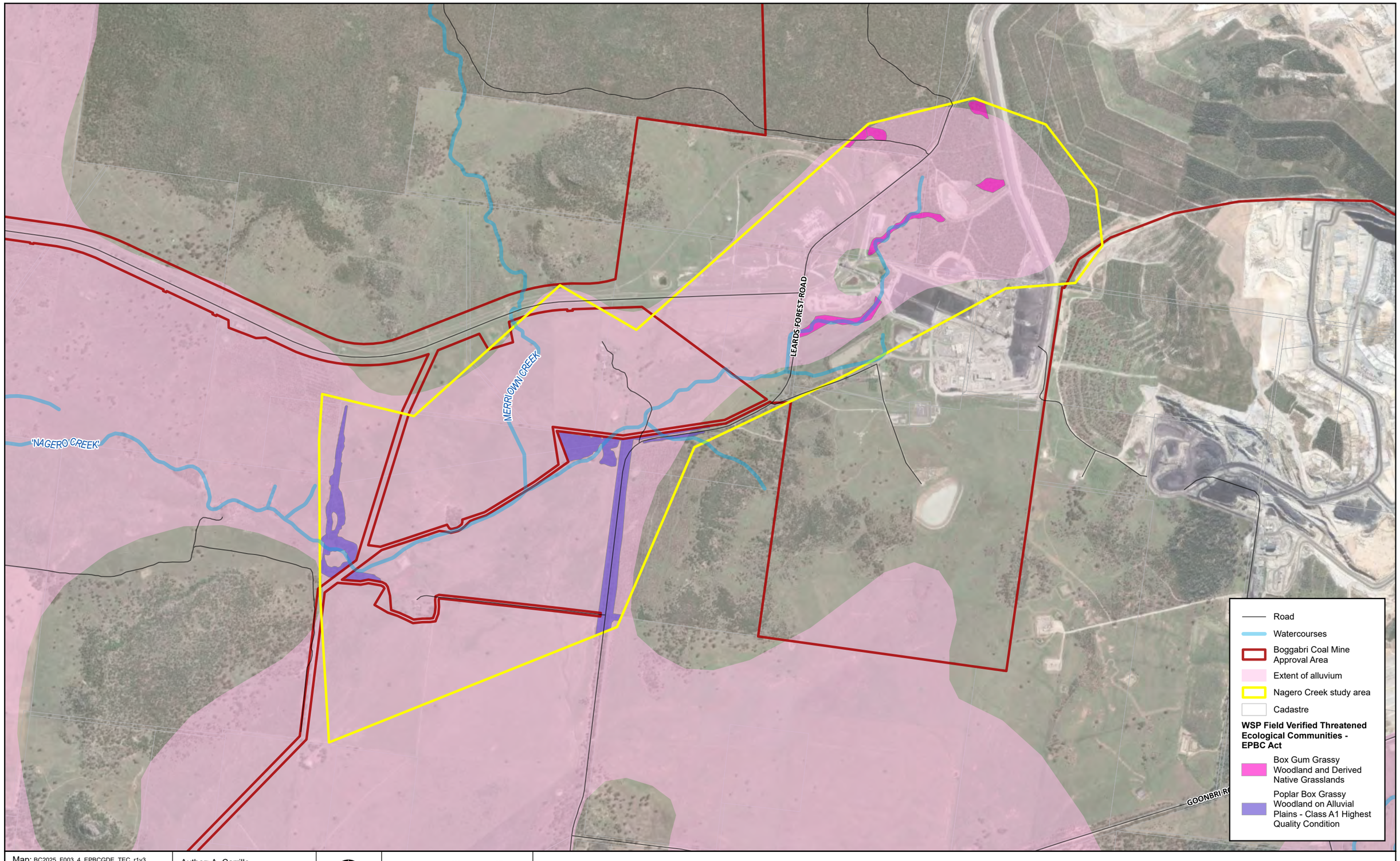
3.4.1.4 White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grasslands

White Box – Yellow Box – Blakely's Red Gum Woodland and Derived Native Grasslands (Box Gum Woodland) is listed as a Critically Endangered Ecological Community under the EPBC Act. The community occurs as an open grassy woodland with an understorey dominated by native tussock grasses, herbs and scattered shrubs (Threatened Species Scientific Committee, 2006).

Three PCTs recorded within the regional study area have been identified as having potential to align to the Critically Endangered Box Gum Woodland threatened ecological community being:

- PCT 599 Blakely's Red Gum – Yellow Box grassy tall woodland on flats and hills in the Brigalow Belt South Bioregion and Nandewar Bioregion (previously mapped and including areas of PCT 1329).
- PCT 1383 White Box grassy woodland of the Nandewar Bioregion and Brigalow Belt South Bioregion.
- PCT 433 White Box grassy woodland to open woodland on basalt flats and rises in the Liverpool Plains sub-region.

PCT 599 and PCT 1383 recorded in the Nagero Creek study area were both assessed as meeting the Box Gum Woodland EPBC Act TEC key diagnostic features and condition thresholds (WSP, 2021c). As no field verification has been undertaken for the remaining areas in the regional study area where these PCT's occur, it is assumed that all patches of Box Gum Woodland mapped in Figure 3.5 are assumed to be consistent with the Box Gum Woodland condition criteria outlined in the community's Commonwealth Listing Advice (Threatened Species Scientific Committee, 2006) as a precautionary approach.



Map: BC2025_F003_4_EPBCGDE_TEC_r1v3	Author: A. Carrillo		0 250 500 Meters 1:20,000 Coordinate system: GDA 1994 MGA Zone 56 Scale ratio correct when printed at A3
Date: 10/04/2025	Approved by: N. Cooper		
Data source: World_Street_Map: Esri, HERE, Garmin, NGA, USGS World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community			

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Figure 3.4

EPBC Act Threatened Ecological Communities in the Nagero Creek study area

ROSSVILLE LANE
BELLVIEW ROAD
OLD NARRABRI ROAD
BROWNS LANE
HARPARARY ROAD
ELLERSLIE ROAD
GLENCOE ROAD
WILLEROI ROAD
SPION KOP ROAD
THORNFIELD CROSSING ROAD
MAULES CREEK
UPPER MAULES CREEK ROAD
CONNORS CREEK ROAD
OAKEY VALLEY ROAD
TESTON LANE
BACK CREEK ROAD
BACK CREEK
BOUNDARY TRAIL
GOODYERS LANE
THERRIBRI ROAD
TRANTHAM ROAD
LEARD BOUNDARY TRAIL
LEARDS FOREST ROAD
MALLEE LANE
HENRIENDI LANE
HENRIENDI STREET
BAAN BAA ROAD
CURRACABAH ROAD
NAMOI RIVER
MERRIOWN CREEK
KAMILAROI HIGHWAY
NAGERO CREEK
THE SLUSH HOLES
DRIPPING ROCK ROAD
THUNDERBOLTS ROAD
GOONBRI ROAD
GOONBRI CREEK
BOLLOL CREEK
BLAIR ATHOL LANE
BAYLEY PARK ROAD
LYNFORD LANE
EAST VIEW LANE
CALOOLA ROAD
VINE LANE
BARBERS LAGOON ROAD
RANGARI ROAD
FINCHS LANE
BRAYMONT ROAD

- Road
- Watercourses
- Boggabri Coal Mine Approval Area
- MOD 10 Subject Land
- Nagero Creek study area
- Regional Study Area

Groundwater Dependent Ecosystems Atlas - Terrestrial GDE

- Natural Grasslands on basalt and fine textured alluvial plains of northern New South Wales and southern Queensland
- White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland
- White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland (Derived Native Grassland)
- Poplar Box Grassy Woodland on Alluvial Plains

Map: BC2025_F003_5_EPBC_RegStudyAreaGDE_r1v3	Author: A. Carrillo	
Date: 15/04/2025	Approved by: N. Cooper	

Data source: Atlass-Aerometrex Pty Ltd via BCOPL (2017), World Imagery, World_Street_Map: Esri, HERE, Garmin, NGA, USGS
World Imagery: Earthstar Geographics

0 1.5 3 Kilometers

1:100,000

Coordinate system: GDA 1994 MGA Zone 56
Scale ratio correct when printed at A3

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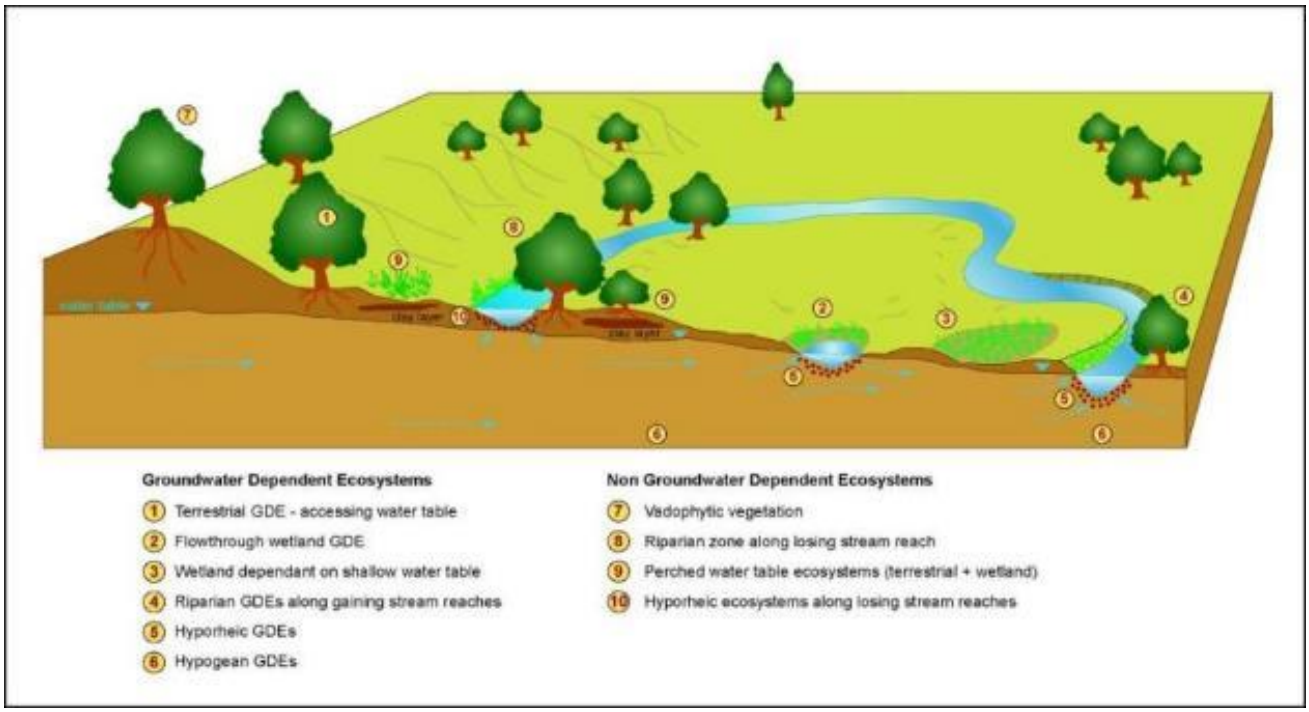
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Figure 3.5
EPBC Act Threatened Ecological Communities in the Regional Study Area

4 Characterising groundwater dependence

GDEs include a diverse range of ecosystems from those entirely dependent on groundwater to those that may use groundwater while not having a dependency on it for survival (i.e., ecosystems or organisms that use groundwater opportunistically or as a supplementary source of water) (Hatton and Evans, 1998). Eamus *et al.* (2006) considers the following broad classes of these ecosystems:

- Aquifer and cave ecosystems, where stygofauna (groundwater-inhabiting organisms) may reside within the groundwater resource. The hyporheic zones (see ecosystem 5 in Figure 4.1) of rivers and floodplains are also included in this category because these ecotones often support stygobites (obligate groundwater inhabitants).
- All ecosystems dependent on the surface expression of groundwater. This category includes base-flow rivers and streams, wetlands (see ecosystems 2 and 3 in Figure 4.1), some floodplains and mound springs and estuarine seagrass beds.
- All ecosystems dependent on the subsurface presence of groundwater, often accessed via the capillary fringe (non-saturated zone above the saturated zone of the water table) when roots penetrate this zone. This class includes terrestrial ecosystems such as River Red Gum (*Eucalyptus camaldulensis*) forests on the Murray–Darling Basin (see ecosystems 1 and 4 in Figure 4.1). No surface expression of groundwater is required in this class of GDE.



Source: (Eamus et al., 2006)

Figure 4.1 Conceptual biophysical model of groundwater dependent ecosystems

4.1 Tree root depth analysis

The development of tree root architecture is influenced by both the tree species and range of soil conditions. Mechanical resistance, aeration, fertility, and moisture of the soil also influence rooting depth.

The majority of vegetation communities in Leard State Forest occur on slopes and ridges associated with well drained soils characterised by shallow skeletal conglomerate on steeper upper slopes and drainage lines and deep basaltic derived fertile soils on the lower slopes. Such vegetation is disconnected from localised groundwater systems as the roots are unable to grow far into soil horizons that are excessively stony. Consequently, rooting depth in areas of shallow bedrock is limited. Groundwater is not within the root zone of these vegetation types given their location in the landscape, and as such they are not groundwater dependent. These vegetation types, which includes vegetation that occurs adjacent to ephemeral streams, rely on rainfall to support growth and photosynthesis.

Ironbark and box eucalypts, such as those that dominate the lower slopes of the Leard State Forest are shallow rooted and allocate substantial biomass to above-ground parts at the expense of an expansive root system (Fensham, 2007). They are unlikely, therefore, to be groundwater dependent.

Riparian forests, such as the River Red Gum open forest on the banks of the Namoi River rely on the availability of groundwater below the surface but within the rooting depth of the vegetation. The loose, deep, well-drained alluvial soils with large pore spaces promote greater root depths as they are well aerated and provide less resistance to root penetration.

While loamy soils allow considerable root development, the remnant vegetation communities (such as PCT 101 Poplar Box – Yellow Box – Western Grey Box grassy woodland on cracking clay soils mainly in the Liverpool Plains, Brigalow Belt South Bioregion) restricted to the lower lying alluvial plain areas with these soils are generally associated with shallow, perched water tables over impermeable clay lenses rather than groundwater fed by subsurface aquifers. Such vegetation is likely to send roots to the perched water table but not through the impermeable clay lens.

Broad ecosystem scale studies have shown the sclerophyllous shrubland and forest (such as that in the regional study area) have a mean rooting depth of 5.2 ± 0.8 m (Canadell J., 1996). Average rooting depth for temperate grassland has been shown to be 2.6 ± 0.2 m (Canadell J., 1996).

A review of literature of rooting ranging depths by Stygoecologica (2013), found that most deep-rooted woody species only extend approximately 10 mbgl. Nevertheless, in a study investigating the relationship between tree condition and groundwater depth, Kath *et al.* (2014) found a groundwater depth threshold for *Eucalyptus populnea* (Poplar Box) in the range of 12.6 mbgl to 26.6 mbgl beyond which canopy condition declined abruptly. It is postulated that this threshold response in canopy condition may be linked to rooting depth, with chronic groundwater decline decoupling trees from deep soil moisture resources.

4.2 Terrestrial GDEs in the Nagero Creek study area

A review of the GDE Atlas (Bureau of Meteorology, 2025) identified some areas of the alluvial plain as having a low potential for vegetation reliance on subsurface groundwater. The vegetation mapped within and immediately surrounding the Nagero Creek study area by the GDE Atlas (Bureau of Meteorology, 2021) is assessed as having a low potential to be a GDE (national assessment) (Bureau of Meteorology, 2025).

Based on field surveys for the Boggabri Coal Mine – Modification 8 BDAR (WSP, 2021b), Boggabri Coal Mine Terrestrial GDE Assessment (WSP, 2021c), Boggabri Coal Mine Modification 8 Response to IESC (WSP, 2022) and desktop assessment of the regional vegetation mapping (Office of Environment & Heritage, 2016), five PCTs and one exotic community (miscellaneous ecosystem) have been recorded in the Nagero Creek study area (Table 4.1).

The dependence (or interaction) of the vegetation communities identified in the Nagero Creek study area on groundwater was determined by aligning them with the GDE types identified by Eamus *et al.* (2006). Table 4.1 describes the list of PCTs recorded in the Nagero Creek study area and outlines their potential dependence on groundwater.

Table 4.1 Vegetation community dependency on groundwater within the Nagero Creek study area

Ecosystem Type[1]	Hydrological Ecosystem[2]	PCTs[3,7]	BC Act[4]	EPBC Act[5]	Known Groundwater Dependency[6,7]
WSP Field verified Mapping					
Terrestrial ecosystems	7 – Vadophytic vegetation 9 – Perched water table ecosystems	PCT 88 Pilliga Box – White Cypress Pine – Buloke shrubby woodland	–	–	No apparent dependency on groundwater
	7 – Vadophytic vegetation	PCT 1313 White Cypress Pine – Narrow-leaved Ironbark shrub/grass open forest	–	–	No apparent dependency on groundwater
	7 – Vadophytic vegetation	PCT 1383 White Box grassy woodland	CEEC	CEEC	No apparent dependency on groundwater
	7 – Vadophytic vegetation	Highly disturbed areas with no or limited native vegetation	–	–	No apparent dependency on groundwater
	1 – Terrestrial GDE – potentially accessing the water table	**PCT 101 Poplar Box – Yellow Box – Western Grey Box grassy woodland**	–	EEC	**Proportional dependency on groundwater**
River Base Flow	8 – Riparian zone along losing stream reach	PCT 599 Blakely's Red Gum – Yellow Box grassy tall woodland	CEEC	CEEC	No apparent dependency on groundwater
Regional state-based vegetation mapping					
Terrestrial ecosystems	7 – Vadophytic vegetation	PCT 592 – Narrow-leaved Ironbark – Cypress Pine – White Box shrubby open forest (equivalent to PCT 1313)	–	–	No apparent dependency on groundwater
	7 – Vadophytic vegetation	PCT 1 – Candidate Native Grasslands	–	–	No apparent dependency on groundwater
	7 – Vadophytic vegetation	Not native	–	–	No apparent dependency on groundwater

(1) Ecosystem Types as per Eamus *et al* (2006) and Murray *et al* (2003).

(2) Hydrological ecosystem classification (Eamus et al., 2006).

(3) PCTs mapped as per WSP (WSP, 2021b, WSP, 2022) and Office of Environment and Heritage (Office of Environment & Heritage, 2016).

(4) CEEC = Critically Endangered Ecological Community listed under the BC Act.

(5) CEEC = Critically Endangered Ecological Community, EEC = Endangered Ecological Community listed under the EPBC Act.

(6) Known groundwater dependency as per Hatton & Evans (1998).

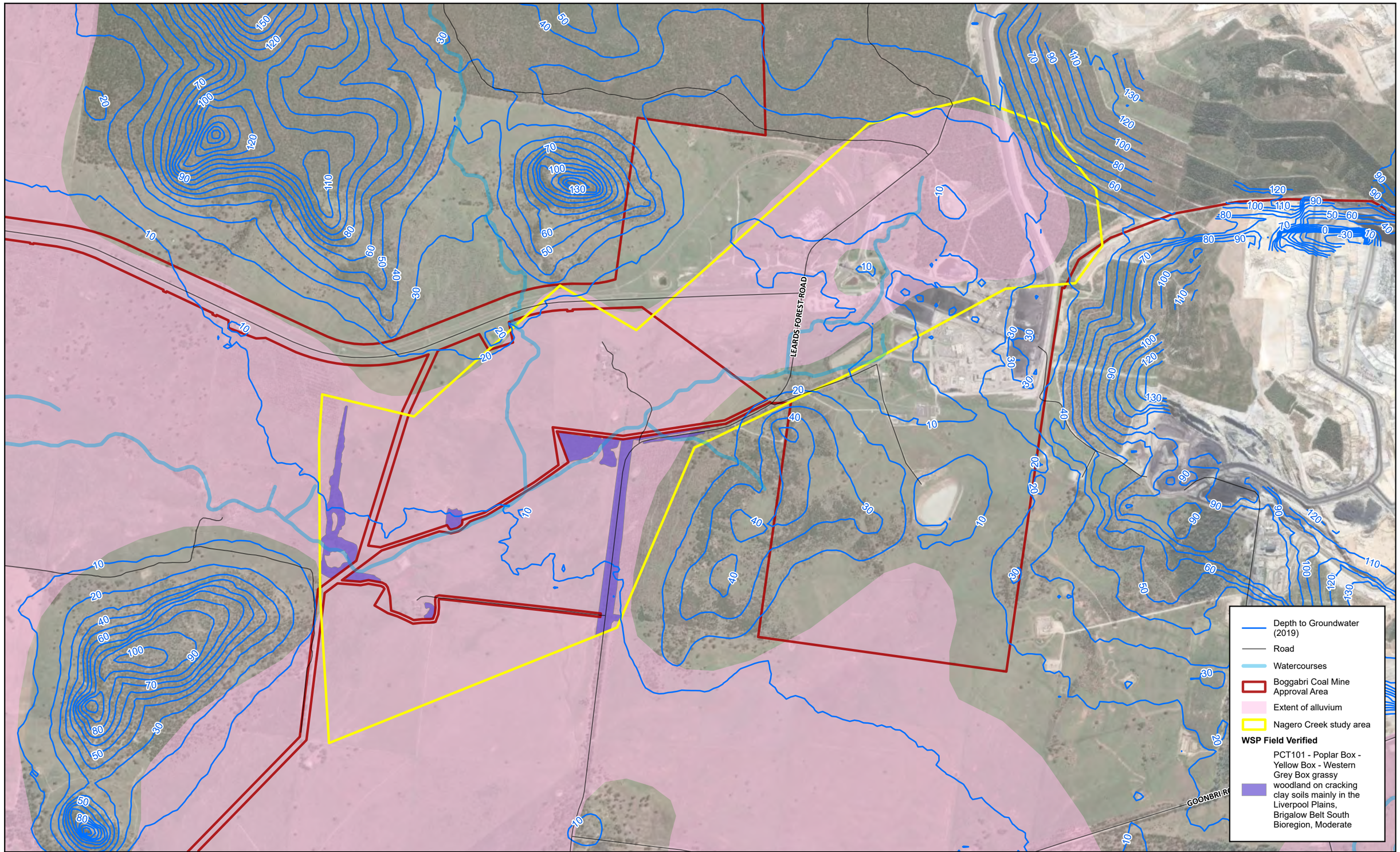
(7) **Bold** text denotes potential proportional groundwater dependence.

4.2.1 Potential terrestrial GDEs

Based on the desktop assessment and vegetation classification of GDE types identified by Murray *et al.* (2003) and Eamus *et al*. (2006), one PCT was considered to have potential to be at least partially reliant on access to groundwater (phreatophytic vegetation) in the Nagero Creek study area, being PCT 101 Poplar Box – Yellow Box – Western Grey Box grassy woodland.

PCT 101 Poplar Box – Yellow Box – Western Grey Box grassy woodland, which is identified as a low potential terrestrial GDE (Bureau of Meteorology, 2025), occurs on the lower lying floodplain and within the upper reaches of Nagero Creek (Figure 4.2). As PCT 101 is considered a low potential terrestrial GDE, it is not likely to be entirely dependent on groundwater; rather it is likely to be opportunistic (facultative) in its use of groundwater. Therefore, it is likely to depend on the subsurface presence of groundwater (often accessed via the capillary fringe – subsurface water just above the water table) in some locations, but not others. As the plants within PCT 101 may at times rely on capillary water in the soil that rises from the water table, any lowering of the water table may result in a reduction in groundwater availability and declining vegetation health during low rainfall periods.

Within the Nagero Creek study area, the depth to the groundwater table is estimated between 7 mbgl and 10 mbgl where this community occurs (Australian Groundwater & Environmental Consultants Pty Ltd, 2021) (Australasian Groundwater & Environmental Consultants Pty Ltd, 2025). Kath *et al* (2014) found a groundwater depth threshold for *Eucalyptus populnea* (Poplar Box) in the range of 12.6 mbgl to 26.6 mbgl beyond which canopy condition declined abruptly. Consequently, it is suggested that this threshold response in canopy condition may be linked to rooting depth. Whilst *Eucalyptus populnea* (Poplar Box) would access soil water and perched aquifers, due to their potential for extensive tap roots, they are likely to proportionally use groundwater to fulfil their requirements. Therefore, PCT 101 is considered a GDE due to its proportional dependence on groundwater.



Map:BC2025_F004_2_PotentialGDEs_NCreek_Deep_GW_r1v3	Author: A.Carrillo		0 250 500 Meters
Date: 10/04/2025	Approved by: N. Cooper		1:20,000
Data source: World_Street_Map: Esri, HERE, Garmin, NGA, USGS World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community			Coordinate system: GDA 1994 MGA Zone 56 Scale ratio correct when printed at A3

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Figure 4.2
GDEs within the Nagero Creek Study Area and Depth to Groundwater

4.3 Groundwater use by vegetation potentially impacted by drawdown

Recommended methods for determining groundwater use of vegetation are detailed in Information Guidelines Explanatory Note: Assessing groundwater-dependent ecosystems (Doody, 2019) and the Australian groundwater-dependent ecosystems toolbox part 2: assessment tools (Richardson et al., 2011). In association with recommended methods (Appendix B. App Table 2, (Doody, 2019)) and BCMs MOD 8, an analysis of leaf green index and correlation against climate data was undertaken in the alluvium, including riparian vegetation associated with Nagero, Bollol and Goonbri Creeks, to build upon desktop analysis to support assessment of potential GDEs dependency on groundwater (WSP, 2022).

4.3.1 Analysis of Leaf Green Index

Remote sensing data is an important source for monitoring and mapping vegetation cover (Vani and Mandlea, 2017) and various vegetation indices have been developed to monitor vegetation distribution and vegetation phenology, including Normalised Difference Vegetation Index (NDVI) and Soil-Adjusted Vegetation Index (SAVI).

An analysis of leaf green index was undertaken to examine the potential connection to groundwater between PCTs located on alluvial plains or occurring as linear strips of riparian vegetation lining ephemeral drainage lines in the vicinity of BCM and the Leard State Forest. This method applied a remote sensing analysis of 'leaf green' index to reflect vegetation health correlated against climate rainfall data. The interpretation of this analysis looks for patterns in areas of vegetation showing of high leaf greenness during below average rainfall conditions as an indication of potential groundwater reliance of vegetation.

4.3.1.1 Method

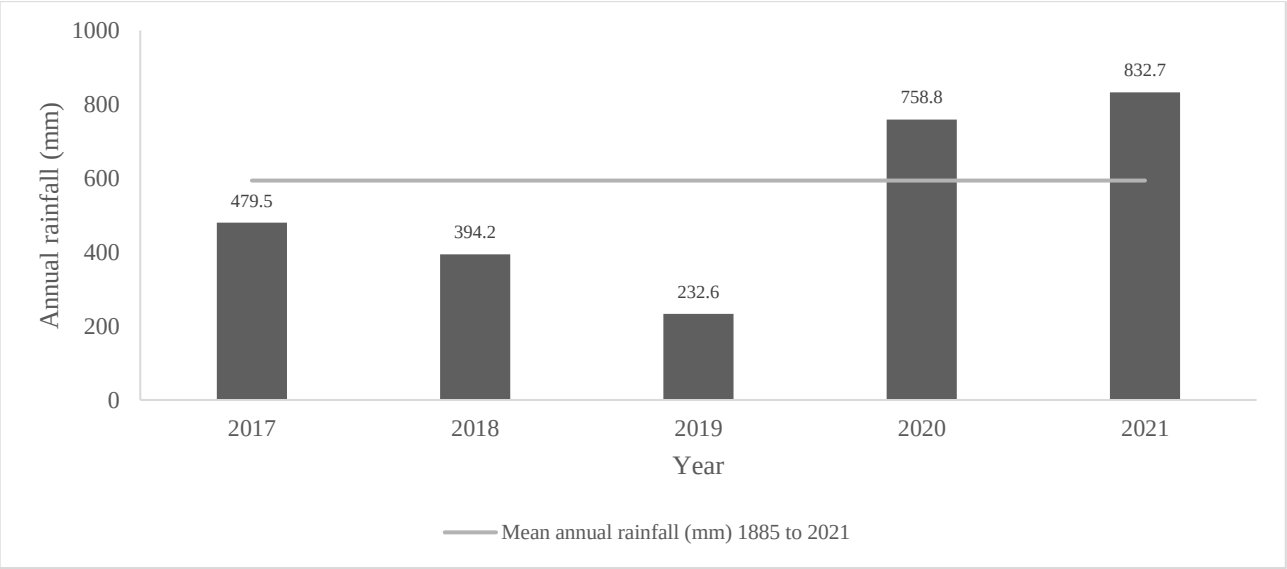
The general methodology for undertaking this assessment included:

- Obtain satellite data (Landsat-8).
- Calculate the SAVI results from obtained satellite images using ArcGIS software.
- Overlay and sample against PCTs in the Nagero Creek study area, high-potential GDE polygons along Goonbri Creek and Bollol Creek within the regional study area, and the Leard State Forest reference site.

Imagery catalogues controlled by NSW Spatial Services were reviewed for mapping data useful in undertaking an analysis of leaf greenness. Landsat-8 has captured data from 2017 to present, with earlier captures being Landsat-7. Large gaps of missing data were observed in some years (e.g., 2005 and 2010) for the project locality. Two years of Landsat-8 were selected 2018 and 2021, where enough data was available to undertake the assessment. Based on climate data, these years represent one year of below average rainfall (2018) and one year of above average rainfall (2021) (Figure 4.3).

Rainfall data

Figure 4.3 illustrates annual rainfall recorded for the Boggabri Post Office Automatic Weather Station (AWS) 55007 (Bureau of Meteorology, 2022) between 2017 and 2021. The annual rainfall figure for 2019, however, is taken from the Gunnedah Airport AWS 55202, as a complete set of annual rainfall was not available from the Boggabri Post Office AWS. The mean annual rainfall of 593.3 mm depicted in Figure 4.3 is the long-term average derived from the Boggabri Post Office AWS, where rainfall records commenced in 1884 (Bureau of Meteorology, 2022).



Source: BOM Boggabri Post Office (AWS 55007)

Figure 4.3 Comparison of mean annual rainfall (mm) from 2017 to 2021 against mean annual rainfall (mm) as averaged between 1885-2021

Data analysis

Normalised Difference Vegetation Index

The NDVI is a standardised index allowing the generation of an image displaying greenness, which is also known as relative biomass. This index uses the contrast of characteristics between two bands from a multispectral raster dataset – the chlorophyll pigment absorption in the red band and the high reflectivity of plant material in the near-infrared band. Extremely low or negative values represent areas with no vegetation at all, such as cloud, water, or snow. Very low values represent areas of little to no vegetation, such as concrete, rock, or bare soil. Moderate values represent areas of shrubs and grassland. High values represent forest areas and lush vegetation.

Soil Adjusted Vegetation Index

Soil Adjusted Vegetation Index (SAVI) is used to correct NDVI for the influence of soil brightness in areas where vegetative cover is low.

SAVI is calculated as a ratio between the Red and Near InfraRed values with a soil brightness, a soil correction factor (L) is used to reduce the influence of soil brightness. The soil correction factor ranges from 0–1 (Almutairi et al., 2013). Vani and Mandlea (2017) concluded that a soil correction factor of 0.5 was best suited to forest vegetation in comparison to other land use types such as wasteland, agricultural, urban areas, fallow land and waterbodies.

Like any normalised difference index, SAVI values can range from -1 to 1. High SAVI values indicate denser, healthier vegetation, whereas lower values indicate less potency. The following SAVI categories were measured during this analysis:

- 0 – <0.2
- 0.2 – <0.4
- 0.4 – <0.6
- 0.6 – <0.8
- 0.8 or greater.

Nagero Creek study area

The following PCTs were sampled due to their potential for impact associated with groundwater drawdown:

- PCT 101 Poplar Box – Yellow Box – Western Grey Box grassy woodland on cracking clay soils mainly in the Liverpool Plains, Brigalow Belt South Bioregion
- PCT 599 Blakely's Red Gum – Yellow Box grassy tall woodland on flats and hills in the Brigalow Belt South Bioregion and Nandewar Bioregion.

Regional study area (Goonbri Creek and Bollol Creek)

The regional study area was sampled specifically with regard to Goonbri Creek and Bollol Creek as shown on Figure 4.9 and Figure 4.11. Aside from the updated terrestrial GDE assessment presented in Section 4.4.2, the location and boundaries of PCTs associated with these drainage lines, outside of BCM owned land, is known from State Vegetation Mapping Projects; specifically State Vegetation Type Map: Border Rivers Gwydir/Namoi Region V2.0 VIS_ID 4467 (Office of Environment & Heritage, 2016).

As there are inaccuracies associated with this broad-scale vegetation mapping, particularly along parts of Bollol Creek, analysis was completed by calculating SAVI values within the boundaries of High Potential Terrestrial GDEs (Bureau of Meteorology, 2021) mapped along theses drainage lines. Separate analysis was undertaken for Goonbri Creek and Bollol Creek, which is presented below under regional study area and illustrated on Figure 4.6 and Figure 4.7 respectively.

Leard State Forest reference site

For the analysis of vegetation patches associated with drainage lines and alluvial plains for their potential connection to groundwater sources, it was considered appropriate to provide an analysis for an area generally not considered to have groundwater dependence. A reference site was selected within the larger forest remnant where PCTs are unlikely to be groundwater-dependent. The reference site was also selected for its distance from advancing mine operations in the Leard Forest Mining Precinct.

4.3.1.2 Results

Nagero Creek study area

Figure 4.4 illustrates the difference between SAVI values recorded for PCT 101 in 2018 and 2021, based on 30 m x 30 m pixels. Approximately 60% of SAVI values were associated with little greenness (0.2 – <0.4 and 0.4 – <0.6) in 2018, a period with below average rainfall, whilst areas of high greenness (0.6 – <0.8 and 0.8 or greater) predominated in 2021, a period associated with above-average rainfall (Figure 4.3).

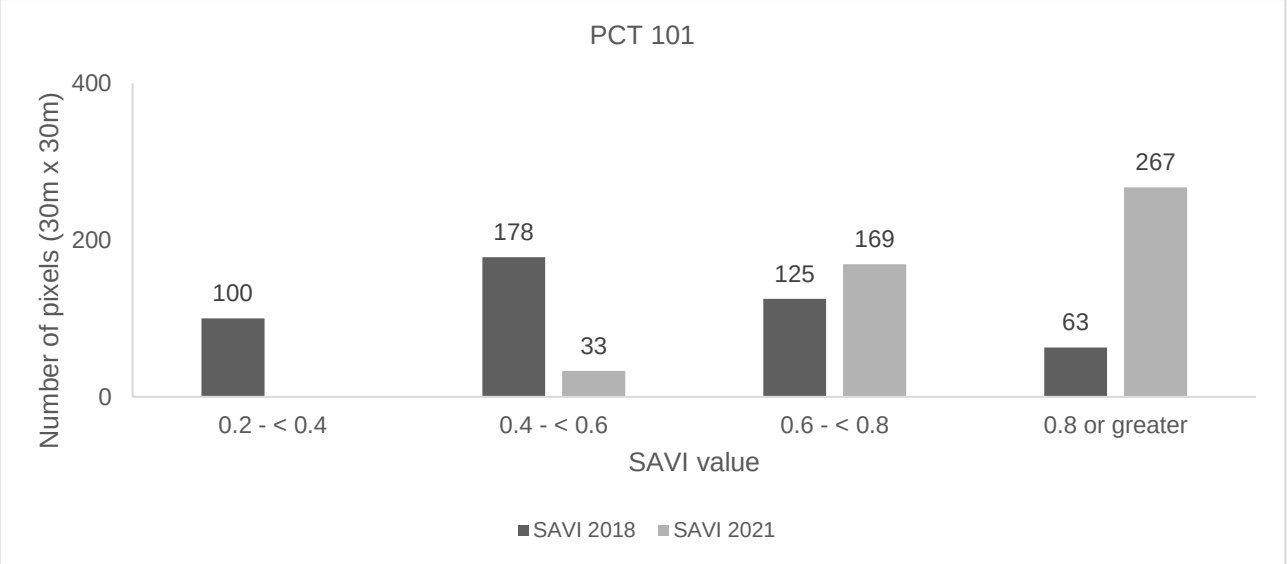


Figure 4.4 SAVI values for PCT 101 between 2018 and 2021

Figure 4.5 illustrates the difference between SAVI values recorded for PCT 599 in 2018 and 2021. It was observed that 68% of SAVI values in 2018 related to relatively high greenness (0.6 – <0.8 and 0.8 or greater) during a period allocated with below average rainfall (Figure 4.3). In 2021, the same SAVI values indicating relatively high greenness predominated, albeit with a substantial increase (~83%) in the 0.8 or greater value.

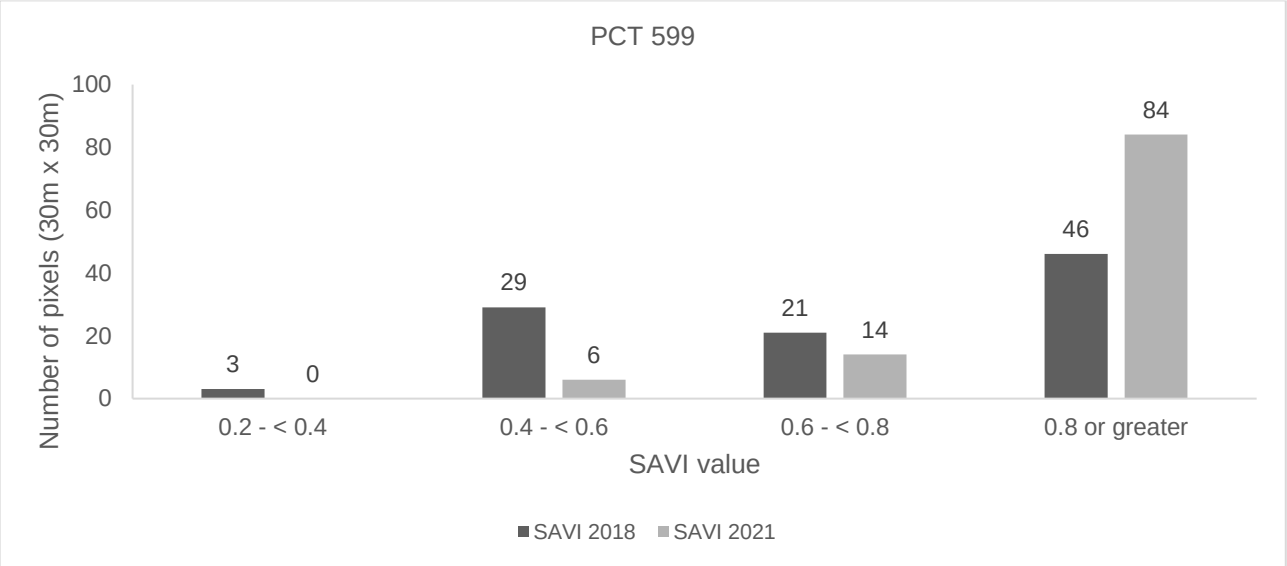


Figure 4.5 SAVI values for PCT 599 between 2018 and 2021

Regional study area

Goonbri Creek

Figure 4.6 exhibits the difference between SAVI values recorded in areas mapped as High Potential Terrestrial GDEs along Goonbri Creek in 2018 and 2021. It was observed that 55% of SAVI values in 2018 were linked with relatively high greenness (0.6 – <0.8 and 0.8 or greater) during a period allocated with below average rainfall (Figure 4.3). In 2021, there was an 80% reduction in the combined 0.2 – <0.4 and 0.4 – <0.6 SAVI values and an obvious (216%) increase in the 0.8 or greater category.

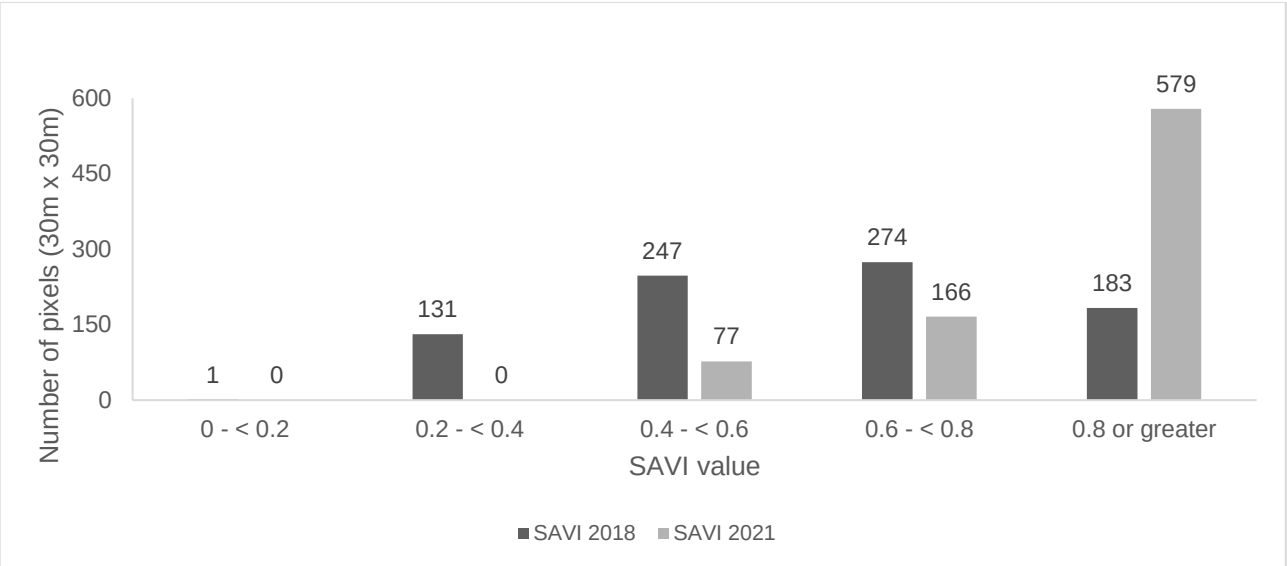


Figure 4.6 SAVI values for areas mapped as high-potential terrestrial GDEs along Goonbri Creek between 2018 and 2021

Bollol Creek

Figure 4.7 shows the difference between SAVI values recorded in areas mapped as High Potential Terrestrial GDEs along Bollol Creek in 2018 and 2021. In 2018, approximately 34% of SAVI values occurred with relatively high greenness and 66% were associated with values of lower greenness. In 2021, there was an 83% reduction in the combined 0.4 – <0.6 and 0.6 – <0.8 SAVI values and a 361% increase in the 0.8 or greater category.

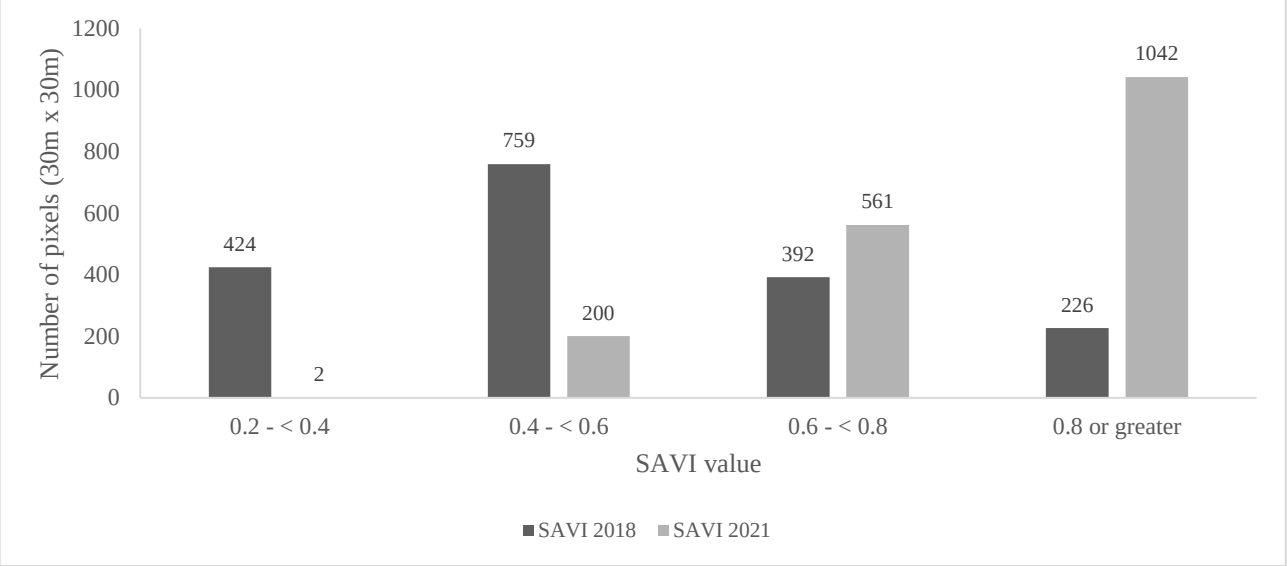


Figure 4.7 SAVI values for areas mapped as high-potential terrestrial GDEs along Bollol Creek between 2018 and 2021

Leard State Forest reference site

Figure 4.8 illustrates the difference between SAVI values recorded for Leard State Forest reference site in 2018 and 2021. It was observed that 90% of SAVI values in 2018 were associated with a high greenness value of 0.8 or greater (Figure 4.3). In 2021, the same SAVI value indicating high greenness predominated, with a small increase from 2018.

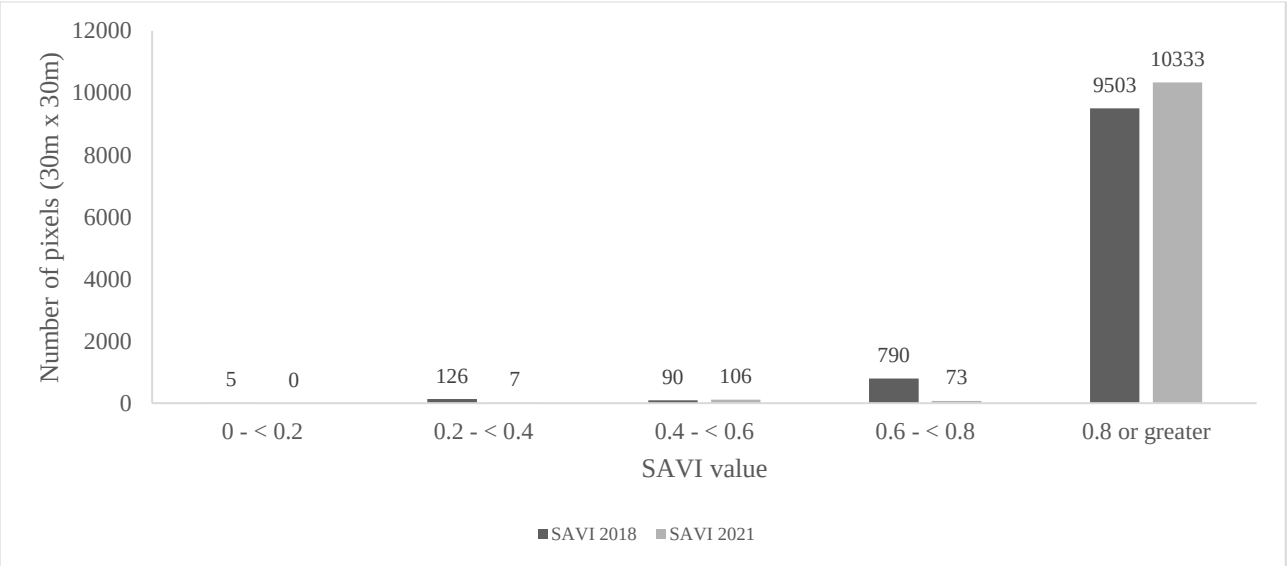


Figure 4.8 SAVI values for Leard State Forest reference site between 2018 and 2021

Comparison of study areas

An analysis of leaf green index was undertaken to examine the potential connection to groundwater between PCTs located on alluvial plains or occurring as linear strips of riparian vegetation lining ephemeral drainage lines in the vicinity of BCM and the Leard State Forest. It was observed that PCT 101, which is located on an alluvial plain in association with Nagero Creek, mostly contained values associated with little greenness in 2018 (below average rainfall year). In 2021 (above average rainfall year) values associated with higher levels of greenness predominated with an approximate 324 % increase in the 0.8 or greater category. Whilst a connection with sub-surface water cannot be ruled out, this data indicates that PCT 101 is reliant on soil moisture and is unlikely to be groundwater dependent. In contrast, PCT 599 exhibited approximately 70% of SAVI values linked to relatively high greenness during the period associated with below average rainfall. The same values indicating high greenness predominated in 2021, albeit with a significant increase in the highest SAVI category. Whilst it could be suggested that PCT 599 may have a connection with sub-surface water, be it a perched water table or subsurface aquifer, this is confounded by the Leard State Forest reference site.

The Leard State Forest reference site was selected within the larger forest remnant where PCTs are unlikely to be groundwater-dependent. In 2018, approximately 90% of values returned in the Leard State Forest reference site were associated with the highest SAVI category. Therefore, as PCT 599 in the Nagero Creek study area occurred as intact patches of vegetation, it is possible that there is no substantial difference between the reference site and PCT 599; both having recorded high SAVI values in 2018 and 2021. Consequently, it is difficult to assign cause and effect. An alternative explanation could include that rainfall received in 2018 (approximately 66 % of the long-term average) was not of a sufficient shortfall to affect SAVI values as determined by plant photosynthetic activity and associated biomass.

Similarly to the contrast observed in the Nagero Creek study area, there was a difference between areas of High Potential Terrestrial GDEs mapped along Goonbri Creek and Bollol Creek. Approximately 55% of SAVI values associated with Goonbri Creek were related to relatively high greenness during the below average rainfall year, whereas 66 % of SAVI values were linked to values of low greenness along Bollol Creek. In 2021, an above average rainfall year, both drainage lines observed significant increases in values associated with high levels of greenness, which is likely attributable to increased surface/soil moisture.

12 July 2018

4 July 2021

MAULES CREEK
HARPARARY ROAD
THERRIBRI ROAD
ELLERSLIE ROAD
TESTON LANE
BACK CREEK ROAD
BROWNS LANE
BOUNDARY TRAIL
BACK CREEK
ILEARDS FOREST ROAD
TRANTHAM ROAD
GOONBRI CREEK
MALLEE LANE
DRIPPING ROCK ROAD
MERROWN CREEK
'NAGERO CREEK'
WARNERS ROAD
NAMOI RIVER
GOONBRI ROAD
BOLLOL CREEK
BLAIRATHOL LANE
THUNDERBOLTS ROAD
BARBER LAGOON
RANGARI ROAD
VINE LANE
FINCHS LANE
BOGGABRI
COX CREEK
BYNALONG ROAD
FLOOD HILL ROAD
BRAYMONT ROAD
HOAD LANE

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0 1 2 Kilometres

Scale 1:115,000

Projection: Transverse Mercator
Coordinate System: GDA 1994 MGA Zone 56
Scale correct when printed at A3 Landscape

Imagery: U.S. Geological Survey, Landsat 8 Collection 2 Level 2, 12/07/2018 and 04/07/2021

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DRAWING.	BC2025_F004_9_Overview_SoilVegetationIndex_SAVI_r1v2
AUTHOR.	A. Carrillo
REVIEW	N. Cooper
DATE.	10/04/2025

Legend

- Regional Study Area
- Nagero Creek Study Area
- Leard State Forest Reference Site
- Boggabri Coal Mine Approval Area
- Maules Creek Coal Mine Approval Area
- Tarrawonga Coal Mine Project Approval Area
- Road
- Watercourse
- Cadastre

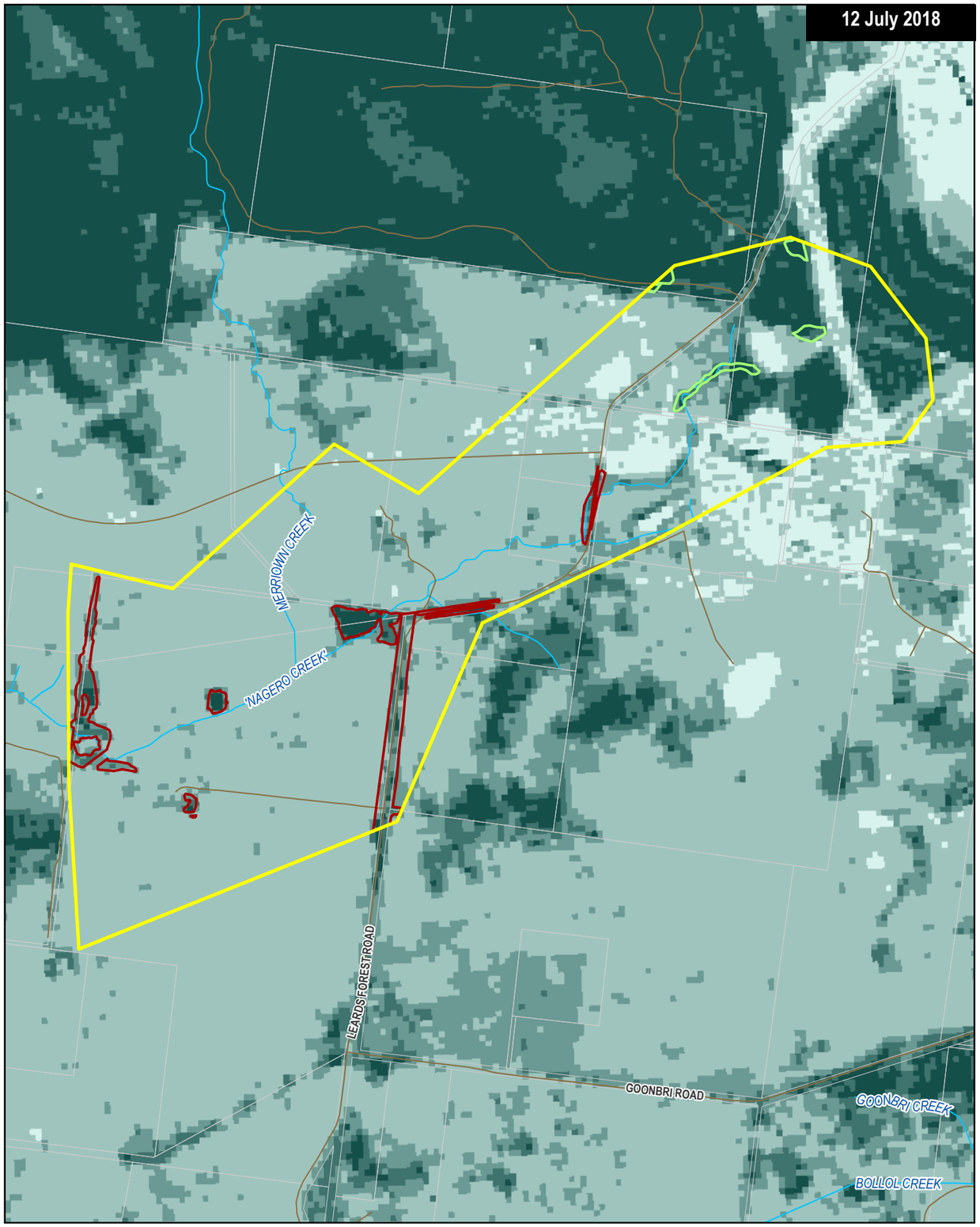
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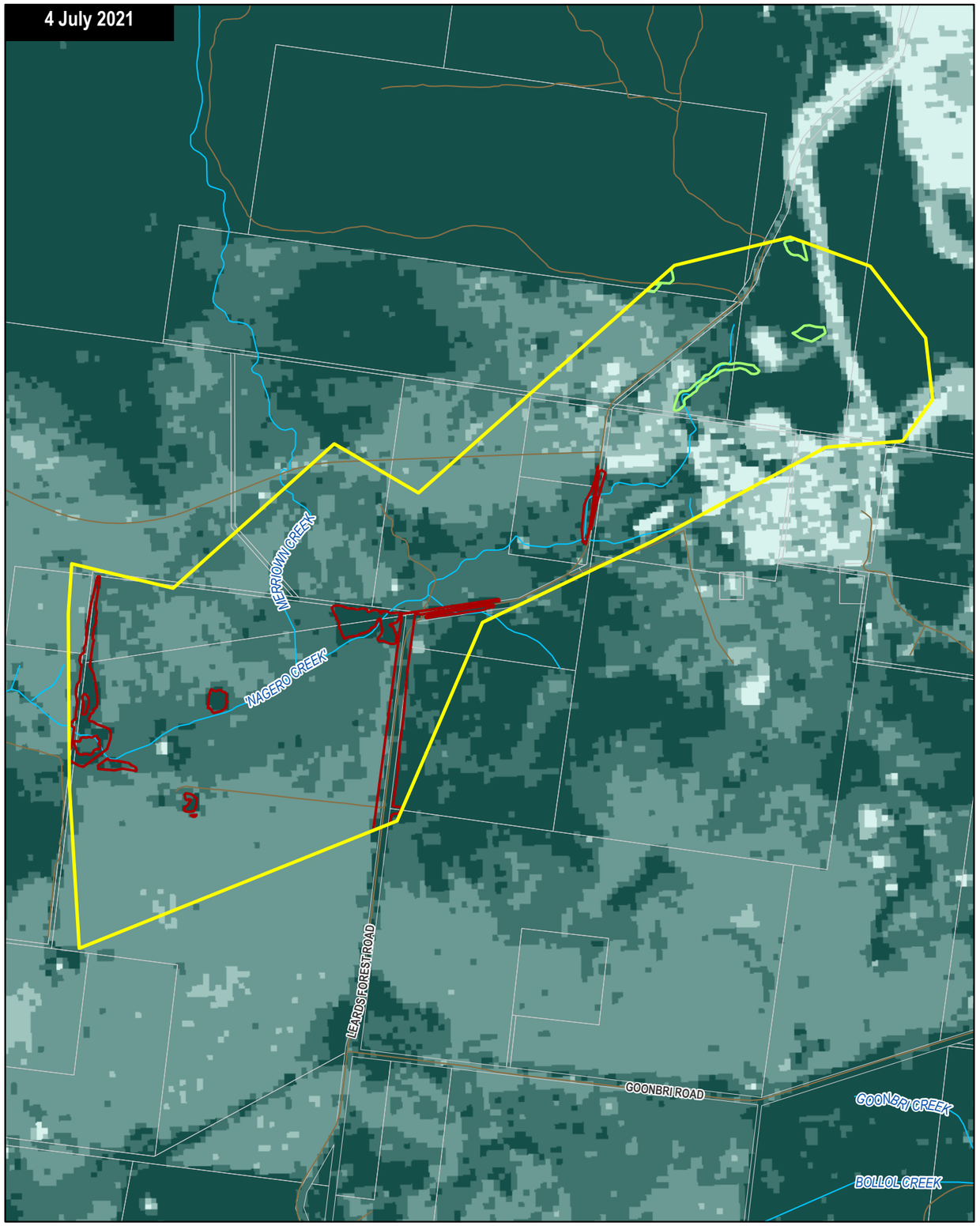
- 0 - < 0.2
- 0.2 - < 0.4
- 0.4 - < 0.6
- 0.6 - < 0.8
- >= 0.8

FIGURE **4.9**

TITLE. **OVERVIEW OF SOIL ADJUSTED VEGETATION INDEX (SAVI) COMPARISON (2018 AND 2021)**

DRAWING PATH. C:\Users\AUAC507280\WSP O365\Boggabri GIS-Ecology - General\5_Shared\54_Production\Maps\2025\Environment\Groundwater\BC2025_F004_9_Overview_SoilVegetationIndex_SAVI_r1v1\BC2025_F004_9_Overview_SoilVegetationIndex_SAVI_r1v2.aprx





0 0.25 0.5 Kilometres

Scale 1:25,000

Projection: Transverse Mercator
Coordinate System: GDA 1994 MGA Zone 56
Scale correct when printed at A3 Landscape

Imagery: U.S. Geological Survey, Landsat 8 Collection 2 Level 2, 12/07/2018 and 04/07/2021

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DRAWING. BC2025_F004_10_NageroCk_SAVI_r1v1

AUTHOR. A. Carrillo

REVIEW N. Cooper

DATE. 21/03/2025

Legend

- Nagero Creek Study Area
- Road
- Watercourse
- Cadastre
- PCT101 - Poplar Box - Yellow Box - Western Grey Box grassy woodland on cracking clay soils mainly in the Liverpool Plains, Brigalow Belt South Bioregion
- PCT599 - Blakely's Red Gum - Yellow Box grassy tall woodland on flats and hills in the Brigalow Belt South Bioregion and Nandewar Bioregion

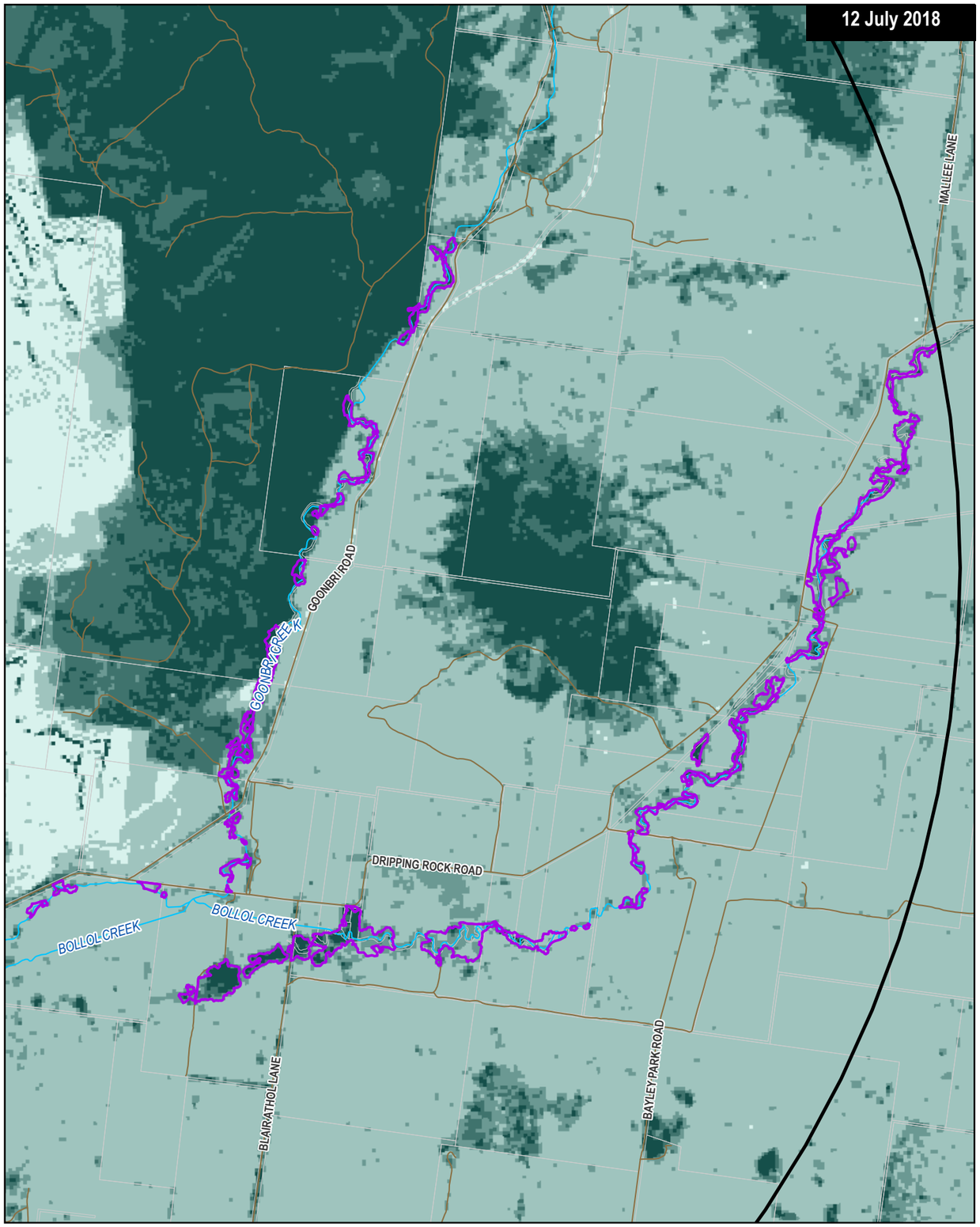
SAVI range

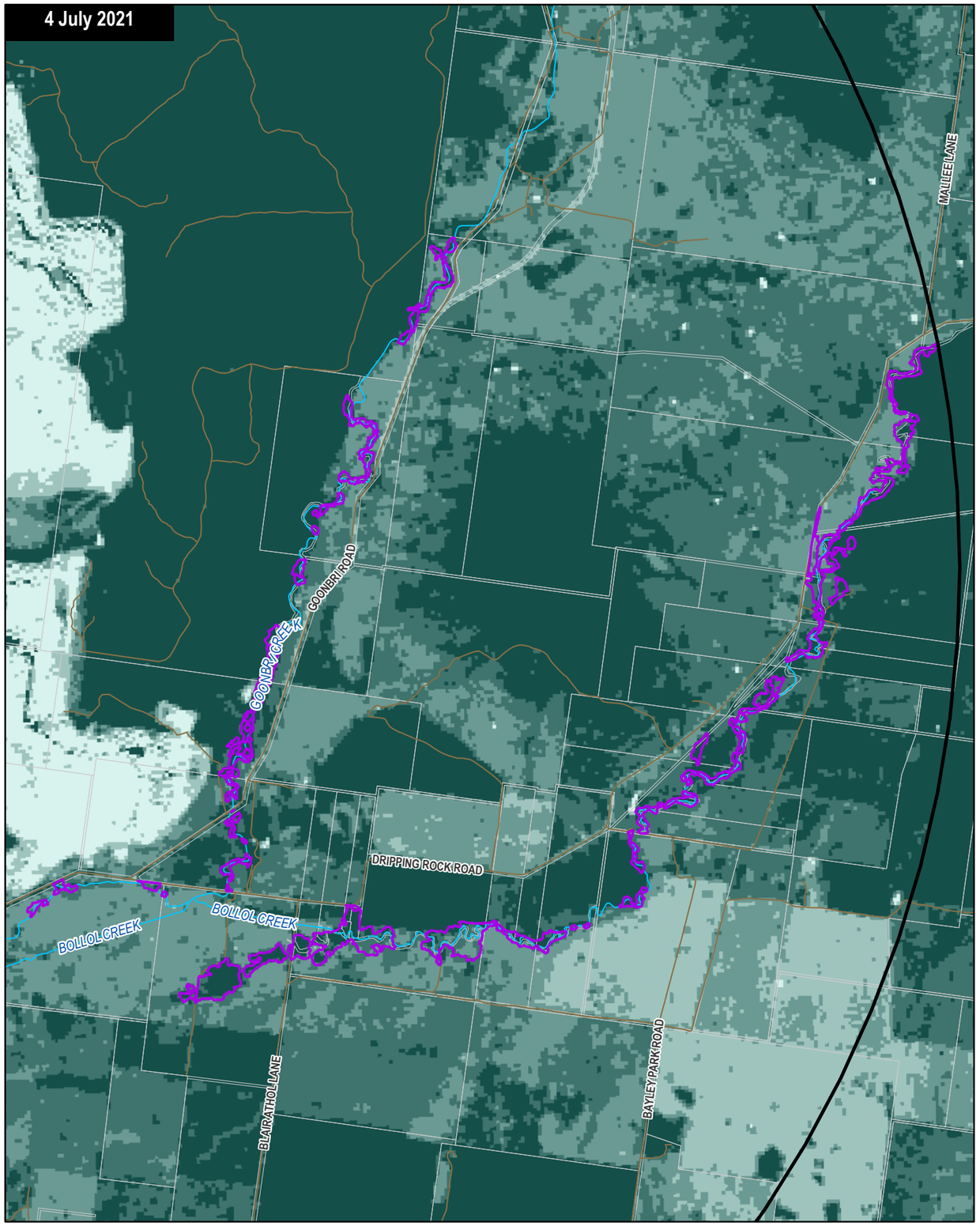
- 0 - < 0.2
- 0.2 - < 0.4
- 0.4 - < 0.6
- 0.6 - < 0.8
- >= 0.8

FIGURE **4.10**

TITLE. **NAGERO CREEK STUDY AREA - SOIL ADJUSTED VEGETATION INDEX (SAVI) COMPARISON (2018 AND 2021)**

DRAWING PATH. C:\Users\AUAC507280\WSP O365\Boggabri GIS-Ecology - General\5_Shared\54_Production\Maps\2025\Environment\Groundwater\BC2025_F004_10_NageroCk_SAVI_r1v1\BC2025_F004_10_NageroCk_SAVI_r1v1.aprx





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Scale 1:42,000

Projection: Transverse Mercator
Coordinate System: GDA 1994 MGA Zone 56
Scale correct when printed at A3 Landscape

Imagery: U.S. Geological Survey, Landsat 8 Collection 2 Level 2, 12/07/2018 and 04/07/2021

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DRAWING. BC2025_F004_11_RegionalCks_SAVI_r1v2

AUTHOR. A. Carrillo

REVIEW N. Cooper

DATE. 10/04/2025

Legend

- Regional Study Area
- Road
- Watercourse
- Cadastre
- High potential terrestrial GDE

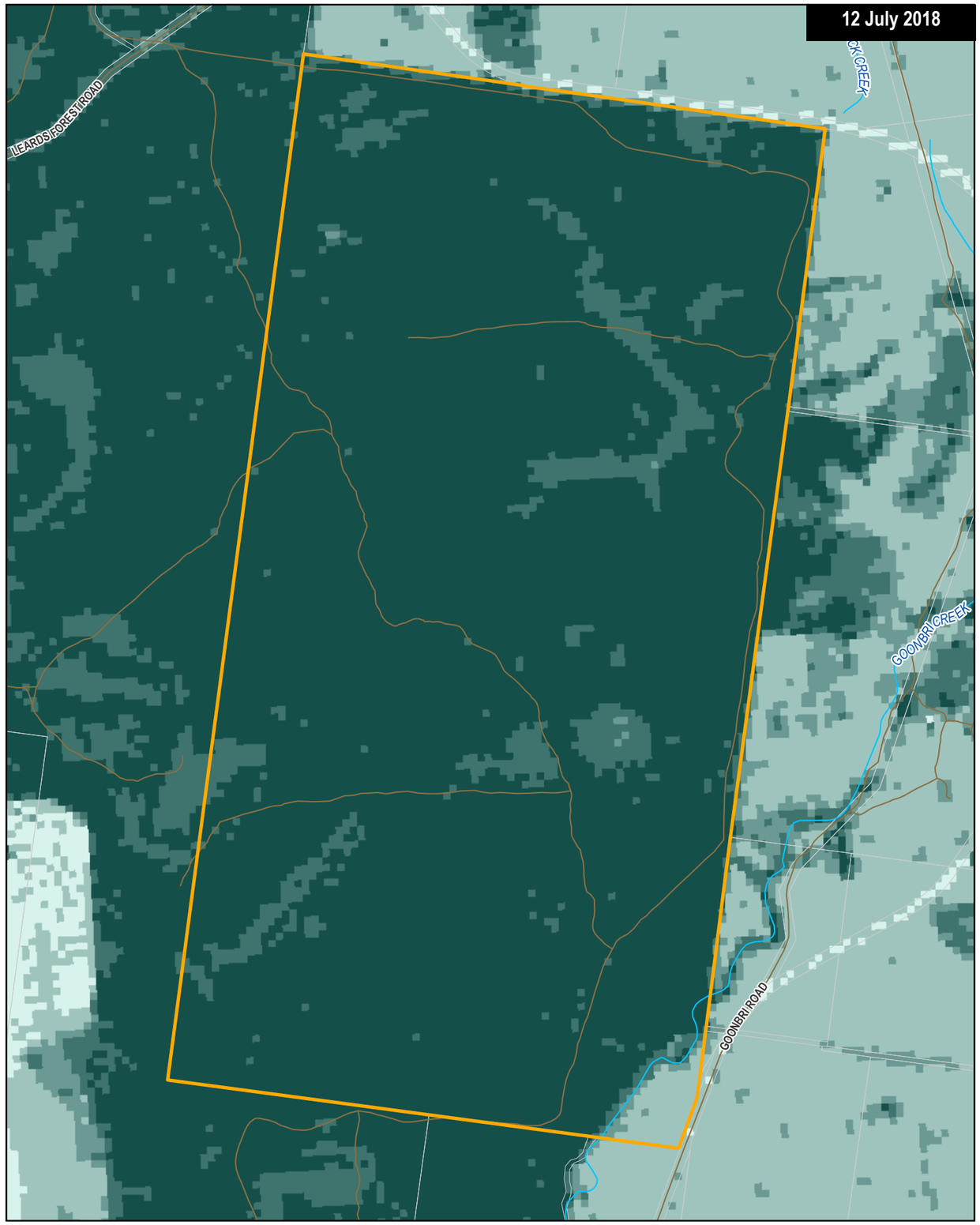
SAVI range

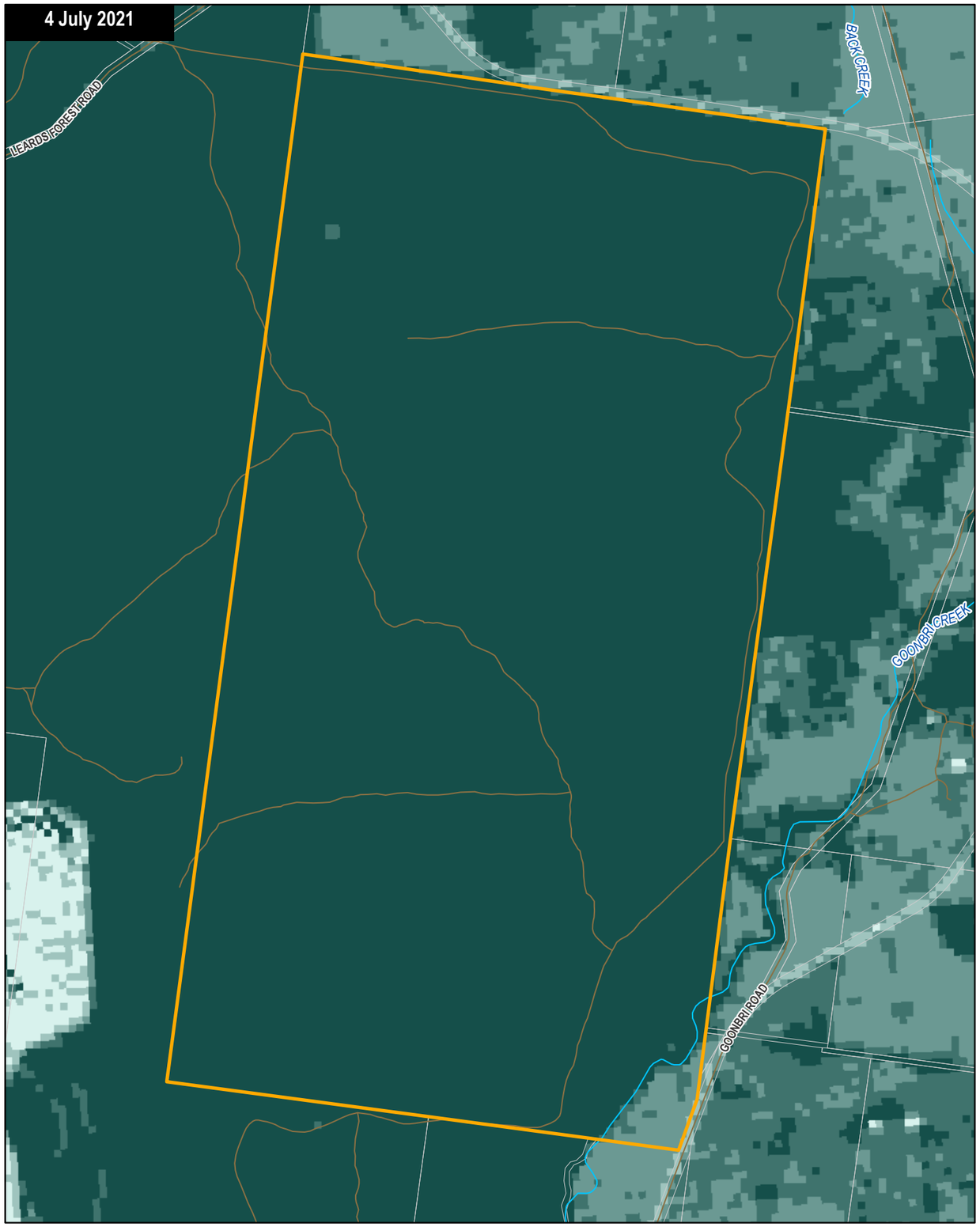
- 0 - < 0.2
- 0.2 - < 0.4
- 0.4 - < 0.6
- 0.6 - < 0.8
- >= 0.8

FIGURE **2.11**

TITLE. **REGIONAL STUDY AREA (GOONBRI AND BOLLOL CREEKS) - SOIL ADJUSTED VEGETATION INDEX (SAVI) COMPARISON (2018 AND 2021)**

DRAWING PATH. C:\Users\AUAC507280\WSP O365\Boggabri GIS-Ecology - General\5_Shared\54_Production\Maps\2025\Environment\Groundwater\BC2025_F004_11_RegionalCks_SAVI\BC2025_F004_11_RegionalCks_SAVI_r1v2.aprx





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0 0.25 0.5 Kilometres

Scale 1:20,000

Projection: Transverse Mercator
Coordinate System: GDA 1994 MGA Zone 56

Scale correct when printed at A3 Landscape

Imagery: U.S. Geological Survey, Landsat 8 Collection 2 Level 2, 12/07/2018 and 04/07/2021

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DRAWING. BC2025_F004_12_LeardStateForest_SAVI_r1v2

AUTHOR. A. Carrillo

REVIEW N. Cooper

DATE. 10/04/2025

Legend

- Leard State Forest Reference Site
- Road
- Watercourse
- Cadastre

SAVI range

- 0 - < 0.2
- 0.2 - < 0.4
- 0.4 - < 0.6
- 0.6 - < 0.8
- >= 0.8

FIGURE **2.12**

TITLE. **LEARD STATE FOREST REFERENCE SITE - SOIL ADJUSTED VEGETATION INDEX (SAVI) COMPARISON (2018 AND 2021)**

DRAWING PATH. C:\Users\AUAC507280\WSP O365\Boggabri GIS-Ecology - General\5_Shared\54_Production\Maps\2025\Environment\Groundwater\BC2025_F004_12_LeardStateForest_SAVI\BC2025_F004_12_LeardStateForest_SAVI_r1v2.aprx

4.4 Vegetation health monitoring

4.4.1 BCM monitoring

BCM currently implements monitoring programs that sample and analyse vegetation health within the alluvial plain in association with Nagero Creek and the Namoi River (Figure 6.1), including:

- Stream and riparian vegetation health monitoring.
- Terrestrial GDE monitoring.

Monitoring to date indicates that the condition of terrestrial vegetation health has remained relatively consistent since the commencement of the monitoring programs in 2018 (WSP, 2024). Vegetation attributes associated with floristic composition, structure and functionality were consistent with or only showed slight increases/decreases in values since 2018. Fluctuations in some vegetation attribute values, such as percent overstorey cover, have been observed, but this is likely attributable to severe drought conditions experienced between 2017 and 2019. Furthermore, such fluctuations were within the boundaries of the probable mean as predicted by the standard error (WSP, 2024).

4.4.2 Updated vegetation survey of potential GDEs located in Bollol and Goonbri Creeks

At the recommendation of the IESC an updated assessment of community composition, canopy cover, and tree condition was completed in accessible locations of potential GDEs located in Bollol Creek and Goonbri Creek (in the regional study area) for BCMs MOD 8 (WSP, 2022). This survey was undertaken to determine whether changes in populations had occurred since mining commenced in the Leard State Forest Mining Precinct and to provide a more recent baseline against which to assess potential impacts.

4.4.2.1 Previous vegetation sampling

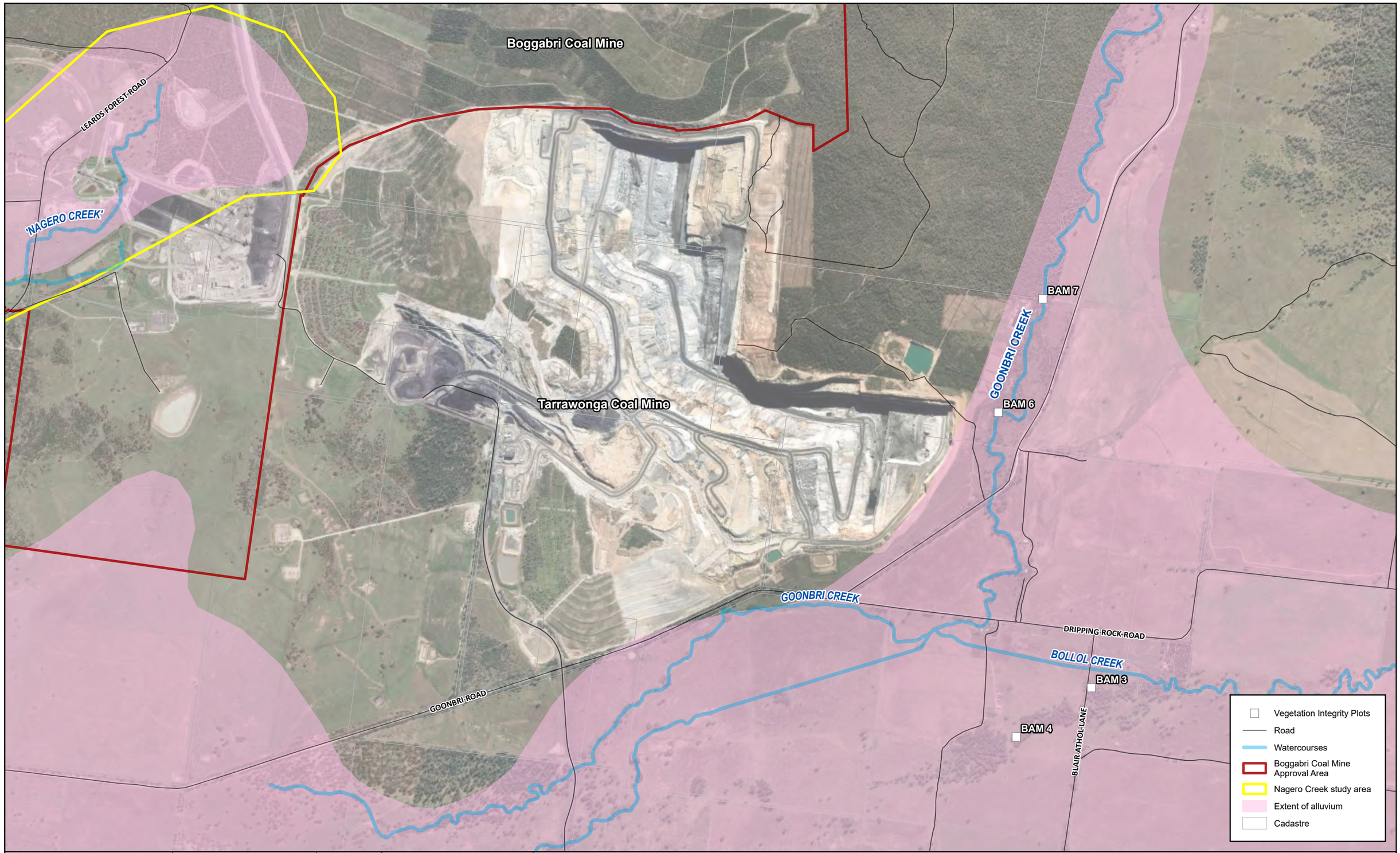
As part of TCMs Environmental Assessment for the continuation and extension of their operations (Resource Strategies, 2011), a flora assessment was undertaken to sample and map vegetation using standard flora survey techniques (FloraSearch, 2011). This assessment incorporated Goonbri Creek, which drains the eastern side of the Willow Tree Range in Leard State Forest, Middle Mountain and Goonbri Mountain, and Bollol Creek, which occurs as a low non-incised drainage line, draining west from the Nandewar Range.

Vegetation mapped in association with Goonbri Creek and Bollol Creek consisted of Bracteate Honeymyrtle Low Riparian Forest (FloraSearch, 2011). Based on contemporary PCTs used in the NSW BioNet Vegetation Classification System (NSW Environment and Heritage, 2025), this vegetation community is consistent with PCT 112 Black Tea-tree – River Oak – Wilga riparian low forest/shrubland wetland of rich soil depressions in the Brigalow Belt South Bioregion.

4.4.2.2 BCM MOD 8 vegetation sampling

Updated vegetation sampling was completed in accessible lands (Whitehaven Coal owned land) in September 2022 (WSP, 2022), whereby four vegetation integrity plots were completed in accordance with the BAM (Department of Planning Industry and Environment, 2020a) (Figure 4.13). One terrestrial PCT was recorded along Bollol Creek and Goonbri Creek being:

- PCT 112 Black Tea-tree – River Oak – Wilga riparian low forest/shrubland wetland.



Map: BC2025_F004_13_Vegetation_Plots_Bollol_Goonbri_Cks_r1v3	Author: A. Carrillo		0 250 500 Meters 1:20,000 Coordinate system: GDA 1994 MGA Zone 56 Scale ratio correct when printed at A3
Date: 10/04/2025	Approved by: N. Cooper		
Data source: World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community			

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BOGGABRI COAL MINE MOD 10 GROUNDWATER DEPENDENT ECOSYSTEM ASSESSMENT

Figure 4.13
Vegetation Integrity Plots along Bollol and Goonbri Creeks

PCT 112 was dominated by a dense canopy of *Melaleuca bracteata* (Black Tea-tree), a sparse shrub layer of juvenile *Melaleuca bracteata* (Black Tea-tree) and *Geijera parviflora* (Wilga). The ground layer was dominated by exotic species in Bollol Creek (BAM 3 and 4), whilst the groundlayer in Goonbri Creek was dominated by a dense layer of sedges (BAM 6 and 7). Goonbri Creek had a defined creek bank, which contained flowing water during the survey, whereas Bollol Creek occurred as a low, non-incised drainage line. Trees were considered in good condition, with no dieback or dead trees present in either Bollol Creek or Goonbri Creek (Photo 4.1 to Photo 4.4). PCT 112 along Bollol Creek and Goonbri Creek was assessed in moderate condition, as detailed below (WSP, 2022).

PCT 112 Black Tea-tree – River Oak – Wilga riparian low forest/shrubland wetland of rich soil depressions in the Brigalow Belt South Bioregion

PCT 112 Black Tea-tree – River Oak – Wilga riparian low forest/shrubland wetland was recorded in both Goonbri and Bollol Creeks. The location of the vegetation integrity plots completed within PCT 112 are illustrated in Figure 4.13. A profile of PCT 112 is provided in Table 4.2 and the community is depicted in Photo 4.1 to Photo 4.4.

Table 4.2 Description of PCT 112 Black Tea-tree – River Oak – Wilga riparian low forest/shrubland wetland along Goonbri and Bollol Creeks

PCT 112 Black Tea-tree – River Oak – Wilga riparian low forest/shrubland wetland			
Conservation status	Not listed		
Percent cleared	67%		
Vegetation Class	Inland Riverine Forests		
Vegetation Formation	Forested Wetlands		
Condition	Moderate condition – low to moderate diversity of native species with BAM 3 and 4 on Bollol Creek containing high density weed diversity and cover.		
Strata	**Height range & average**	**Percentage Foliage Cover range**	**Dominant Species**
Emergent	18-20 m	0-5%	*Angophora floribunda* (Rough-barked Apple)
Canopy	10-15 m	20-60%	Dominated by *Melaleuca bracteata* (Black Tea-tree)
Shrub	1.5-5 m	0-20%	Juvenile *Melaleuca bracteata* (Black Tea-tree) and *Geijera parviflora* (Wilga)
Ground layer	0.1-1.5 m	10-90%	Low diversity of native grasses, sedges and herbs including *Carex appressa* (Tall Sedge), *Carex inversa* (Knob Sedge), *Cyperus gracilis* (Slender Flat-sedge), *Dichondra repens* (Kidney Weed) and *Microlaena stipoides* var. *stipoides.* Common exotic species include *Galium aparine* (Goosegrass), *Sida rhombifolia* (Paddy's Lucerne) and *Ehrharta erecta* (Panic Veltgrass).



Photo 4.1 PCT 112, BAM 3 Bollol Creek



Photo 4.2 PCT 112, BAM 4 Bollol Creek



Photo 4.3 PCT 112, BAM 6 Goonbri Creek



Photo 4.4 PCT 112, BAM 7 Goonbri Creek

PCT 112 condition assessment

A comparison of the field data collected for PCT 112 was conducted against the benchmarks outlined in the BioNet Vegetation Classification System (Department of Planning and Environment, 2023b), to determine the condition of this PCT. The species richness for the shrub stratum was above average for BAM 3, 4 and 6, however the majority of all the remaining stratums species richness were below benchmarks.

The tree cover values were all below benchmark; however, *Melaleuca bracteata* (Black Tea-tree) is classified as a shrub (Department of Planning and Environment, 2023b). *Melaleuca bracteata* (Black Tea-tree) was the dominant canopy species and, if it was classified as a tree, the tree cover for BAM 3, 4 and 7 would meet or exceed the benchmark for tree cover. The shrub layer cover was sparse and did not meet the benchmarks, except for BAM 6. The forb and other covers were all above benchmarks. The large trees were all below benchmark values with the fallen logs being above benchmark values. Log jams from flooding associated with Bollol and Goonbri Creeks were observed during the survey in 2022. The litter covers were all below benchmarks and this was due to the high density of sedges present in the ground layer. Bollol Creek (BAM 3 and 4) had high levels of exotic species cover, with Goonbri Creek (BAM 6 and 7) having a relatively low cover of exotic species. Based on the above assessment it was concluded that PCT 112 was in moderate condition.

4.4.2.3 Comparison of 2011 and 2022 community composition

A single plant species list derived from four vegetation quadrats located along Goonbri Creek and Bollol Creek (Resource Strategies, 2011) were the only historical information returned from desktop searches for comparative analysis of community composition. Information pertaining to canopy cover and tree condition for direct comparison to survey in 2022 was limited to photographic evidence.

The original field-based survey (Resource Strategies, 2011) and recent updated sampling (WSP, 2022) identified that emergent trees such as *Angophora floribunda* (Rough-barked Apple) and *Eucalyptus blakelyi* (Blakely's Red Gum) occur along creeks, whilst a dense shrub layer of *Melaleuca bracteata* (Black Tea-tree) and *Geijera parviflora* (Wilga) are present. Groundcovers have remained similar over time and variously include native grasses, sedges and herbs including, *Carex appressa* (Tall Sedge), *Carex inversa* (Knob Sedge), *Cyperus gracilis* (Slender Flat-sedge), *Dichondra repens* (Kidney Weed), *Microlaena stipoides* var. *stipoides*, *Geranium solanderi* subsp. *Solanderi* (Native Geranium), *Austrostipa verticillata* (Slender Bamboo Grass), *Alternanthera denticulata* (Lesser Joyweed) and *Rumex brownii* (Swamp Dock). The original (2010-2011) survey and recent (2022) updated baseline assessment estimated native species richness at 59% and 53% respectively.

Similarly, a wide range of exotic species are associated with the PCT along Goonbri Creek and Bollol Creek owing to the favourable fertile alluvial soils where this community occurs and land uses. Exotic species richness was estimated at approximately 41% and 47% between the original and updated surveys respectively. Exotic species recorded during the surveys have included *Conyza bonariensis* (Flaxleaf Fleabane), *Sida rhombifolia* (Paddy's Lucerne), *Malva parviflora* (Small-flowered Mallow), *Cyclospermum leptophyllum* (Slender Celery), *Bidens pilosa* (Cobblers Pegs), *Galium aparine* (Goosegrass), *Lolium perenne* (Perennial Ryegrass), *Verbena quadrangularis, Verbena caracasana* and *Medicago polymorpha* (Burr Medic).

Photographic evidence from 2022 (Photo 4.1 to Photo 4.4) show *Melaleuca bracteata* (Black Tea-tree) trees in good condition with no dieback or dead trees present in either Goonbri Creek or Bollol Creek. Consequently, the above comparison suggests that changes in PCT 112 are not likely to have occurred since the approved project commenced.

4.5 Alluvial aquifer ecosystem

Four stygofauna crustacean species, including Notobathynella (Parabathynellidae), Harpacticoid, Syncarida and one unidentified species, have previously been recorded from the alluvial aquifer to the south-west of BCM operations (Austral Research and Consulting, 2024). Stygofauna records associated with BCM monitoring have been recorded from several shallow monitoring bores, including MW6, MWP07, Victoria Park bore, Cooboobindi House bore, and Belleview bore, expanding the local distribution of stygofauna in the alluvium between BCM and the Namoi River. BCOPLs monitoring records support the wider range of stygofaunal species identified in the Gunnedah Coal Basin, which encompasses the Namoi River catchment and the BCM site (Korbel et al., 2013). The occurrence of stygofauna in an aquifer can also be a useful indicator that an aquifer supports a broader ecological community that may include components such as bacteria and the roots of phreatophytic trees (Doody, 2019). As stygofauna are subterranean animals that live in groundwater systems, they can be critical components of the aquifer ecosystem that are themselves entirely dependent on groundwater.

4.6 GDEs in the regional study area

A review of the GDE Atlas (Bureau of Meteorology, 2025) identified one known and one high potential aquatic GDE and 10 high potential terrestrial GDEs mapped in an approximate 10 km radius of MOD 10 subject land (Table 3.2). The location of known and high potential aquatic and terrestrial GDEs is illustrated on Figure 3.1.

The dependence (or interaction) of the vegetation communities identified in the regional study area on groundwater was determined by aligning them with the GDEs types identified by Eamus *et al.* (2006). Table 4.3 describes the PCTs recorded in the regional study area and outlines their potential dependence on groundwater. Based on the desktop assessment and vegetation classification of GDE types identified by Murray *et al.* (2003) and Eamus *et al.* (2006), four PCTs were considered to have potential to be at least partially reliant on access to groundwater and two aquatic systems (Table 4.3).

Table 4.3 Potential GDEs within the regional study area

Ecosystem Type[1]	Hydrological Ecosystem[2]	PCTs[3,6]	EPBC Act[4]	Known Groundwater Dependency[5,6]	Associated Drainage Line
Aquatic	6 – Hypogean	**Namoi River**	–	**Known dependency on groundwater**	Namoi River
Aquatic	6 – Hypogean	**Maules Creek**	–	**Known dependency on groundwater**	Maules Creek
Terrestrial ecosystems	7 – Vadophytic vegetation	PCT 55 Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains	–	No apparent dependency on groundwater	–
	7 – Vadophytic vegetation	PCT 516 Grey Box grassy woodland or open forest of the Nandewar Bioregion and New England Tableland Bioregion	–	No apparent dependency on groundwater	–
	7 – Vadophytic Vegetation	PCT 112 Black Tea-tree – River Oak – Wilga riparian low forest/shrubland wetland	–	No apparent dependency on groundwater	Back Creek, Goonbri Creek, Bollol Creek
	7 – Vadophytic Vegetation	PCT 433 White Box grassy woodland on basalt flats and rises in the Liverpool Plains sub-region, Brigalow Belt South Bioregion	–	No apparent dependency on groundwater	–
River Base Flow	4 – Riparian zone along gaining stream	**PCT 78 River Red Gum riparian tall woodland/open forest**	–	**Proportional dependency on groundwater**	Namoi River
	1 – Terrestrial GDE – potentially accessing water table	**PCT 101 Poplar Box – Yellow Box – Western Grey Box grassy woodland**	E	**Proportional dependency on groundwater**	Back Creek Alluvial floodplains
	1 – Terrestrial GDE – potentially accessing water table	**PCT 244 Poplar Box grassy woodland on alluvial clay-loam soils in the temperate (hot summer) climate zone of central NSW (wheatbelt)**	E	**Proportional dependency on groundwater**	–
	8 – Riparian zone along losing stream	PCT 599 Blakely's Red Gum – Yellow Box grassy tall woodland	CEEC	No apparent dependency on groundwater	Namoi River Bollol Creek
	3 – Wetland dependent on shallow water table	**PCT 53 Shallow freshwater wetland sedgeland in depressions on floodplains on inland alluvial plains**	EEC	**Potential dependency on groundwater**	Namoi River Bollol Creek Maules Creek

Ecosystem Type[1]	Hydrological Ecosystem[2]	PCTs[3,6]	EPBC Act[4]	Known Groundwater Dependency[5,6]	Associated Drainage Line
	3 – Wetland dependent on shallow water table	**PCT 241 River Coobah swamp wetland on the floodplains of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion**	EEC	**Potential dependency on groundwater**	Namoi River

(1) Ecosystem Types as per Eamus *et al*, (2006) and Murray *et al*, (2003).

(2) Hydrological ecosystem classification (Eamus *et al*., 2006).

(3) PCTs mapped as per Office of Environment and Heritage (2016).

(4) CEEC = Critically Endangered Ecological Community, E = Endangered Ecological Community listed under the EPBC Act.

(5) Known groundwater dependency as per Hatton & Evans (1998).

(6) Bold denotes potential groundwater dependency.

5 Potential cumulative impacts

5.1 Nagero Creek study area

5.1.1 Cumulative drawdown impacts

There are three operating mines that have a potential cumulative effect on the alluvial aquifer associated with the Nagero Creek study area, including BCM, TCM and MCCM. At a regional scale, the alluvium is generally thickest within the main Namoi River alluvial plain, thinning towards the edges of the plain and along tributaries (NcNeilage, 2006). There is a small tongue of the alluvial aquifer that is directly adjacent to the south-west corner of BCM, which is associated with the Nagero Creek; a minor watercourse that is fed from the catchment area occupied by BCM (Australian Groundwater & Environmental Consultants Pty Ltd, 2021).

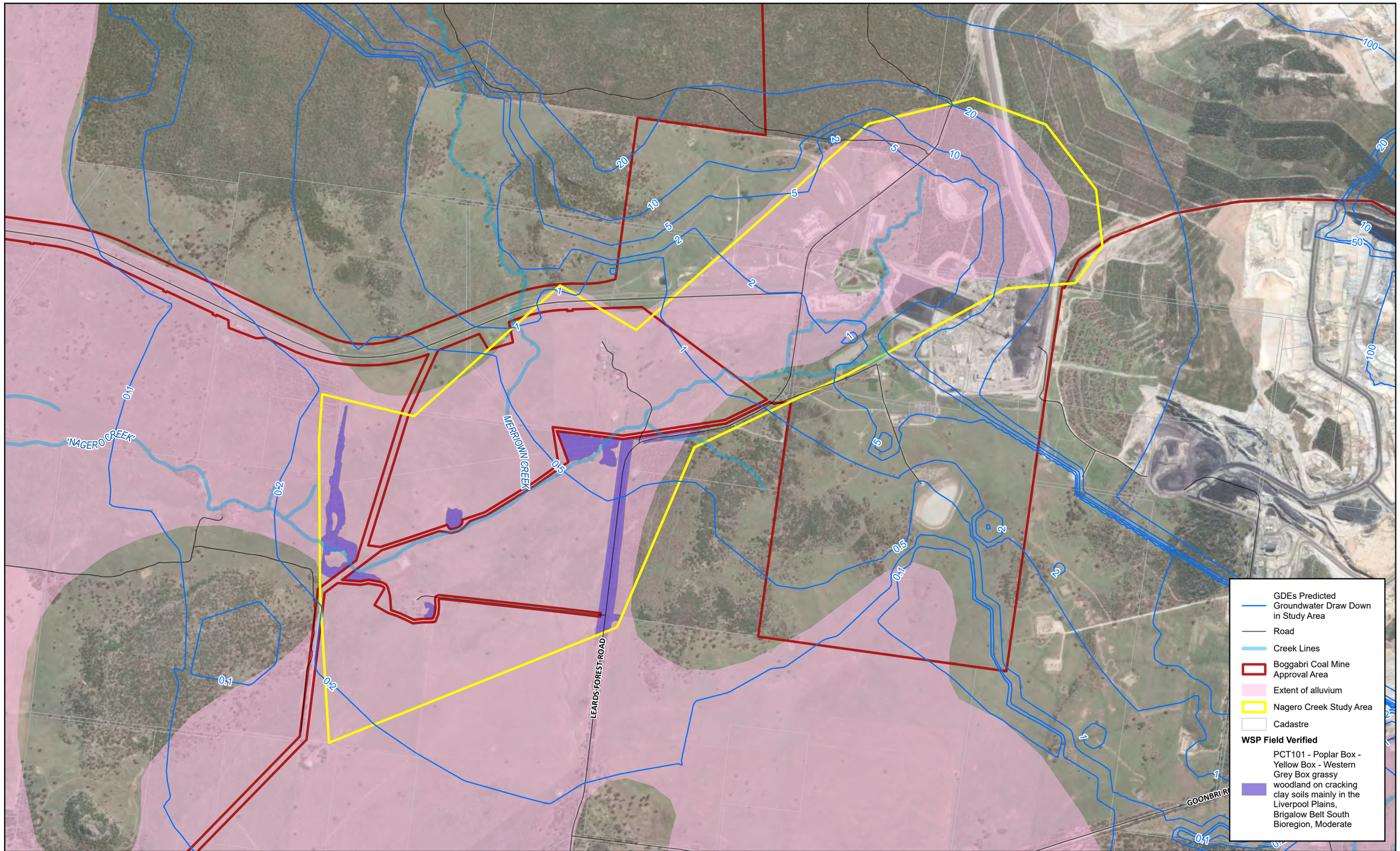
Detailed studies indicate that groundwater levels are typically 7 mbgl to 10 mbgl on the alluvial plain but can be deeper in places upslope towards the outcropping Boggabri Volcanics (Australian Groundwater & Environmental Consultants Pty Ltd, 2010, Boggabri Coal Operations Pty Ltd, 2017a, Australian Groundwater & Environmental Consultants Pty Ltd, 2021). Additionally, groundwater levels can be shallower in the vicinity of drainage depressions and creeks, as observed in areas proximate to Nagero Creek with MW6 (near BCM infrastructure) recording groundwater <5 mbgl during stygofauna sampling in late 2018 (Austral Research and Consulting, 2020).

Mining induced effects to the alluvial groundwater system closest to BCM is conceptualised to occur due to dewatering of coal seams that sub-crop beneath the alluvium. To date, no mining induced effects to the alluvial groundwater system have been observed. Recent groundwater modelling of the BTM Complex and MOD 10 predicts drawdown (i.e., the loss of saturated thickness) to occur only in the eastern fringes of the alluvial tongue closest to BCM directly south-west of BCM on BCOPL owned land (Australasian Groundwater & Environmental Consultants Pty Ltd, 2025). The drawdown in the alluvial tongue attributable to BCM is predicted to reach a maximum of 1.3 m which is consistent with current approved mining (MOD 8). No BCM specific incremental change in the alluvium attributable to MOD 10 was predicted (Australasian Groundwater & Environmental Consultants Pty Ltd, 2025).

Maximum cumulative drawdown predicted in the alluvium is generally less than 2 m for current approved BTM Complex and planned MOD 10. Predicted drawdown exceeds 2 m in a small proportion of the alluvial tongue that is directly south-west of BCM, where a maximum drawdown of 5.1 m is predicted at the very fringes of the alluvium. Drawdown directly attributable to BCM and MOD 10 in this area reaches a maximum of 1.3 m (Australasian Groundwater & Environmental Consultants Pty Ltd, 2025). A maximum drawdown of 3.8 m is predicted in areas near PCT 599 along Nagero Creek, and moving away from the BCM, to the south-west of the Nagero Creek study area, a maximum drawdown of 0.7 m is predicted in the alluvium near patches of field verified PCT 101 (Australasian Groundwater & Environmental Consultants Pty Ltd, 2025).

5.1.2 Potential impacts to GDEs

The Nagero Creek study area has been historically modified for agriculture and much of its original vegetation (canopy and shrub layers) has been removed. Although some small patches of native vegetation exist on the alluvial plain, most of the extant vegetation occurs in adjacent areas of higher elevation, which are comprised of volcanic outcropping. Nevertheless, one remnant native vegetation community recorded on the alluvial plain was considered to have at least a partial dependency on groundwater, being Poplar Box – Yellow Box – Western Grey Box grassy woodland (PCT 101). Several patches of PCT 101 in the Nagero Creek study area were commensurate with the EPBC Act listed Poplar Box Grassy Woodland on Alluvial Plains TEC (Section 3.4.1.2) (WSP, 2022).



Map: BC2025_F005_1_PotentialGDEsNagero_r1v3	Author: A. Carrillo		0 250 500 Meters 1:20,000 Coordinate system: GDA 1994 MGA Zone 56 Scale ratio correct when printed at A3
Date: 10/04/2025	Approved by: N.Cooper		
Data source: World_Street_Map: Esri, HERE, Garmin, NGA, USGS World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community			

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BOGGABRI COAL MINE MOD 10 GROUNDWATER DEPENDENT ECOSYSTEM ASSESSMENT

Figure 5.1

Potential GDEs and Modelled Predicted Cumulative Groundwater Drawdown (Nagero Creek Study Area)

For many terrestrial plants, groundwater forms only part of their overall water balance. Vegetation will extract water from sources where the combination of soil moisture content, root density and hydraulic connectivity requires the least amount of energy (Stygoecologia, 2013). Accordingly, vegetation will use shallow soil water first before seeking groundwater. Where soil water is insufficient to meet plant water requirements, plants that can access groundwater will become increasingly dependent on that water source as soil water is depleted (Howe *et al.*, 2007).

GDEs that rely solely on groundwater are particularly at risk from water level fluctuations due to roots being distributed just above the water table in the vadose zone (the unsaturated zone above the water table). The viability of these GDEs are likely influenced by groundwater regime parameters, such as alteration of water level and pressure regimes (Stygoecologia, 2013). *Eucalyptus* spp. have a dual (dimorphic) root system, with lateral roots that are close to the surface, and a taproot that penetrates deep in the soil (Holloway *et al.*, 2013). Therefore, these species can source water from multiple sources (i.e., surface water, soil moisture after rainfall or flooding, and groundwater). Their reliance and use of groundwater are therefore potentially facultative (optional).

A review of literature of rooting ranging depths by Stygoecologia (2013) found that deeper rooting depths down to 30 mbgl or greater for larger tree species are an exception, with most deep-rooted woody species only extending approximately 10 mbgl. In a study by Kath *et al.* (2014), *Eucalyptus populnea* (Poplar Box) was observed to have a tree condition to groundwater depth threshold between 12.6 mbgl and 26.7 mbgl before the canopy showed signs of dieback, suggesting that the species has extensive tap roots capable of accessing alluvial groundwater.

Patches of Poplar Box – Yellow Box – Western Grey Box grassy woodland (PCT 101) occurring in the Nagero Creek study area were subject to an analysis of leaf green index and correlated with climate data (Section 4.3). This analysis indicated that PCT 101 was reliant on soil moisture. However, as PCT 101, occurring in the Nagero Creek study area typically occur where groundwater levels are around 10 mbgl (Figure 4.2), a connection with sub-surface water cannot be discounted and this community has the potential to be impacted. Cumulative drawdown predicted in the alluvium of the Nagero Creek study area that may affect this terrestrial GDE is less than 1 m for current approved mining and MOD 10. Therefore, it is not likely that this potential terrestrial GDE would be substantially impacted by the modelled groundwater drawdown in the alluvium (Figure 5.1).

5.1.3 Risk assessment

A risk assessment was conducted that considered the method outlined in Serov *et al.* (2012) to determine if the GDEs within the Nagero Creek study area is at high, moderate or low risk from the potential impacts. Based on the risk assessment presented in Serov *et al.* (2012), the alluvial aquifer was considered of high ecological value due to:

- The presence of stygofauna.
- The presence of patches of PCT 101 Poplar Box – Yellow Box – Western Grey Box grassy woodland, some of which meet the condition thresholds of EPBC Act listed Poplar Box Grassy Woodland on Alluvial Plains TEC.

Table 5.1 provides an initial assessment for consideration of the magnitude of the risk to the alluvial aquifer and potential terrestrial GDEs. The assessment allows for a high-level examination of the potential impacts and allows the impacts to be ranked based on a high, medium, or low rating. Cumulative impacts associated with current mining operations and MOD 10 is considered to have a low risk of potential impact to terrestrial GDEs (Table 5.1).

Table 5.1 Aquifer and GDE risk assessment

Risk factor	High	Moderate	Low	Insufficient data
Water quantity asset				
What will be the risk of a change in groundwater levels/pressure on GDEs?	Predicted reduction in groundwater levels beyond seasonal variation	–	–	–

Risk factor	High	Moderate	Low	Insufficient data
What will be the risk of a change in the timing or magnitude of groundwater level fluctuations on GDEs?	Predicted fluctuation in groundwater levels potentially beyond seasonal variation	–	–	–
What will be the risk of changing base flow conditions of GDEs?	–	–	Outside of the mined areas, there is no expected change in the direction of flow	–
Water quality asset				
What is the risk changing the chemical conditions of the aquifer?	–	–	Predicted negligible change	–
What is the risk on the aquifer by a change in the freshwater/saltwater interface?	–	–	Predicted negligible change	–
What is the likelihood of a change in beneficial use on the aquifer?	–	–	Predicted negligible change	–
Aquifer integrity asset				
What is the risk of damage to the geologic structure?	–	–	–	Uncertain
Biological integrity asset				
What is the risk of alterations to the number of native species within the groundwater dependent communities (flora and fauna)?	–	–	Predicted limited reduction to deep-rooted canopy species, however, given partial dependency on groundwater, they are unlikely to be removed completely	–
What is the risk of alterations to the species composition of the groundwater dependent communities (flora and fauna)?	–	–	Predicted negligible change to PCT 101 in the form of potential partial impacts to canopy	–
What is the risk of increasing the presence of exotic flora or fauna?	–	–	Predicted negligible change	–
What is the risk of removing or altering a GDE subtype habitat, e.g., quarrying of limestone around karsts, tramping of cave habitats, sand and gravel extraction?	–	–	–	Uncertain

Risk factor	High	Moderate	Low	Insufficient data
Risk valuation	**2**	**0**	**7**	**2**
Risk			**Low risk**	

Note: These rankings are indicative only and are means of reaching a descriptive rating for the purpose of the risk assessment. They do not necessarily represent real quantities and should not be used in any other context.

The risk assessment detailed in Serov *et al.* (2012) is a method of outlining the most appropriate management response for a given environmental value under a particular activity. The risk matrix is a component of adaptive management and was designed to recommend the most appropriate management strategies and to test the effectiveness of the management strategies over a time period by combining a monitoring program with an effective framework for adaptive management.

Management strategies are based on the comparison of the ecological value of the aquifer and its associated GDEs, against the risk to them by the proposed or current activity (Serov, 2012). Table 5.2 details management actions proposed by Serov *et al.* (2012) based on the high ecological value of the alluvial aquifer and potential terrestrial GDEs (PCT 101) associated with Nagero Creek, and the predicted low magnitude of risk (Table 5.1).

Table 5.2 Risk matrix management actions

Risk descriptor	Management action for short term	Management action for mid term	Management action for long term
High value/low risk	Protection measures for aquifer and GDEs	Continue protection measures for aquifers and GDEs	Adaptive management Continue monitoring
	Baseline risk monitoring	Periodic monitoring and assessment	

BCM currently implements several monitoring programs associated with terrestrial GDEs to satisfy the requirements detailed in the Surface Water Management Plan (Boggabri Coal Operations Pty Limited, 2024) and Groundwater Management Plan (Boggabri Coal Operations Pty Ltd, 2017a), including:

- Stream and riparian health monitoring program.
- Terrestrial vegetation health and composition monitoring program.
- Stygofauna monitoring.

These programs are described in further detail in Section 6.

5.2 Regional study area

There are three coal mines currently operating in the regional study area that are collectively contributing to groundwater impacts. The three mines include the BCM, TCM and the MCCM, which are collectively known as the BTM Complex. The cumulative impacts of the BTM Complex on groundwater are routinely assessed using a 3D numerical groundwater flow model, which has been refined and updated over the past 13 years (Australasian Groundwater & Environmental Consultants Pty Ltd, 2025) (Figure 5.2).

The current version of the BTM Complex 3D numerical groundwater flow model was used to simulate potential impacts associated with the BTM current mining impacts and any additional impacts that may arise due to MOD 10. The simulation predicted that any declines in the water table and water pressure would predominantly be due to the existing active mine operations, whilst the incremental impact of MOD 10 would be small (Australasian Groundwater & Environmental Consultants Pty Ltd, 2025).

A summary of the predicted impacts on groundwater within the regional study area is provided below in Section 5.2.1 to Section 5.2.3.

ROSSVILLE LANE
BELLVIEW ROAD
BROWNS LANE
HARPARARY ROAD
TRANTHAM ROAD
ELLERSLIE ROAD
GLENCOE ROAD
THORNFIELD CROSSING ROAD
MAULES CREEK
UPPER MAULES CREEK ROAD
WILLEROI ROAD
SPION KOP ROAD
OAKEY VALLEY ROAD
BACK CREEK
TESTON LANE
BACK CREEK ROAD
BOUNDARY TRAIL
THERRIBRI ROAD
LEARD BOUNDARY TRAIL
LEARDS FOREST ROAD
OLD NARRABRI ROAD
HENRIENDI LANE
NAMOI RIVER
KAMILAROI HIGHWAY
MERROWNGA CREEK
GOONBRI CREEK
MALLEE LANE
DRIPPING ROCK ROAD
THUNDERBOLTS ROAD
CURRACABAH ROAD
NAGERO CREEK
THE SLUSH HOLES
GOONBRI ROAD
BOLLOL CREEK
BLAIR ATHOL LANE
BAYLEY PARK ROAD
RANGARI ROAD
EASTVIEW LANE
CALOOLA ROAD
VINE LANE
FINCHS LANE
BARBERS LAGOON ROAD

GDEs Predicted Groundwater Draw Down in Study Area
Road
Creek Lines
Boggabri Coal Mine Approval Area
MOD 10 Subject Land
Extent of alluvium
Nagero Creek Study Area
Cadastre
Indicative Rehabilitation Area

WSP Surveyed

PCT102 - Liverpool Plains grassland mainly on basaltic black earth soils, Brigalow Belt South Bi0oregion [PCT102/ NA181], Moderate
PCT1307 - White Cypress Pine - Silver-leaved Ironbark shrubby open forest of the Nandewar Bioregion [PCT1307_NA224], Moderate
PCT1329 - Yellow Box - Blakely's Red Gum grassy woodland of the Nandewar Bioregion [PCT1329/NA237], Good
PCT1329 - Yellow Box - Blakely's Red Gum grassy woodland of the Nandewar Bioregion [PCT1329/NA237]. Moderate
PCT1329 - Yellow Box - Blakely's Red Gum grassy woodland of the Nandewar Bioregion [PCT1329/NA237], Low
PCT1381 - Narrow-leaved Ironbark shrubby woodland of the Brigalow Belt South Bioregion [PCT1381/NA165], Good
PCT1383 - White Box grassy woodland of the Nandewar Bioregion and Brigalow Belt South Bioregion [PCT1383/ NA226], Good
PCT1383 - White Box grassy woodland of the Nandewar Bioregion and Brigalow Belt South Bioregion [PCT1383/ NA226], Low
PCT438 - River Red Gum riparian tall woodland wetland on basaltic alluvial soils mainly in the Liverpool Plains sub-region, Brigalow Belt South Bioregion [PCT438/ NA336], Good
PCT438 - River Red Gum riparian tall woodland wetland on basaltic alluvial soils mainly in the Liverpool Plains sub-region, Brigalow Belt South Bioregion [PCT438/ NA336], Moderate
PCT438 - River Red Gum riparian tall woodland wetland on basaltic alluvial soils mainly in the Liverpool Plains sub-region, Brigalow Belt South Bioregion [PCT438/ NA336], Low
PCT78 - River Red Gum riparian tall woodland/ open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion [PCT78/ NA193], Good
PCT78 - River Red Gum riparian tall woodland/ open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion [PCT78/ NA193], Moderate
PCT78 - River Red Gum riparian tall woodland/ open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion [PCT78/ NA193], Low
PCT84 - River Oak riparian woodland of the Brigalow Belt South and Nandewar Bioregions [PCT84/NA191], Moderate
PCT88 - Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion [PCT88/NA179], Good
PCT88 - Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion [PCT88/NA179], Moderate
PCT88 - Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion [PCT88/NA179], Low
Miscellaneous Ecosystem – highly disturbed areas with no or limited native vegetation, Undefined
Miscellaneous Ecosystem – highly disturbed areas with no or limited native vegetation, Not applicable (crop land)
PCT not defined, Moderate

Groundwater Dependent Ecosystems - Terrestrial GDE

PCT 53 - Shallow freshwater wetland sedgeland in depressions on floodplains on inland alluvial plains and floodplains
PCT 55 - Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions
PCT 78 - River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion
PCT 101 - Poplar Box - Yellow Box - Western Grey Box grassy woodland on cracking clay soils mainly in the Liverpool Plains, Brigalow Belt South Bioregion
PCT 112 - Black Tea-tree - River Oak - Wilga riparian low forest/ shrubland wetland of rich soil depressions in the Brigalow Belt South Bioregion and Nandewar Bioregion
PCT 241 - River Coobah swamp wetland on the floodplains of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion
PCT 244 - Poplar Box grassy woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt)
PCT 433 - White Box grassy woodland to open woodland on basalt flats and rises in the Liverpool Plains sub-region, Brigalow Belt South Bioregion
PCT 516 - Grey Box grassy woodland or open forest of the Nandewar Bioregion and New England Tableland Bioregion
PCT 599 - Blakely's Red Gum - Yellow Box grassy tall woodland on flats and hills in the Brigalow Belt South Bioregion and Nandewar Bioregion

Map: BC2025_F005_2_PotentialGDEsRegional_r1v3	Author: A. Carrillo
Date: 10/04/2025	Approved by: N. Cooper

Data source: World_Street_Map: Esri, HERE, Garmin, NGA, USGS
World Imagery: Earthstar Geographics

0 1 2 Kilometers
1:100,000
Coordinate system: GDA 1994 MGA Zone 56
Scale ratio correct when printed at A3

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BOGGABRI COAL MINE MOD 10 GROUNDWATER DEPENDENT ECOSYSTEM ASSESSMENT

Figure 5.2
Potential GDEs and Modelled Predicted Cumulative Groundwater Drawdown (Regional Study Area)

5.2.1 Regional cumulative impacts

High priority GDEs are specified in the Water Sharing Plan for the Namoi Alluvial Groundwater Sources 2020 (NSW Government, 2020a), the Water Sharing Plan for the Murray Darling Basin Porous Rock Groundwater Sources 2020 (NSW Government, 2020b), and the GDE Atlas. The GDE Atlas (Bureau of Meteorology, 2025) has mapped known GDEs as occurring along Maules Creek and high potential GDEs as occurring along Back Creek, Namoi River, Barber's Lagoon, Goonbri Creek, and its unnamed tributaries, as well as the upper reaches of Bollol Creek within the regional study area.

Australasian Groundwater & Environmental Consultants Pty Ltd (AGE) (2025) has predicted that the maximum cumulative groundwater drawdown impacts beneath potential high priority GDEs mapped by the Bureau of Meteorology (2025) and the Water Sharing Plan for the Namoi Alluvial Groundwater Sources 2020 (NSW Government, 2020a), is as follows:

- Up to 3.8 m of cumulative drawdown in the alluvium underlying terrestrial GDEs adjacent to a small section of the lower reaches of Goonbri Creek adjacent to mining at TCM.
- Less than 1 m of cumulative drawdown in the alluvium underlying terrestrial GDEs along Goonbri Creek away from mining at TCM.
- Between 3.8 m and 11.9 m of cumulative drawdown in the water table underlying terrestrial GDEs in the mid to upper reaches of Goonbri Creek.
- Up to 43 m of cumulative groundwater drawdown in the water table underlying GDEs adjacent to Back Creek.
- Up to 0.3 m cumulative drawdown in the alluvium underlying GDEs associated with Maules Creek.

Several of the areas that have been predicted to be impacted by cumulative effects of mining operations have been previously assessed as part of other environmental assessments completed for the BTM Complex. A brief discussion on each of the above creeks and potential impacts associated with the cumulative impacts from MOD 10 are provided below.

5.2.2 Back Creek

The GDE Atlas has mapped Back Creek in the north of the MCCM as being a high potential terrestrial GDE based on regional studies (Bureau of Meteorology, 2025). The vegetation along Back Creek has been previously mapped by Cumberland Ecology (2011) to consist of riparian vegetation dominated by *Melaleuca bracteata* (Black Tea-tree), which concurs with the broad-scale vegetation mapping which has mapped PCT 112 Black Tea-tree – River Oak – Wilga riparian low forest/shrubland wetland of rich soil depressions in the Brigalow Belt South Bioregion (Office of Environment & Heritage, 2016).

Cumberland Ecology (2011) determined that the riparian vegetation along Back Creek was unlikely to be a GDE as *Melaleuca bracteata* was expected to have a root zone depth of 2-3 mbgl whilst the groundwater monitoring showed that the groundwater was greater than 10 mbgl below the surface thereby suggesting that the *Melaleuca bracteata* riparian vegetation at this location is unlikely to be accessing or dependent upon groundwater.

Simulated depth to groundwater modelling completed by AGE (2025) suggests that there are sections along Back Creek where groundwater is between 0.1 mbgl to 10 mbgl. This shallow simulated depth to groundwater and the fact that *Melaleuca bracteata*, like other *Melaleuca* species in the Namoi Catchment Management Authority (Stygoecologia, 2013), are considered to have shallow rooting depths suggests that this community is likely to have access to groundwater at least along some sections of Back Creek. Despite this, there are large portions of Back Creek simulated to have groundwater depths >10 mbgl and up to 40 mbgl (Australian Groundwater & Environmental Consultants Pty Ltd, 2020) suggesting that PCT 112 is unlikely to be totally reliant on groundwater and therefore not considered to be a terrestrial GDE.

5.2.3 Goonbri Creek and Bollol Creek

The Bureau of Meteorology (2025) and the Water Sharing Plan for the Namoi Alluvial Groundwater Sources 2020 (NSW Government, 2020a) has mapped areas of Goonbri Creek and Bollol Creek as having high potential to be a terrestrial GDE. Florasearch (2011) also identified a potential terrestrial GDE associated with *Melaleuca bracteata* riparian vegetation along Goonbri Creek and Bollol Creek (i.e., Bracteata Honeymyrtle Riparian Forest). This vegetation is consistent with the broad-scale vegetation mapping that has mapped PCT 112 as also occurring along these creek lines (Office of Environment & Heritage, 2016).

As part of the TCM environment assessment, potential impacts to *Melaleuca bracteata* riparian vegetation along Goonbri Creek and Bollol Creek were considered. The assessment concluded that the project would not have a significant impact on the potential GDE (FloraSearch, 2011).

Similarly to Back Creek, there are sections along Goonbri Creek where the depth to groundwater has been simulated to occur between 0-10 mbgl (Australasian Groundwater & Environmental Consultants Pty Ltd, 2025). Despite this, there are also portions of Goonbri Creek that contain *Melaleuca bracteata* riparian vegetation where the depth to groundwater is >10 mbgl like the riparian vegetation along Back Creek. Although riparian vegetation along Goonbri Creek may have access to groundwater along some sections of the waterway, it is unlikely to be totally reliant upon it and therefore not considered to be a terrestrial GDE.

The depth to groundwater along Bollol Creek was simulated between 10-20 mbgl (Australasian Groundwater & Environmental Consultants Pty Ltd, 2025). As *Melaleuca bracteata* have shallow root systems likely to extend only 2– 3 mbgl (Cumberland Ecology, 2011), the species is not considered likely to access or be reliant upon groundwater along Bollol Creek and therefore, is not likely to be a terrestrial GDE. Furthermore, as the cumulative impacts along Bollol Creek are likely to be up to 1.5 m, this vegetation community is not considered likely to be impacted upon by the predicted cumulative groundwater drawdown impacts.

Under the NSW Aquifer Interference Policy (NSW Office of Water, 2012), minimal impact considerations comprise a series of thresholds that define the minimal impact on high priority GDEs. Two levels of minimal impact considerations are specified for highly productive groundwater sources, such as those along the Namoi River and tributaries:

- Level 1 – less than or equal to a 10 % cumulative variation in the water table, allowing for typical climatic variations, 40 m from any high priority GDE listed in the schedule of the relevant water sharing plan.
- Level 2 – if more than a 10 % cumulative variation in the water table, allowing for typical climatic variations, 40 m from any high priority GDE listed in the schedule of the relevant water sharing plan then appropriate studies will need to demonstrate to the Minister's satisfaction that the variation will not prevent the long-term viability of the GDE.

If the predicted impacts are less than the Level 1 minimal impact considerations, then these impacts will be considered acceptable. If the predicted impacts exceed the Level 1 thresholds but are within the accuracy of an otherwise robust (groundwater) model, the impacts will be considered within the range of acceptability with additional monitoring, mitigation or remediation. Where the predicted impacts are greater than the Level 1 minimal impact considerations by more than the accuracy of an otherwise robust model, then the assessment will involve additional studies to fully assess the predicted impacts (NSW Office of Water, 2012).

Australasian Groundwater and Environmental Consultants (2025) found that whilst maximum cumulative drawdown associated with current approved mining for the BTM Complex is likely to exceed the 10 % cumulative drawdown threshold near several high priority GDEs along Goonbri Creek and Bollol Creek, impacts associated with MOD 10 are not significant and demonstrate minimal incremental change from current approved mining.

Goonbri Creek and Bollol Creek are conceptualised as losing streams (Australasian Groundwater & Environmental Consultants Pty Ltd, 2025), whereby surface water is lost to groundwater. The depth of the water table beneath Goonbri Creek and Bollol Creek suggests that groundwater drawdown would not affect their flow regimes or any associated GDEs. An updated assessment of community composition, canopy cover and tree condition was completed in several accessible locations along Goonbri Creek and Bollol Creek in September 2022, at the recommendation of the IESC with respect to BCM MOD 8 (WSP, 2022). As described in Section 4.4.2, moderate condition PCT 112 Black Tea-tree – River Oak – Wilga riparian low forest/shrubland wetland was identified at each vegetation integrity plot, with photographic evidence displaying *Melaleuca bracteata* (Black Tea-tree) trees in good condition with no dieback or dead trees present in either Goonbri Creek or Bollol Creek. Consequently, changes in PCT 112 are not likely to have occurred since the approved project commenced. Moreover, analysis of leaf green index (Section 4.3.1) of high potential terrestrial GDEs along Goonbri Creek and Bollol Creek indicate reliance on surface/soil moisture rather than groundwater.

5.3 Impacts to Matters of National Environmental Significance

An assessment of vegetation occurring in the Nagero Creek study area identified the presence of one remnant native vegetation community on the alluvial plain that may have a partial dependency on groundwater, being PCT 101 Poplar Box – Yellow Box – Western Grey Box grassy woodland (Table 4.1). Field validation of PCT 101 in the Nagero Creek study area confirmed that several patches met the key diagnostic criteria and condition thresholds, and therefore met the EPBC Act listing for the Poplar Box Grassy Woodland on Alluvial Plains TEC (Section 3.4.1.2, Table 3.7) (WSP, 2022).

No BCM specific incremental impact in the Nagero Creek alluvium is predicted for MOD 10 (Australasian Groundwater & Environmental Consultants Pty Ltd, 2025).Predicted cumulative drawdown within the Nagero Creek alluvium affecting this terrestrial GDE is predicted to reach a maximum of 0.7 m for both current approved and MOD 10 (Australasian Groundwater & Environmental Consultants Pty Ltd, 2025).

An Assessment of Significance has been completed to assess the predicted groundwater drawdown impacts associated with MOD 10 on Poplar Box Grassy Woodland on Alluvial Plains TEC listed under the EPBC Act (Appendix A). This Assessment of Significance concluded that any cumulative impact on this TEC within the Nagero Creek study area is likely to be negligible and not result in a significant impact.

6 Management measures

6.1 Current management plans and monitoring

6.1.1 Current management plans

As specified in the *'Groundwater Impact Assessment Boggabri Coal Mine MOD 10 to SSD 09_0182'* report (Australasian Groundwater & Environmental Consultants Pty Ltd, 2025), BCM operates under the project's approved:

- Water Management Plan (WMP) (Boggabri Coal Operations Pty Ltd, 2017b).
- Groundwater Management Plan (GMP) (Boggabri Coal Operations Pty Ltd, 2017a).
- Surface Water Management Plan (SWMP) (Boggabri Coal Operations Pty Limited, 2024).
- BTM Complex's (BTMs) Groundwater Management Strategy (Resource Strategies, 2019).

These management plans were prepared in consultation with relevant NSW government authorities in accordance with each BTM Complex mine's planning approval (SSD 09_0182 for BCM) due to potential impacts on surface and groundwater systems associated with the project. These management plans have recently been revised and updated to address the conditions for MOD 8 to SSD 09_0182 and EPBC 2021/8875. These plans have been distributed to the relevant Government authorities for their review and comment prior to lodging with for Department of Planning Housing and Infrastructure for approval.

In accordance with the SSD 09_0182, these management plans incorporate requirements for monitoring and assessing terrestrial GDEs (including stygofauna) and stream and riparian vegetation health. The specific requirements for the monitoring and assessment of water stipulated in SSD 09_0182, and therefore already included in the SWMP and GWMP, are summarised below in Table 6.1.

Table 6.1 BCM Conditions of Approval relevant to stygofauna, GDEs and stream and riparian vegetation health

Condition of Approval	Requirement
Schedule 3 Condition 38	The proponent shall prepare and implement a Water Management Plan for the project to the satisfaction of the Secretary. This plan must be prepared in consultation with OEH, DPI Water, North West LLS and the CCC, by suitably qualified and experienced person/s whose appointment has been approved by the Secretary, and be submitted to the Secretary for approval within 6 months of the date of this approval… (which shall include)
	B) A Surface Water Management Plan, which includes:
	— Performance criteria for the following, including trigger levels for investigating any potentially adverse impacts associated with the project. — Stream and riparian vegetation health, including the Namoi River.
	C) A Groundwater Management Plan, which includes:
	— Detailed baseline data of groundwater levels, yield and quality in the region, and privately-owned groundwater bores including a detailed survey/schedule of groundwater dependent ecosystems (including stygofauna), that could be affected by the project.
	— A program to monitor and assess: — Groundwater dependent ecosystems (including potential impacts on stygofauna and riparian vegetation).

Condition of Approval	Requirement

	— Modification 5 (MOD5) specific monitoring requirement:
	  — To assess the impacts of the borefield on the native vegetation, monitoring of health and composition of the terrestrial vegetation, which will include biannual vegetation monitoring within the locality of MOD5 and proposed draw down impacts will be conducted to identify potential poor vegetation health associated with the groundwater extraction. If impacts are identified they will be assessed against water levels in groundwater monitoring bores and climatic conditions to identify any potential correlation between vegetation health and groundwater extraction. The result of the monitoring will be reported in the Annual Review.
	— Modification 8 (MOD 8) specific monitoring requirement:
	  — A program to monitor alluvial groundwater and groundwater dependent ecosystem health, as recommended by WSP in Appendix I of the *Boggabri Coal Mine Modification 8 to SSD 09_0182 Submissions Report* (WSP, 2022)
	  — Specific performance criteria and trigger levels for alluvial groundwater and groundwater dependent ecosystem function
	  — Reporting procedures for the results of the monitoring program
	  — A plan to respond to any exceedances of the performance criteria, and to mitigate any adverse effects of the Action
	  — A plan to offset any adverse effects to groundwater dependent ecosystems in accordance with the EPBC Act Environmental Offsets Policy or NSW Biodiversity Offset Scheme.

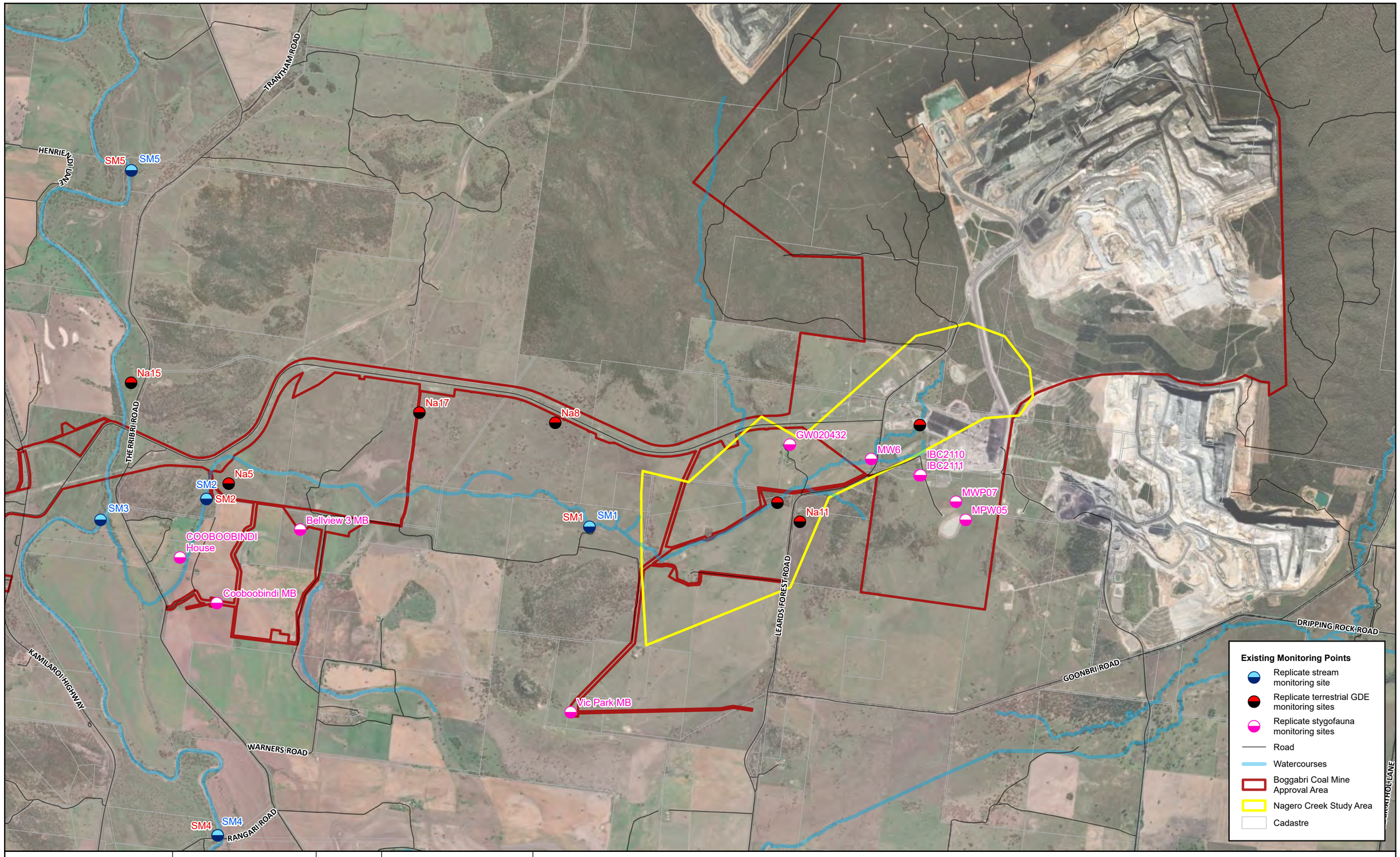
6.1.2 *Existing monitoring programs being implemented*

The current monitoring programs associated with terrestrial GDEs being implemented by BCM to satisfy the requirements detailed in the WMP, GMP and SWMP include:

- Stream and riparian health monitoring program (five permanent monitoring locations situated along Nagero Creek and the Namoi River), involves annual recording photographs to identify changes over time as mining operations at BCM progress.
- Terrestrial vegetation health and composition monitoring program, which includes:
  - Thirteen permanent monitoring locations positioned within the Namoi River and Nagero Creek floodplains (including PCT 101 and PCT 78) (Figure 6.1).
    - Includes the five stream and riparian heath monitoring sites.
    - Includes two monitoring locations in the Nagero Creek alluvium stipulated in the BCM MOD 8 Response to IESC (WSP, 2022).
  - Quantitative transect/plot survey as described in Section 2.1.1, Insert 5 and Table 7.2 of the Biodiversity Management Plan (WSP, 2018), which captures the general structure, health, floristic composition, habitat attributes, weed invasion and disturbances at each location.
  - Photographic monitoring of the vegetation and immediate landscape at the start of the 50 m transect.
  - Photographic monitoring of the canopy from the start and end of the 50 m transect line to monitor canopy condition, noting observations of canopy dieback or water stress with considerations of seasonal conditions.

- Stygofauna bore monitoring (GDE bore monitoring locations situated along the Namoi River and Nagero Creek floodplain) (Figure 6.1), which includes the following procedure at each groundwater monitoring bore on an annual basis:
  - Photographic monitoring of bore
  - Depth of bore
  - In-situ water quality testing
  - Net dipped and raised through the water column six times (three with a 150 µm mesh size net and three times with a 50 πm mesh)
  - Samples placed into a tray, stained with rose Bengal and preserved in ethanol
  - Sample analysed in a laboratory under a microscope to identify any potential stygofauna present.

The above monitoring programmes have been regularly implemented since the baseline monitoring session in 2018 to establish and monitor baseline conditions of stream, riparian and terrestrial vegetation health and stygofauna associated with the Namoi River floodplain aquifer.



Map:BC2025_F006_1_MonitoringLocations_r1v4	Author: A. Carrillo		0 500 1,000 Meters 1:40,000 Coordinate system: GDA 1994 MGA Zone 56 Scale ratio correct when printed at A3
Date: 10/04/2025	Approved by: N. Cooper		

Data source: World_Street_Map: Esri, HERE, Garmin, NGA, USGS
World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

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BOGGABRI COAL MINE MOD 10 GROUNDWATER DEPENDENT ECOSYSTEM ASSESSMENT

Figure 6.1
Existing and Proposed Monitoring Locations

7 Conclusion

BCOPL (on behalf its joint venture participants) is seeking a modification to SSD 09_0182 under Section 4.55 of the EP&A Act to recover known coal resources within the approved BCM Project Boundary and to extend mining to the northwest beyond the approved Mine Disturbance Boundary (MOD 10). This will entail the recovery of an additional 30 Mt of ROM coal to the base of the Templemore Coal Seam. The Commonwealth DCCEEW has determined that the proposed MOD 10 would be a controlled action under the EPBC Act (EPBC 2024/09887) for listed threatened species and communities and unconventional gas or large coal mining development with impact on water resources. As the Commonwealth DCCEEW considered impacts to a water resource were likely to rise from altered surface and groundwater hydrology, advice from the IESC on Coal Seam Gas and Large Coal Mining Development would be sought for MOD 10.

This assessment considered the potential groundwater dependence of vegetation types present, analysis of hydrological modelling, and depth to groundwater simulations completed as part of the MOD 10 Groundwater Impact Assessment, and an assessment of potential groundwater drawdown impacts. This analysis was undertaken in two disparate study areas, the first of which incorporated an assessment of the alluvial aquifer that extends to the south-west of BCM in association with an episodic drainage line known locally as Nagero Creek. The second incorporated an extended regional setting to consider the potential for GDEs to occur in association with several drainage features proximate to BCM and the Leard State Forest.

Although heavily cleared for agriculture, the characterisation of potential GDEs within the Nagero Creek study area identified one EPBC Act listed TEC as a potential terrestrial GDE that may access groundwater as part of their overall water requirements. This included field validated areas of PCT 101 consistent with the Poplar Box Grassy Woodland on Alluvial Plains Endangered Ecological Community.

Groundwater levels are typically 7 to 10 mbgl on the alluvial plain but can be shallower in the vicinity of drainage depressions and creeks, as observed in some areas proximate to Nagero Creek. Mining induced impacts to the alluvial groundwater system are yet to be observed and groundwater modelling undertaken did not identify any incremental drawdown in the alluvium directly attributable to MOD 10. Maximum cumulative drawdown predicted in the alluvium is generally less than 2 m for current approved BTM mining and MOD 10. The predicted drawdown exceeds 2 m in a small proportion of the alluvial tongue that is directly south-west of BCM, where a maximum drawdown of 5.1 m is predicted at the very fringes of the alluvium where it extends into the current approved BCM mine disturbance boundary. Drawdown directly attributable to BCM and MOD 10 in this area reaches a maximum of 1.3 m, which is consistent with current approved mining. A maximum drawdown of 3.8 m is predicted in areas near PCT 599 along Nagero Creek, and moving away from the BCM, to the south-west of the Nagero Creek study area, a maximum drawdown of 0.7 m is predicted in the alluvium near PCT 101.

Eucalyptus spp. have a dual (dimorphic) root system, with lateral roots that are close to the surface, and a taproot that penetrates deep in the soil. Therefore, these species can source water from multiple sources and their reliance and use of groundwater may therefore be facultative. It is considered that most deep-rooted woody species only extend approximately 10 mbgl. However, *Eucalyptus populnea* (Poplar Box) has been observed to have a tree condition to groundwater depth threshold between 12 mbgl and 26 mbgl before the canopy showed signs of dieback, suggesting that the species has extensive tap roots capable of accessing alluvial groundwater. A maximum potential cumulative groundwater drawdown of 0.7 m as a result of current mining approvals and MOD 10 in areas where PCT 101 Poplar Box – Yellow Box – Western Grey Box grassy woodland TEC occurs is not likely to significantly impact this community as determined by the Assessment of Significance completed as part of this investigation.

Within the regional study area, the GDE Atlas mapped known GDEs as occurring along Maules Creek and high potential GDEs as occurring along Back Creek, Namoi River, Barber's Lagoon, Goonbri Creek, and its unnamed tributaries, as well as the upper reaches of Bollol Creek. Based on the desktop assessment and vegetation classification of GDE types, three PCTs were considered to have potential to be at least partially reliant on access to groundwater and two aquatic systems (the Namoi River and Maules Creek). The predicted cumulative groundwater drawdown impacts beneath potential high priority GDEs mapped by the Bureau of Meteorology, includes:

- Up to 3.8 m of cumulative drawdown in the alluvium underlying terrestrial GDEs adjacent to a small section of the lower reaches of Goonbri Creek, adjacent to mining at TCM.
- Less than 1 m of cumulative drawdown in the alluvium underlying terrestrial GDEs along Goonbri Creek away from mining at TCM.
- Between 3.8 m and 11.9 m of cumulative drawdown in the water table underlying terrestrial GDEs in the mid to upper reaches of Goonbri Creek adjacent to BCM and TCM.
- Up to 43 m of cumulative groundwater drawdown in the water table underlying GDEs on Back Creek adjacent to MCCM.
- Up to 0.3 m cumulative drawdown in the alluvium underlying GDEs associated with Maules Creek adjacent to MCCM.

A risk assessment completed on potential GDEs in the study area determined that the alluvial aquifer was of high ecological value, due to the presence of stygofauna and patches of PCT 101 Poplar Box – Yellow Box – Western Grey Box grassy woodland TEC. A high-level examination of the cumulative impact associated with current mining operations and MOD 10 was considered to have a low risk to terrestrial GDEs.

It is recommended that existing monitoring programs required under the BCM GMP and SWMP be continued. If these monitoring programs identify impacts associated with the predicted MOD 10 groundwater drawdown, it is recommended that affected areas be rehabilitated.

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Appendix A

EPBC Act Assessment of Significance

A1 Poplar Box Grassy Woodland on Alluvial Plains

A1.1 Status

Poplar Box Grassy Woodland on Alluvial Plains is listed as an Endangered Ecological Community (EEC) under the EPBC Act.

A1.2 Specific impacts

Poplar Box Grassy Woodland on Alluvial Plains has been identified as a potential terrestrial GDE within the Nagero Creek study area, which has the potential to be indirectly impacted by the predicted groundwater drawdown associated with current approved mining (MOD 8) and MOD 10. Within the Nagero Creek study area, several patches of PCT 101 Poplar Box – Yellow Box – Western Grey Box grassy woodland on cracking clay soils mainly in the Liverpool Plains, Brigalow Belt South Bioregion met the key diagnostic criteria, and their condition was assessed as Class A1 – highest quality of Poplar Box Grassy Woodland on Alluvial Plains EEC (Figure 3.4). Derived native grassland of PCT 101 occurs within the Nagero Creek study area and the conservation advice (Department of Environment and Energy, 2019) excludes derived native grassland to be part of this EEC.

PCT 101 within the Nagero Creek study area had a canopy typically dominated by *Eucalyptus populnea* (Poplar Box), which can have a deep extensive taproot system (recorded to extend up to a maximum of 25 mbgl) capable of and previously observed as accessing groundwater (Kath et al., 2014) to obtain its water requirements. The species is considered to access groundwater preferably between 12 mbgl and 25 mbgl (Kath et al., 2014). As the groundwater level within the Nagero Creek study area is predicted to be approximately 10 mbgl (Australasian Groundwater & Environmental Consultants Pty Ltd, 2025) the roots of *Eucalyptus populnea* are considered likely to penetrate and utilise the groundwater to some degree. Therefore, PCT 101's reliance on groundwater within the Nagero Creek study area cannot be discounted and may be impacted by the predicted maximum cumulative drawdown of 0.7 m in the alluvium near patches of field verified Poplar Box Grassy Woodland on Alluvial Plains, which is consistent with current approved mining. Importantly, no BCM specific incremental impact in the Nagero Creek alluvium is predicted for MOD 10 (Australasian Groundwater & Environmental Consultants Pty Ltd, 2025).

A1.3 EPBC Act significant impact assessment

The following assessment has been undertaken following the Matters of National Environmental Significance, Significant Impact Guidelines 1.1 (Department of the Environment, 2013).

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

A1.3.1 Reduce the extent of the ecological community

The predicted groundwater drawdown impacts associated with current approved mining and MOD 10 have potential to indirectly impact small patches of Poplar Box Grassy Woodland on Alluvial Plains. A maximum cumulative drawdown of 0.7 m is predicted in the alluvium near patches of field verified Poplar Box Grassy Woodland on Alluvial Plains, which is consistent with current approved mining (Australasian Groundwater & Environmental Consultants Pty Ltd, 2025).

Approximately 1,881.9 ha of PCT 101 has been mapped within 15 km of the Nagero Creek study area by broad-scale vegetation mapping (Office of Environment & Heritage, 2016). The small patches of Poplar Box Grassy Woodland on Alluvial Plains in the study area with potential to be indirectly impacted upon represents <1% of that mapped as occurring within the region.

No BCM specific incremental impact in the Nagero Creek alluvium is predicted for MOD 10 (Australasian Groundwater & Environmental Consultants Pty Ltd, 2025). Given that a maximum cumulative groundwater drawdown of 0.7 m predicted in association with current approved mining may potentially impact less than 1% of the Poplar Box Grassy Woodland on Alluvial Plains mapped within the region, MOD 10 is unlikely to significantly reduce the extent of the EEC to an extent that would place it at risk of extinction.

A1.3.2 Fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission easements

Poplar Box Grassy Woodland on Alluvial Plains within the Nagero Creek study area is already highly fragmented as a result of past and current land uses, primarily agriculture and mine infrastructure. MOD 10 will not result in the direct removal or fragment the community into two or more patches.

If indirect impacts result in canopy dieback, localised fragmentation of the canopy stratum may occur to the small patches of Poplar Box Grassy Woodland on Alluvial Plains within the Nagero Creek study area. In this circumstance, midstorey and groundcover components of the community are likely to remain as species that occur within these two stratums are unlikely to be reliant on groundwater given their shallow root depth (i.e., shrub, forb, fern and grass species likely to have shallow root systems < 7 mbgl where the groundwater table is predicted to occur).

A1.3.3 Adversely affect habitat critical to the survival of an ecological community

Areas critical to the survival of the ecological community are identified in the Conservation Advice (including listing advice) for the Poplar Box Grassy Woodland on Alluvial Plains (Department of Environment and Energy, 2019). As specified in the conservation advice for the ecological community, the areas considered most critical to the survival of Poplar Box Grassy Woodland on Alluvial Plains are those in the '*best quality, most intact patches… as outlined in Class A – Highest Condition of Table 3'.*

All patches of PCT 101 identified as meeting the EPBC Act TEC in Figure 3.4 have been assessed as Class A – highest condition (Section 3.4.1.2), which are habitat that is critical to the survival of Poplar Box Grassy Woodland on Alluvial Plains. Whilst these patches are not likely to be indirectly impacted by groundwater drawdown associated with MOD 10, they could be impacted by the predicted 0.7 m groundwater drawdown associated with current cumulative active mining. However, the potential drawdown of 0.7 m in the alluvium underlying patches of Poplar Box Grassy Woodland on Alluvial Plains is likely to have a negligible impact.

A1.3.4 Modify or destroy abiotic (non-living) factors (such as water, nutrients or soil) necessary for an ecological community's survival, including reduction in groundwater levels, or substantial alteration of surface water drainage patterns

No BCM specific incremental impact in the Nagero Creek alluvium is predicted for MOD 10 (Australasian Groundwater & Environmental Consultants Pty Ltd, 2025). That is, the same impacts are expected to be experienced with MOD 10 as those associated with current approved mining (MOD 8). However, the predicted 0.7 m maximum cumulative drawdown in the alluvium associated with current mining has the potential to modify existing groundwater levels within the Nagero Creek study area. Impacts associated with the predicted drawdown are likely to be limited largely to the canopy stratum of PCT 101, which is typically dominated by *Eucalyptus populnea* (Poplar Box). This species has been known to have extensive roots systems that utilise groundwater resources preferably between 12 mbgl and 25 mbgl (Kath et al., 2014).

A predicted drawdown of 0.7 m may have impacts on the root systems of *Eucalyptus populnea*. However, these impacts are relatively slight given the current groundwater level is predicted to be approximately 10 mbgl (Australasian Groundwater & Environmental Consultants Pty Ltd, 2025), whereas the root systems of *Eucalyptus populnea* have been observed to reach up to 25 mbgl (Kath et al., 2014). This suggests that if the cumulative drawdown of 0.7 m does occur, the species will continue to be able to access the groundwater for its water requirements. An exception to this maybe during times of severe and/or extended drought conditions where the groundwater may drawdown further.

Although drought conditions may exacerbate the predicted drawdown impacts, it is considered unlikely that severe or prolonged drought would impact the canopy stratum of PCT 101 to an extent that it would result in severe canopy dieback. However, climate change might lead to more extreme weather events and potentially extend the period between wet and dry cycles. Stream and terrestrial GDE monitoring undertaken between 2018 and 2020 occurred through severe drought conditions that affected most of NSW. This drought was assisted by well below average rainfall received in the region for an extended period between 2017 and 2019, which gradually eased in 2020. Vegetation attributes associated with floristic composition, structure and functionality were consistent with or only showed slight increases/decreases in values since 2018 (WSP, 2021a). Fluctuations in some vegetation attribute values, such as per cent overstorey cover, have been observed, and are likely attributable to severe drought conditions experienced between 2017 and 2019. However, such fluctuations were not considered significant as observations occurred within the boundaries of the probable mean as predicted by the standard error (WSP, 2021a).

Given the above, MOD 10 is considered unlikely to modify or destroy any abiotic factors necessary for the survival of the ecological community within the Nagero Creek study area.

A1.3.5 Cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species, for example through regular burning or flora or fauna harvesting

Patches of PCT 101 that met the criteria for this EEC were in high condition. The remaining patches within the Nagero Creek study area are already highly disturbed as a result of past and current land uses, primarily agriculture and mine infrastructure. Consequently, the species composition of the community within the Nagero Creek study area is already modified.

The predicted drawdown impacts associated with current approved mining (an MOD 10) are anticipated to be relatively minor and potentially to only impact the canopy stratum of the ecological community. As mentioned above, even if extended drought conditions prevail it is considered unlikely that the canopy stratum would suffer as a result of these drawdown impacts. As such, it is considered unlikely that the predicted cumulative drawdown impacts will cause a substantial change in the species composition of the ecological community.

A1.3.6 Cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to:

(i) Assisting invasive species, that are harmful to the listed ecological community, to become established, or

No BCM specific incremental impact in the Nagero Creek alluvium is predicted for MOD 10 (Australasian Groundwater & Environmental Consultants Pty Ltd, 2025). However, the predicted cumulative drawdown within the Nagero Creek alluvium affecting this terrestrial GDE, which is predicted to reach a maximum of 0.7 m for both current approved mining and MOD 10, is unlikely to significantly increase the spread of existing invasive species or contribute to the introduction of new species that are harmful to the Poplar Box Grassy Woodland on Alluvial Plain EEC.

(ii) Causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the ecological community which kill or inhibit the growth of species in the ecological community, or

No BCM specific incremental impact in the Nagero Creek alluvium is predicted for MOD 10 (Australasian Groundwater & Environmental Consultants Pty Ltd, 2025). However, the predicted cumulative drawdown within the Nagero Creek alluvium affecting this terrestrial GDE, which is predicted to reach a maximum of 0.7 m for both current approved mining and MOD 10, is unlikely to cause regular mobilisation of fertilisers, herbicides or other chemicals and pollutants into the Poplar Box Grassy Woodland on Alluvial Plain EEC.

(iii) Interfere with the recovery of the ecological community

A recovery plan has not been prepared for the ecological community, however, priority protection, conservation management and recovery actions have been identified in the Conservation Advice (including listing advice) for the Poplar Box Grassy Woodland on Alluvial Plains (Department of Environment and Energy, 2019). These include:

- Protect the ecological community to prevent further loss of extent and condition.
- Restore the ecological community within its current and potential range by active abatement of threats, revegetation and other conservation initiatives.
- Communicate with, engage with, and support people to increase understanding of the value and function of the ecological community and encourage their efforts in its protection and recover.
- Research and monitoring to improve our understanding of the ecological community and methods for restoration and protection over the long-term.

Cumulative active mining (with MOD 10) has potential to interfere with one of the above actions; being ‘protect the ecological community to prevent further loss of extent and condition’.

A1.3.7 Conclusion

The predicted groundwater drawdown impacts associated with cumulative active mining (and MOD 10) has potential to indirectly impact small patches of Poplar Box Grassy Woodland on Alluvial Plains. Based on broad-scale vegetation mapping this equates to a potential impact on <1% of the community within the region (i.e., within 15 km of the Nagero Creek study area).

As there are no predicted incremental groundwater drawdown impacts associated with MOD 10 in the Nagero Creek alluvium and cumulative groundwater drawdown impacts associated with current approved BTM Complex mining (0.7 m) are considered negligible, it is considered unlikely that MOD 10 would lead to a significant impact on this ecological community.

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