Australian Government
Department of Agriculture, Water and the Environment
Bureau of Meteorology
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BIOREGIONAL ASSESSMENTS

CSIRO

Protected matters for the Cooper GBA region

Technical appendix for the Geological and Bioregional Assessment: Stage 2

2020

A scientific collaboration between the Department of Agriculture, Water and the Environment, Bureau of Meteorology, CSIRO and Geoscience Australia

The Geological and Bioregional Assessment Program

The Geological and Bioregional Assessment Program will provide independent scientific advice on the potential impacts from development of selected unconventional hydrocarbon plays on water and the environment. The geological and environmental data and tools produced by the Program will assist governments, industry, landowners and the community to help inform decision making and enhance the coordinated management of potential impacts.

The Program is funded by the Australian Government Department of the Environment and Energy. The Department of the Environment and Energy, Bureau of Meteorology, CSIRO and Geoscience Australia are collaborating to undertake geological and bioregional assessments. For more information, visit http://www.bioregionalassessments.gov.au.

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Authorship is listed alphabetically after first author.

On 1 February 2020 the Department of the Environment and Energy and the Department of Agriculture merged to form the Department of Agriculture, Water and the Environment. Work for this document was carried out under the then Department of the Environment and Energy. Therefore, references to both departments are retained in this report.

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Cover photograph

Cooper Creek in flood, 4 km east of Windorah, March 2018.
Credit: Geological and Bioregional Assessment Program, Russell Crosbie (CSIRO)
Element: GBA-COO-2-343

Executive summary

Expansion of Shale and tight gas industries in Australia has potential to impact on environmental matters. A strategic assessment process examines impacts on matters of national environmental significance (i.e. EPBC matters) at a regional level and enables regulators to assess cumulative impacts of development on these matters. Matters of National Environmental Significance in the Cooper GBA region include the Ramsar-listed wetland (Coongie Lakes) and 26 taxa (plants, reptiles, birds and mammals) listed as threatened (being either critically endangered, endangered or vulnerable) under federal legislation and the Burke, Wills, King and Yandruwandha National Heritage Place is located along the course of Cooper Creek.

Additionally, eight nationally important wetlands (i) Bulloo Lakes; ii) Coongie Lakes; iii) Cooper Creek - Wilson River Junction; iv) Cooper Creek Overflow Swamps - Nappa Merrie; v) Cooper Creek Overflow Swamps - Windorah; vi) Lake Cuddapan; vii) Lake Yamma Yamma; and viii) the Strezlecki Creek Wetland System) occur in the Cooper GBA region.

Matters of State Environmental Significance are divided along the Queensland – South Australia state boundary. In Queensland, there are 2 birds and 3 mammals listed as endangered, 2 near threatened plants, 10 vulnerable species from 4 taxa (plants, mammals, birds, and reptiles) and 11 iconic species classified as special least concern. South Australia identifies 3 birds and 1 plant in the extinct or threatened category and 13 vulnerable species including 4 mammals, 4 birds, 1 reptile and 4 plant species. Additionally, for the Cooper GBA region, Queensland has 7 matters of state environmental significance (QLD MSES) that focus on areas of environmental values. The Cooper GBA region has protected areas in both states that reserve the regions iconic landform and associated biota.

The Cooper GBA region contains important wetlands and groundwater-dependent ecosystems (GDEs) that resource development may impact and that fall outside of the matters of environmental significance. These include springs, GDE wetlands and surface GDEs.

Listed in the Australian Heritage Database are 9 indigenous sites, 12 heritage sites and 2 recreational areas in the Register of the National Estate. Many of the Cooper Creek waterholes and Cooper Creek itself form part of extensive Aboriginal trading routes throughout the Lake Eyre Basin.

To determine how impacts due to shale, tight and deep coal gas exploration and development may affect ecosystems at a landscape scale in the Cooper GBA region, seven landscape classes have been identified. The landscape classification was developed to provide a basis for a systematic assessment of the potential impacts on landscape function and the protected matters nested in each landscape class. The Cooper GBA region is dominated by; floodplain and alluvium, known as ‘Channel Country’, inland dunefields and undulating country on fine grained sedimentary rocks. There are smaller spatial areas of loamy and sandy plains, and tablelands and duricrusts, and only traces of clay plains. Recharge springs have been mapped within the region. Discharge springs occur outside the GBA region boundary but are likely to be hydrologically connected.

Contents

Figures

Tables

Contributors to the Program

The following individuals have contributed to the Geological and Bioregional Assessment Program.

Role or team	Contributor(s)
Program Director	Department of the Environment and Energy: Anthony Swirepik
Program Implementation Board	Department of the Environment and Energy: Beth Brunoro, Nicholas Post Bureau of Meteorology: Kirsten Garwood, Kate Vinot CSIRO: Jane Coram, Warwick MacDonald Geoscience Australia: Stuart Minchin, Richard Blewett
Basin Leader	CSIRO: Kate Holland, Cameron Huddlestone-Holmes, Paul Wilkes Geoscience Australia: Steven Lewis
Program management	CSIRO: Karen Barry, Emanuelle Frery, Linda Merrin, Ruth Palmer Department of the Environment and Energy: Mitchell Bouma, Rod Dann, Andrew Stacey, David Thomas, Alex Tomlinson
Product integration and stakeholder engagement	CSIRO: Clare Brandon, Justine Lacey, Michelle Rodriquez, Sally Tetreault-Campbell
Analysis and visualisation	CSIRO: Dennis Gonzalez, Steve Marvanek Geoscience Australia: Adrian Dehelean, Chris Evenden, Chris Lawson, Bianca Reese, Nigel Skeers, Murray Woods
Basin geology and prospectivity	Geoscience Australia: Lisa Hall (Discipline Leader), Adam Bailey, George Bernardel, Barry Bradshaw, Donna Cathro, Merrie-Ellen Gunning, Amber Jarrett, Megan Lech, Meredith Orr, Ryan Owens, Tehani Palu, Martin Smith, Liuqu Wang
Chemical assessment	CSIRO: Jason Kirby (Discipline Leader), Simon Apte, Lisa Golding, Rai Kookana, Dirk Mallants, Michael Williams
Data management and transparency	Bureau of Meteorology: Andre Zerger (Discipline Leader), Derek Chen, Trevor Christie-Taylor, Donna Phillips CSIRO: Nicholas Car, Philip Davies, Stacey Northover, Matt Stenson Geoscience Australia: Matti Peljo
Hydrogeology	Geoscience Australia: Tim Ransley (Discipline Leader), Sam Buchanan, Scott Cook, Prachi Dixon-Jain, Bex Dunn, Tim Evans, Éamon Lai, Bruce Radke, Baskaran Sundaram
Impact analysis	CSIRO: David Post (Discipline Leader), Brent Henderson, Dane Kasperczyk, James Kear, Regina Sander
Impacts on protected matters	CSIRO: Anthony O'Grady (Discipline Leader), Alexander Herr, Craig MacFarlane, Justine Murray, Chris Pavey, Stephen Stewart
Spatial analysis	CSIRO: Dennis Gonzalez, Steve Marvanek Geoscience Australia: Adrian Dehelean, Murray Woods, Nigel Skeers
Water quantity	CSIRO: Russell Crosbie (Discipline Leader), Jorge Martinez Praveen Kumar Rachakonda, Matthias Raiber, Yongqiang Zhang, Hongxing Zheng

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- Internal Peer Review: CSIRO: Justine Murray
  Technical Peer Review Group: Andrew Boulton, Peter McCabe, Catherine Moore and Jenny Stauber.
- State Government Science Technical Review: This group includes scientists from the Queensland and South Australian governments.

Abbreviations and acronyms

Abbreviation/acronym	Definition
ABS	Australian Bureau of Statistics
AIBTSIS	Australian Institute of Aboriginal and Torres Strait Islander Studies
Carbon dioxide	CO_2
CSG	Coal seam gas
DEM	Digital elevation model
EPBC Act	Australian Government *Environment Protection and Biodiversity Conservation Act 1999*
GAB	Great Artesian Basin
GBA	Geological and Bioregional Assessment
GDE	Groundwater-dependent ecosystem
IBRA	Interim Biogeographic Regionalisation of Australia
ILUA	Indigenous Land Use Agreement
IMEA	Impact Modes and Effects Analysis
LGA	Local government area
MNES	Matters of National Environmental Significance
MSES	Matters of State Environmental Significance
Surface geology	
K	Unnamed Undifferentiated Cretaceous rocks
Knw	Winton Formation
Knw1	Unnamed Shale; siltstone; sandstone
Qhr	Unnamed Undifferentiated Holocene colluvial/regolith sediments
Qp\gy	Unnamed Undifferentiated Pleistocene gypcrete
T	Unnamed Undifferentiated Tertiary rocks
TQ	Unnamed Undifferentiated Tertiary to Pleistocene rocks
Knh	Mount Howie Sandstone
T\si	Unnamed Undifferentiated Tertiary silcrete
Tem\si	Unnamed Regionally older silcrete

Units

Unit	Description
cm	Centimetre
g	Gram
ha	Hectare
km	Kilometre
km^2	Kilometre squared
m	Metre

The Geological and Bioregional Assessment Program

The $35.4 million Geological and Bioregional Assessment (GBA) Program is assessing the potential environmental impacts of shale and tight gas development to inform regulatory frameworks and appropriate management approaches. The geological and environmental knowledge, data and tools produced by the Program will assist governments, industry, landowners and the community by informing decision making and enabling the coordinated management of potential impacts.

In consultation with state and territory governments and industry, three geological basins were selected based on prioritisation and ranking in Stage 1: Cooper Basin, Isa Superbasin and Beetaloo Sub-basin. In Stage 2, geological, hydrological and ecological data were used to define 'GBA regions': the Cooper GBA region in Queensland, SA and NSW; the Isa GBA region in Queensland; and the Beetaloo GBA region in NT. In early 2018, deep coal gas was added to the assessment for the Cooper GBA region, as this play is actively being explored by industry.

The GBA Program will assess the potential impacts of selected shale and tight gas development on water and the environment and provide independent scientific advice to governments, landowners, the community, business and investors to inform decision making. Geoscience Australia and CSIRO are conducting the assessments. The Program is managed by the Department of the Environment and Energy and supported by the Bureau of Meteorology.

The GBA Program aims to:

- inform government and industry and encourage exploration to bring new gas supplies to the East Coast Gas Market within five to ten years
- increase understanding of the potential impacts on water and the environment posed by development of shale, tight and deep coal gas resources
- increase the efficiency of assessment and ongoing regulation, particularly through improved reporting and data provision/management approaches
- improve community understanding of the industry.

The GBA Program commenced in July 2017 and comprises three stages:

- **Stage 1 Rapid regional basin prioritisation** identified and prioritised geological basins with the greatest potential to deliver shale and/or tight gas to the East Coast Gas Market within the next five to ten years.
- **Stage 2 Geological and environmental baseline assessments** is compiling and analysing available data for the three selected regions to form a baseline and identify gaps to guide collection of additional baseline data where needed. This analysis includes a geological basin assessment to define structural and stratigraphic characteristics and an environmental data synthesis.
- **Stage 3 Impact analysis and management** will analyse the potential impacts to water resources and matters of environmental significance to inform and support Commonwealth and State management and compliance activities.

The PDF of this report and the supporting technical appendices are available at https://www.bioregionalassessments.gov.au/geological-and-bioregional-assessment-program.

About this report

Presented in this technical appendix are the environmental and cultural protected matters for the Cooper GBA region. It provides more detailed information regarding the environmental and cultural protected matters, landscape classification, ecohydrological conceptualisation, and the prioritisation and screening process for these protected matters in the Cooper GBA region. The structure and focus of the synthesis report and technical appendices reflect the needs of government, industry, landowners and community groups.

Technical appendices

Other technical appendices that support the geological and environmental baseline assessment for the Cooper GBA region are:

- Owens R, Hall L, Smith M, Orr M, Lech M, Evans T, Skeers N, Woods M and Inskeep C (2020) Geology of the Cooper GBA region.
- Lech ME, Wang L, Hall LS, Bailey A, Palu T, Owens R, Skeers N, Woods M, Dehelean A, Orr M, Cathro D and Evenden C (2020) Shale, tight and deep coal gas prospectivity of the Cooper Basin.
- Evans TJ, Martinez J, Lai ÉCS, Raiber M, Radke BM, Sundaram B, Ransley TR, Dehelean A, Skeers N, Woods M, Evenden C and Dunn B (2020) Hydrogeology of the Cooper GBA region.
- Kirby JK, Golding L, Williams M, Apte S, Mallants D and Kookana R (2020) Qualitative environmental risk assessment of drilling and hydraulic fracturing chemicals for the Cooper GBA region.
- Kear J and Kasperczyk D (2020) Hydraulic fracturing and well integrity review for the GBA regions.

All maps for the Cooper GBA region use the Map Grid of Australia (MGA) projection (zone 54) and the Geocentric Datum of Australia 1994 (GDA 1994).

1 Protected matters

Matters of national environmental significance in the Cooper GBA region include the Ramsar-listed wetland (Coongie Lakes) and 26 taxa (plants, reptiles, birds and mammals) listed as threatened (being either critically endangered, endangered or vulnerable). The threatened ecological community that is dependent on the springs at Lake Blanche is located outside of the region but is likely to be hydrologically connected to groundwater in the region. The Burke, Wills, King and Yandruwandha National Heritage Place is located along the course of Cooper Creek.

Eight nationally important wetlands (i) Bulloo Lakes; ii) Coongie Lakes; iii) Cooper Creek - Wilson River Junction; iv) Cooper Creek Overflow Swamps - Nappa Merrie; v) Cooper Creek Overflow Swamps - Windorah; vi) Lake Cuddapan; vii) Lake Yamma Yamma; and viii) the Strezlecki Creek Wetland System) are also present in the Cooper GBA region.

Matters of state environmental significance are divided along the Queensland – South Australia state boundary. In Queensland, there are 2 birds and 3 mammals as endangered, 2 near threatened plants, 10 vulnerable species from 4 taxa (plants, mammals, birds, and reptiles) and 11 iconic species classified as special least concern. South Australia identifies 3 birds and 1 plant in the extinct or threatened category and 13 vulnerable species including 4 mammals, 4 birds, 1 reptile and 4 plant species. Additionally, for the Cooper GBA region, Queensland has 7 matters of state environmental significance (QLD MSES) that focus on areas of environmental values.

The Cooper GBA region contains important wetlands, waterholes and groundwater dependent ecosystems (GDEs) that resource development may impact on and that fall outside of the matters of environmental significance. These include springs, GDE wetlands and surface GDEs such as Lake Yamma, Coongie Lakes and Lake Blanch.

1.1 Matters of national environmental significance

Matters of National Environmental Significance (MNES) are Australia's national environmental assets as defined in the Environment Protection and Biodiversity Conservation Act (1999, EPBC Act). Matters of national environmental significance that occur in the Cooper GBA region that may potentially be impacted due to shale and tight gas developments are identified for further assessment.

Matters of national environmental significance relevant to the assessment include:

- World heritage properties
- National heritage places
- Wetlands of international significance
- Nationally listed threatened species
- Nationally listed ecological communities
- Migratory species protected under international agreements.

The matters considered in this report were identified in the Cooper GBA region based on the EPBC Act protected matters reports generated for Queensland and SA. There were no world heritage properties or threatened ecological community within the Cooper GBA region and one Ramsar

nominated wetland. Thirty-nine species that are known, likely or may occur were identified within the region. One threatened species is listed as migratory and marine and another threatened species is listed as marine.

Migratory species are those that are protected under bilateral international agreements. Listed migratory species are assembled from four bilateral agreements:

1. China-Australia Migratory Bird Agreement (CAMBA)
2. Japan-Australia Migratory Bird Agreement (JAMBA)
3. Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA)
4. Bonn Convention (Convention on Conservation of Migratory Species of Wild Animals).

Marine species are those that occur in Commonwealth marine areas. There were no listed threatened ecological communities identified in the search. Springs belonging to the threatened ecological community 'The community of native species dependent on the natural discharge of groundwater from the Great Artesian Basin threatened ecological community' occur at Lake Blanche, outside of the Cooper GBA region boundary although they are likely to be hydrologically connected to the region (Sparrow et al., 2015).

The National Heritage List, identifies, historic, and indigenous places of outstanding significance to the nation.

Other matters of national environmental significance include nationally important wetlands.

Matters of national environmental significance highlighted in this report were identified in an EPBC Act protected matters search for the Cooper GBA region run by the Australian Government Department of the Environment on the 18 March 2018. Searches were run separately for the Queensland and SA portions of the Cooper GBA region and combined to create a unified list of nationally protected matters.

1.1.1 Wetlands of international significance

The Coongie Lakes Ramsar site is located in the north-east corner of SA near the township of Innamincka. The Coongie Lakes Ramsar site includes the Cooper Creek system from the SA border downstream to Lake Hope, the north-west branch of Cooper Creek, the northern Overflow and their many water holes and terminal lakes covering an area of almost 19800 km^2. A detailed description of the ecological character of these sites is presented by (Butcher and Hale, 2011).

1.1.2 Nationally listed threatened species

In total, 26 taxa are listed as threatened (critically endangered, endangered or vulnerable) including plants, reptiles, birds and mammals). No invertebrates or frogs that are listed as threatened under the EPBC Act occur or are likely to occur within the Cooper GBA region. Two subspecies of bar-tailed godwit (*Limosa lapponica*) are listed separately as threatened under the EPBC Act; one is critically endangered (*L. l. menzbieri*), the other is vulnerable (*L. l. baueri*). However, the bar-tailed godwit is listed as migratory and marine only at the species level.

Each of the 26 threatened taxa are described in an individual account. The account provides an overview of the ecology, distribution and status of the taxon, followed by an assessment of its

water dependency and a comment on the hazards associated with shale gas development that may negatively impact the conservation status of the taxon. This preliminary assessment is based on an understanding of the types of activities associated with gas resource development, recovery plans and conservation advice.

Table 1 Species classified as Matters of National Environmental Significance under the Commonwealth's Environment Protection and Biodiversity Conservation Act 1999 that occur or potentially occur in the Cooper GBA region

Status	Scientific name	Common name	Records within the study area
Critically endangered	*Calidris ferruginea*[1]	Curlew sandpiper	Species or species habitat known to occur within area
	Limosa lapponica menzbieri	Northern Siberian Bar-tailed godwit (*menzbieri*)	Species or species habitat may occur within area
	Pedionomus torquatus	Plains-wanderer	Species or species habitat likely to occur within area
Endangered	*Frankenia plicata*	Braided sea heath	Species or species habitat known to occur within area
	Amytornis barbatus barbatus	Grey grasswren (Bulloo)	Species or species habitat known to occur within area
	Neochmia ruficauda ruficauda	Star finch (southern), Star finch (eastern)	Species or species habitat likely to occur within area
	Pezoporus occidentalis	Night parrot	Species or species habitat likely to occur within area
	Rostratula australis[2]	Australian painted snipe	Species or species habitat likely to occur within area
Vulnerable	*Acacia peuce*	Waddy-wood	Species or species habitat likely to occur within area
	Hakea maconochieana		Species or species habitat likely to occur within area
	Sclerolaena walkeri		Species or species habitat known to occur within area
	Xerothamnella parvifolia		Species or species habitat known to occur within area
	Maccullochella peelii	Murray cod	Species or species habitat may occur within area
	Mogurnda clivicola	Flinders Ranges purple-spotted gudgeon	Species or species habitat likely to occur within area
	Acanthophis hawkei	Plains death adder	Species or species habitat likely to occur within area
	Egernia rugosa	Yakka skink	Species or species habitat may occur within area
	Amytornis modestus	Thick-billed grasswren	Species or species habitat may occur within area
	Grantiella picta	Painted honeyeater	Species or species habitat known to occur within area
	Limosa lapponica baueri	Bar-tailed godwit (*baueri*), Western Alaskan Bar-tailed Godwit	Species or species habitat may occur within area

Status	Scientific name	Common name	Records within the study area
	Dasyuroides byrnei	Kowari	Species or species habitat likely to occur within area
	Macrotis lagotis	Greater bilby	Species or species habitat likely to occur within area
	Notomys fuscus	Dusky hopping-mouse	Species or species habitat may occur within area
	Petrogale xanthopus celeris	Yellow-footed rock-wallaby (central-western Queensland)	Species or species habitat known to occur within area
	Phascolarctos cinereus	Koala	Species or species habitat may occur within area
	Pseudomys australis	Plains mouse	Species or species habitat may occur within area
	Sminthopsis douglasi	Julia Creek dunnart	Species or species habitat may occur within area
Migratory species	*Actitis hypoleucos*[3]	Common sandpiper	Species or species habitat known to occur within area
	Apus pacificus[3]	Fork-tailed swift	Species or species habitat likely to occur within area
	Calidris acuminata[3]	Sharp-tailed sandpiper	Species or species habitat known to occur within area
	Calidris melanotos[3]	Pectoral sandpiper	Species or species habitat known to occur within area
	Charadrius veredus[3]	Oriental plover	Species or species habitat may occur within area
	Gallinago hardwickii[3]	Latham's snipe	Species or species habitat may occur within area
	Limosa lapponica[3]	Bar-tailed godwit	Species or species habitat known to occur within area
	Motacilla cinerea[3]	Grey wagtail	Species or species habitat may occur within area
	Motacilla flava[3]	Yellow wagtail	Species or species habitat known to occur within area
	Tringa nebularia[3]	Common greenshank	Species or species habitat likely to occur within area
Marine species	*Ardea alba*	Great egret	Species or species habitat known to occur within area
	Ardea ibis	Cattle egret	Species or species habitat may occur within area
	Haliaeetus leucogaster	White-bellied sea-eagle	Species or species habitat may occur within area
	Merops ornatus	Rainbow bee-eater	Species or species habitat may occur within area

[1]Also listed as migratory and marine
[2]Also listed as marine (under the scientific name *Rostratula benghalensis*)
[3]Also listed as marine

1.1.3 Nationally listed marine and migratory species

A total of 13 species occur or potentially occur in the Cooper GBA region and are listed under the EPBC Act but are not threatened (Table 2). This includes nine species that are listed as both migratory and marine and four species that are listed as marine.

Each of the 13 species that is migratory and marine or marine but not threatened has an IUCN Red List of Threatened Species classification of 'least concern'. Many of these species have both a large global population size and a large population size in Australia and are unlikely to be significantly impacted by resource development in the Cooper GBA region.

Table 2 Distribution and habitat of listed migratory and/or marine birds that occur within the Cooper GBA region. Only those species that are not listed as threatened (refer Table 1) are covered here

Scientific name	Common name	Listing in EPBC Act and IUCN Red List	Distribution and habitat
Actitis hypoleucos	Common sandpiper	EPBC Act: migratory and marine IUCN: least concern	Migratory shorebird. Global population estimated at 2.6 to 3.2 million birds. Breeds in Europe and Asia; non-breeding birds occur in summer in large numbers along all coastlines and in many inland areas of Australia. Mapped extent of potential habitat covers entire continent.
Apus pacificus	Fork-tailed swift	EPBC Act: migratory and marine IUCN: least concern	A migratory swift. Breeds in south-east China and adjacent countries; non-breeding birds occur in summer across Australia. An exclusively aerial species. Mapped extent of potential habitat covers majority of continent.
Calidris acuminata	Sharp-tailed sandpiper	EPBC Act: migratory and marine IUCN: least concern	Migratory shorebird. Breeds in northern Siberia; non-breeding birds occur in summer in large numbers along all coastlines and in many inland areas of Australia where population estimated at up to 140,000 birds (global population estimate is >160,000 birds). Mapped extent of potential habitat covers entire continent.
Calidris melanotos	Pectoral sandpiper	EPBC Act: migratory and marine IUCN: least concern	Migratory shorebird. Global population estimate is 25,000 to 100,000 birds. Breeds in northern Russia and North America; non-breeding birds occur in summer in low numbers along coastlines and inland areas of Australia. Mapped extent of potential habitat covers entire continent.
Charadrius veredus	Oriental plover	EPBC Act: migratory and marine IUCN: least concern	Migratory shorebird. Breeds in Mongolia and adjacent Russia. ~90% of global population migrates to Australia in summer occupying coastal and inland areas. 144,000 birds at Eighty Mile Beach, WA in February 2010. Occupies a wide range of marine, freshwater and terrestrial habitats.

Scientific name	Common name	Listing in EPBC Act and IUCN Red List	Distribution and habitat
Gallinago hardwickii	Latham's snipe	EPBC Act: migratory and marine IUCN: least concern	Migratory shorebird. Global population estimate is 25,000 to 100,000 birds. Breeds in Japan and eastern Russia; passage migrant through northern Australia and non-breeding migrant in summer in south-east Australia (where most of global population overwinters). Occupies permanent and ephemeral wetlands.
Motacilla cinerea	Grey wagtail	EPBC Act: migratory and marine IUCN: least concern	Passerine bird. Widespread in Northern Hemisphere and tropics with some populations breeding in Europe and Asia and migrating to tropical Africa and Asia as non-breeding. Global population estimate of 6.9 to 19.8 million birds. A vagrant in Australia. Occupies riverine areas.
Motacilla flava	Yellow wagtail	EPBC Act: migratory and marine IUCN: least concern	Passerine bird. Extremely large range: Europe to Siberia to west Asia and China south to Egypt. Global population estimate of 64 to 107 million birds. A vagrant in Australia. Occupies terrestrial and freshwater habitat.
Tringa nebularia	Common greenshank	EPBC Act: migratory and marine IUCN: least concern	Migratory shorebird. Global population estimated at 440,000 to 1.5 million birds. Breeds in Scandinavia and across Russia; non-breeding birds occur in summer in small numbers along most coastlines and in many inland areas of Australia. Australian population estimated at 18,000 to 19,000 birds. Occupies a range of coastal and inland wetlands.
Ardea alba	Great egret	EPBC Act: marine IUCN: least concern	A waterbird with a massive global distribution including North and South America, Africa, Asia and Europe. Global population estimated at 41.5 to 69.9 million birds. Occupies wide range of inland and coastal wetlands. Mapped extent of potential habitat covers entire Australian continent.
Ardea ibis	Cattle egret	EPBC Act: marine IUCN: least concern	A waterbird with a massive global distribution including North and South America, Africa, Asia and Europe. Global population estimated at 4 to 9.85 million birds. Occupies open grassy areas and some wetlands. Mapped extent of potential habitat covers most of Australian continent.
Haliaeetus leucogaster	White-bellied sea-eagle	EPBC Act: marine IUCN: least concern	A raptor with a range including coastal India, Sri Lanka, south-east Asia, Philippines, Indonesia and Papua New Guinea. In Australia, occurs along coast and extends inland along some of the larger rivers. Australian population size estimated at >500 pairs.
Merops ornatus	Rainbow bee-eater	EPBC Act: marine IUCN: least concern	A bee-eater. Outside Australia occurs in Indonesia, Timor-Leste, Papua New Guinea and Solomon Islands. The population is estimated to number at least 1 million birds. Mapped extent of potential habitat covers entire Australian continent.

1.1.4 Species accounts

Fish

Murray Cod (*Maccullochella peelii*)

Status: Vulnerable

Overview

The Murray cod is a large predatory fish that is one of the largest species of purely freshwater fish in the world. It feeds mainly on fish and large crustaceans. The species typically grows to less than 5 kg in weight and under 1 m in length; however, the largest known specimen had a body mass of 113.6 kg. It is a top order predator in the Murray-Darling River system of south-eastern Australia. The species has also been translocated to the Cooper Creek system in Queensland and SA where it was stocked in 1989 to 1990 (Figure 1). Breeding populations now occur there (National Murray Cod Recovery Team, 2010). The Murray cod is listed in the EPBC Act as vulnerable.

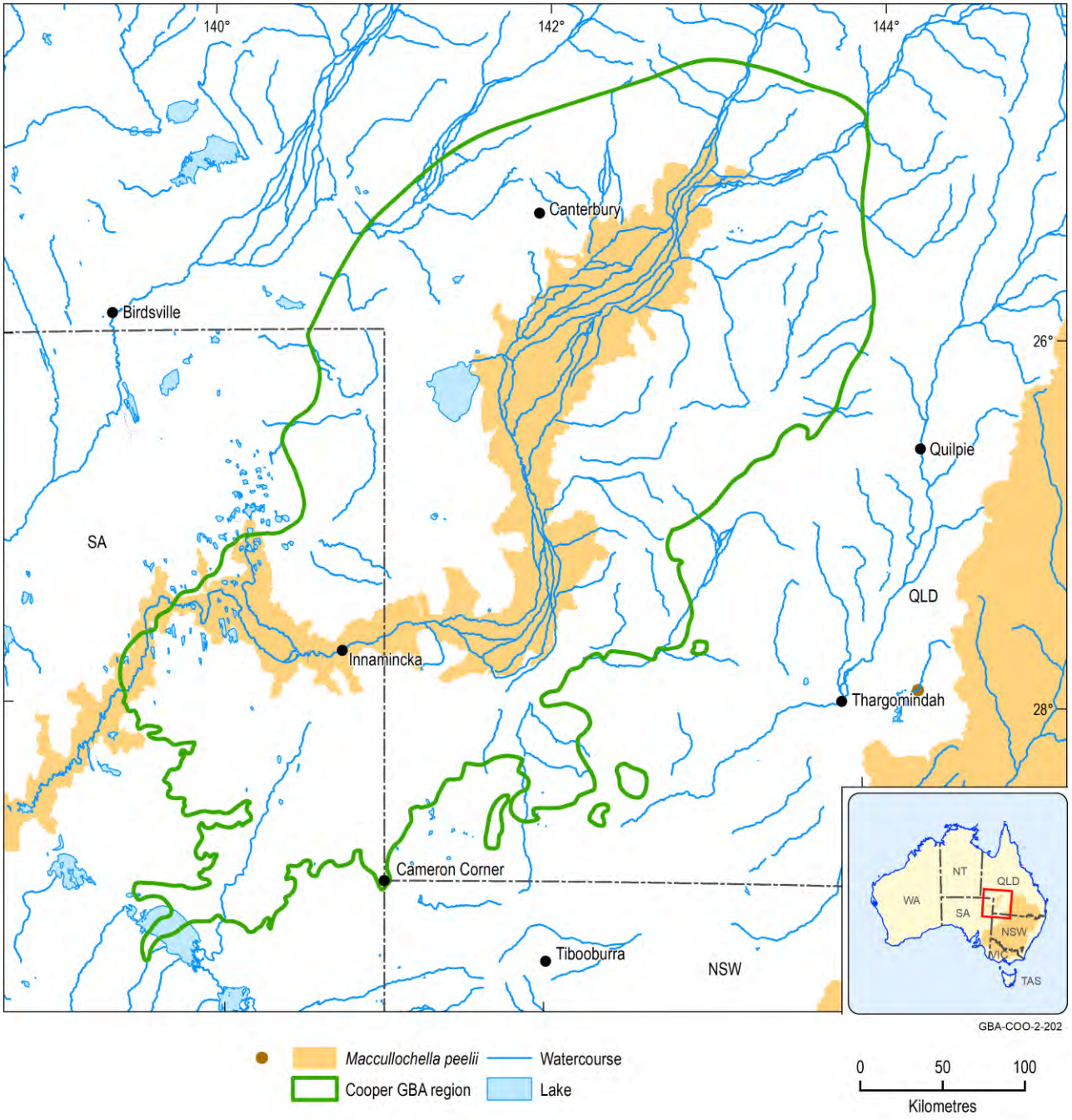

Figure 1 Distribution and Atlas of Living Australia observations of the Murray cod, *Maccullochella peelii*

Data: Atlas of Living Australia (2019); Department of the Environment and Energy (2018a)
Element: GBA-COO-2-202

Water dependency

The Murray cod occurs in a range of flowing and standing waters. It occupies the main channels of rivers, tributaries and creeks. It also occurs in floodplain channels when these are inundated. Lakes and large billabongs are also occupied.

Shale and tight gas development activities with potential to impact species

The key areas of the landscape for this species are river channels and floodplains. Impacts from shale gas development are likely to occur during the following activities:

- exposure to soil, groundwater and/or surface water contamination;
- changed surface water quality and/or flows;
- changed groundwater quality and/or levels;
- bank instability and erosion.

Flinders Ranges gudgeon (*Mogurnda clivicola*)

Status: Vulnerable

Overview

The Flinders Ranges gudgeon is a relatively small species of freshwater fish that has an approximate maximum length of 13 cm. The distribution and biology of this species is not adequately known. Populations have been found in Balcanoona Creek in the north-east Flinders Ranges of SA and in the upper Barcoo River in south-west Queensland (Figure 2). There is also an old record of the species from Tobermorey Station on the Bulloo River. Habitat in Balcanoona Creek is isolated freshwater waterholes in creeks and in spring-fed pools in streams. The upper Barcoo River location is a lowland creek. The Flinders Ranges gudgeon is listed under the EPBC Act as vulnerable.

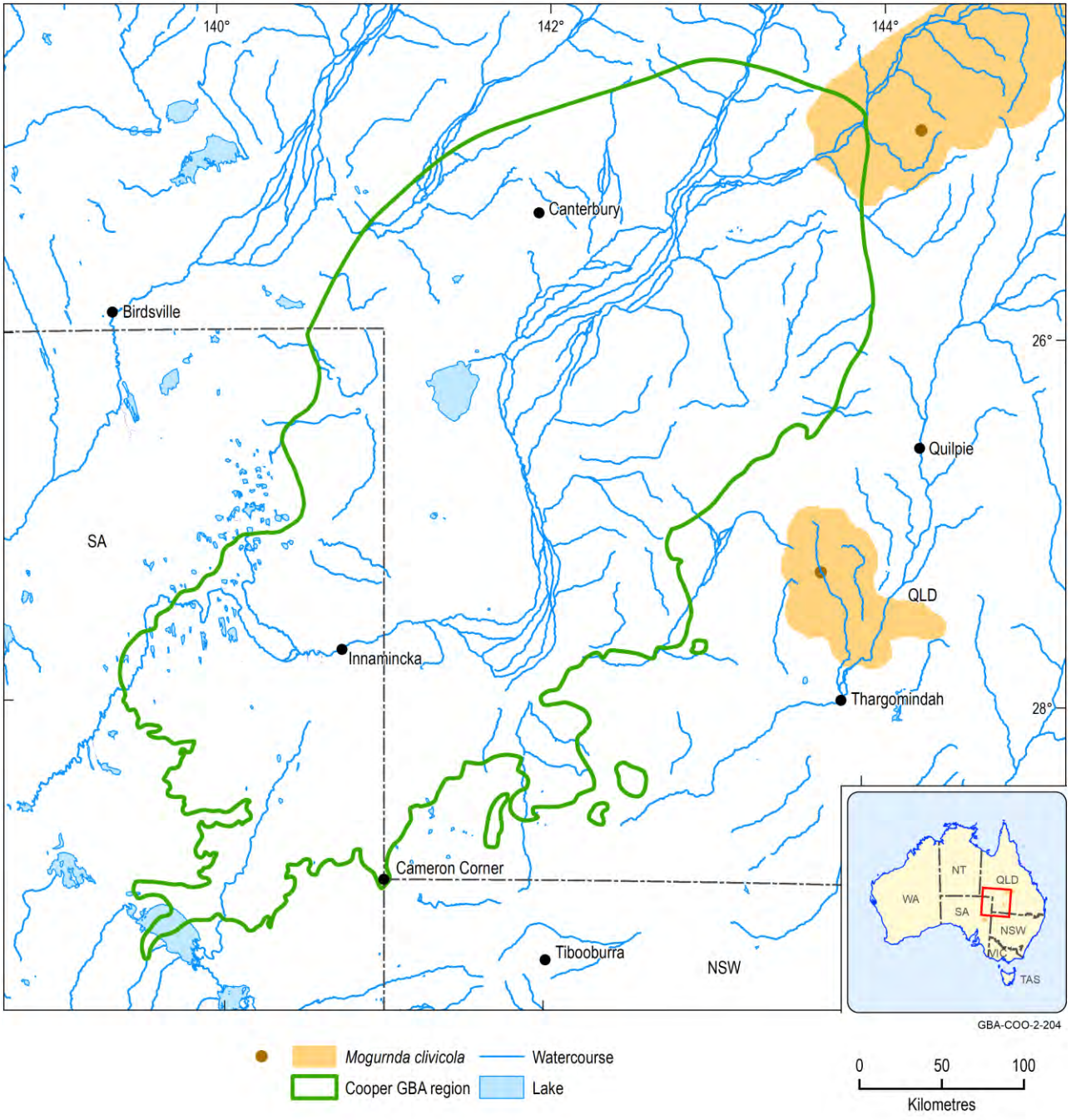

Figure 2 Distribution and Atlas of Living Australia observations of the Flinders Ranges gudgeon, *Mogurnda clivicola*

Data: Atlas of Living Australia (2019); Department of the Environment and Energy (2018a)
Element: GBA-COO-2-204

Water dependency

The Flinders Ranges gudgeon is water dependent. It occurs in isolated freshwater waterholes, spring-fed pools indicating a potential groundwater dependence and in a mud-bottomed lowland creek.

Shale and tight gas development activities with potential to impact species

The key areas of the landscape for this species are riverine landscape classes. Impacts from development are likely to occur during the following activities:

- exposure to soil, groundwater and/or surface water contamination;
- changed surface water quality and/or flows;
- changed groundwater quality and/or levels;
- bank instability and erosion.

Mammals

Plains mouse (*Pseudomys australis*)

Status: Vulnerable

Overview

The plains mouse is a moderate-sized (mean body mass of 42 g) endemic rodent that occupies cracking clay and gibber plains within stony desert in central and southern Australia. The distribution includes north-east SA, south-east NT and western NSW (Figure 3). The species is nocturnal and lives in subterranean shelters (in burrows or natural cracks) during the day. It is mostly herbivorous, feeding on the seeds of forbs and grasses. The species has undergone substantial contraction in its geographic range since European occupation of Australia. Most of the land within the species' current range is used for extensive cattle grazing (Moseby, 2012).

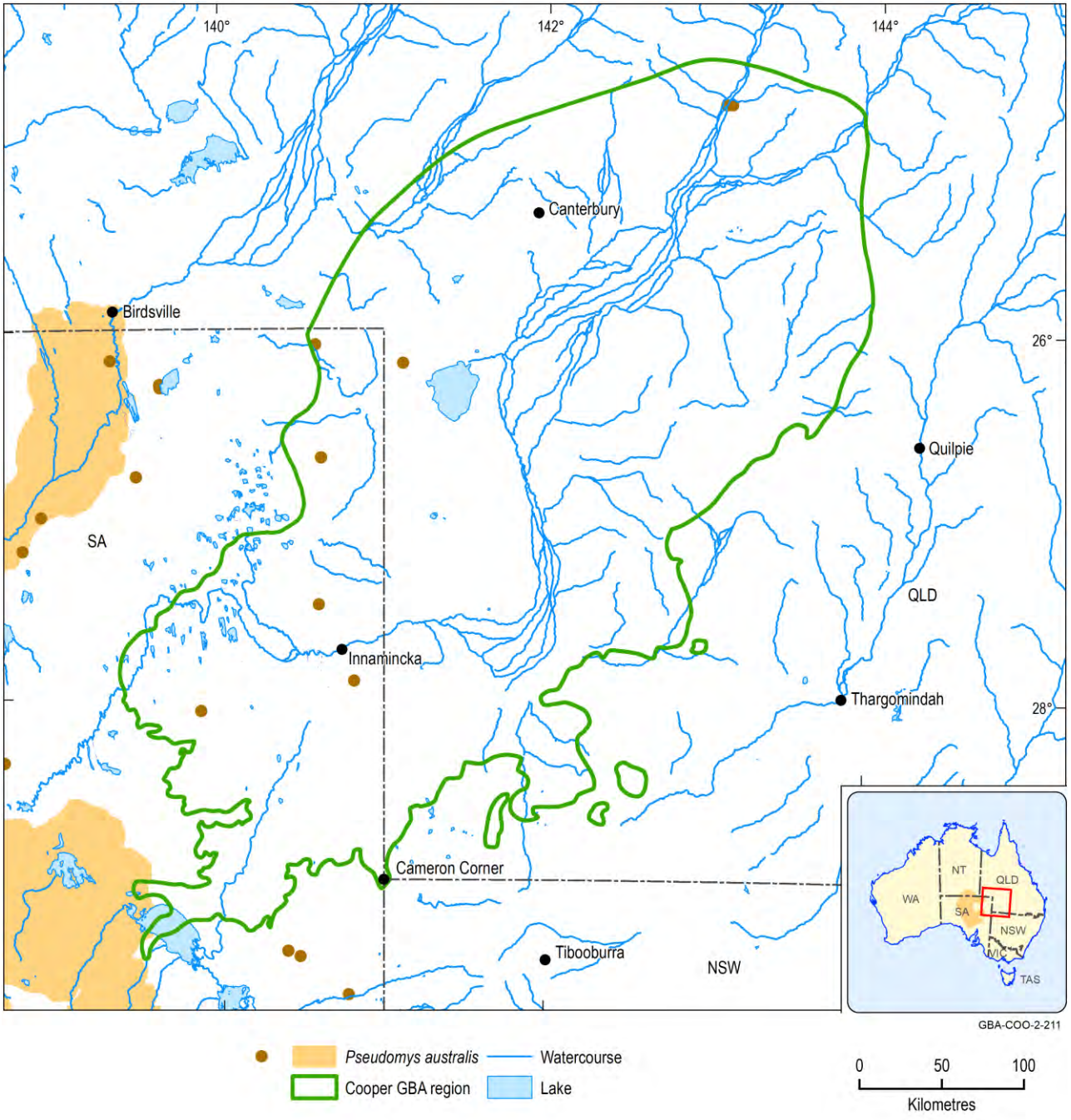

Figure 3 Distribution and Atlas of Living Australia observations of the plains mouse, *Pseudomys australis*

Data: Atlas of Living Australia (2019); Department of the Environment and Energy (2018a)
Element: GBA-COO-2-211

Water dependency

The plains mouse is a species that retracts to specific areas of the landscape, known as refuges, during dry periods. The occurrence of refuges is associated with topographic position (areas of microrelief within the landscape) and soil type (cracking clay soils). Refuges have clay soils that form wide and deep cracks and often also contain small island-like mounds of windblown sand (Pavey et al., 2014). The species depends on plants that are mostly shallow-rooted, short-lived grasses, and forbs that are able to germinate in response to the frequent small rainfall events that occur during dry periods (Pavey et al., 2016). These are areas of microrelief that ensure periodic

access to suitable food plants even during dry years. Thus the species depends on gilgais and run-on areas of the landscape for access to moisture that are essential for its food plants. Reliance on water is thus expected to be from run-on of local rainfall.

Shale and tight gas development activities with potential to impact species

The key areas of the landscape are refuges that are determined by areas of microrelief and presence of cracking clay soils.

Impacts from shale gas development are likely to occur during the following activities:

- habitat loss and fragmentation;
- increased competition and predation;
- erosion;
- reduced soil productivity;
- exposure to soil, groundwater and/or surface water contamination;
- changed surface water quality and/or flows.

Greater bilby (*Macrotis lagotis*)

Status: Vulnerable

Overview

The greater bilby is a medium-sized ground-dwelling native marsupial (body mass 600 to 2500 g) that is the only surviving member of the sub-family Thylacomyidae within the bandicoot family (Peramelidae). Although its range has declined considerably since European settlement of Australia it is still found in south-western Queensland and across the western deserts of the NT and WA (Figure 4). It is a nocturnal species that shelters during the day in burrows that it digs itself. It has an omnivorous diet.

The greater bilby is an iconic desert marsupial that has become a flagship species for conservation in Australia. The species is considered to play an important role as an ecosystem engineer (Pavey, 2006), thus providing an ecological service.

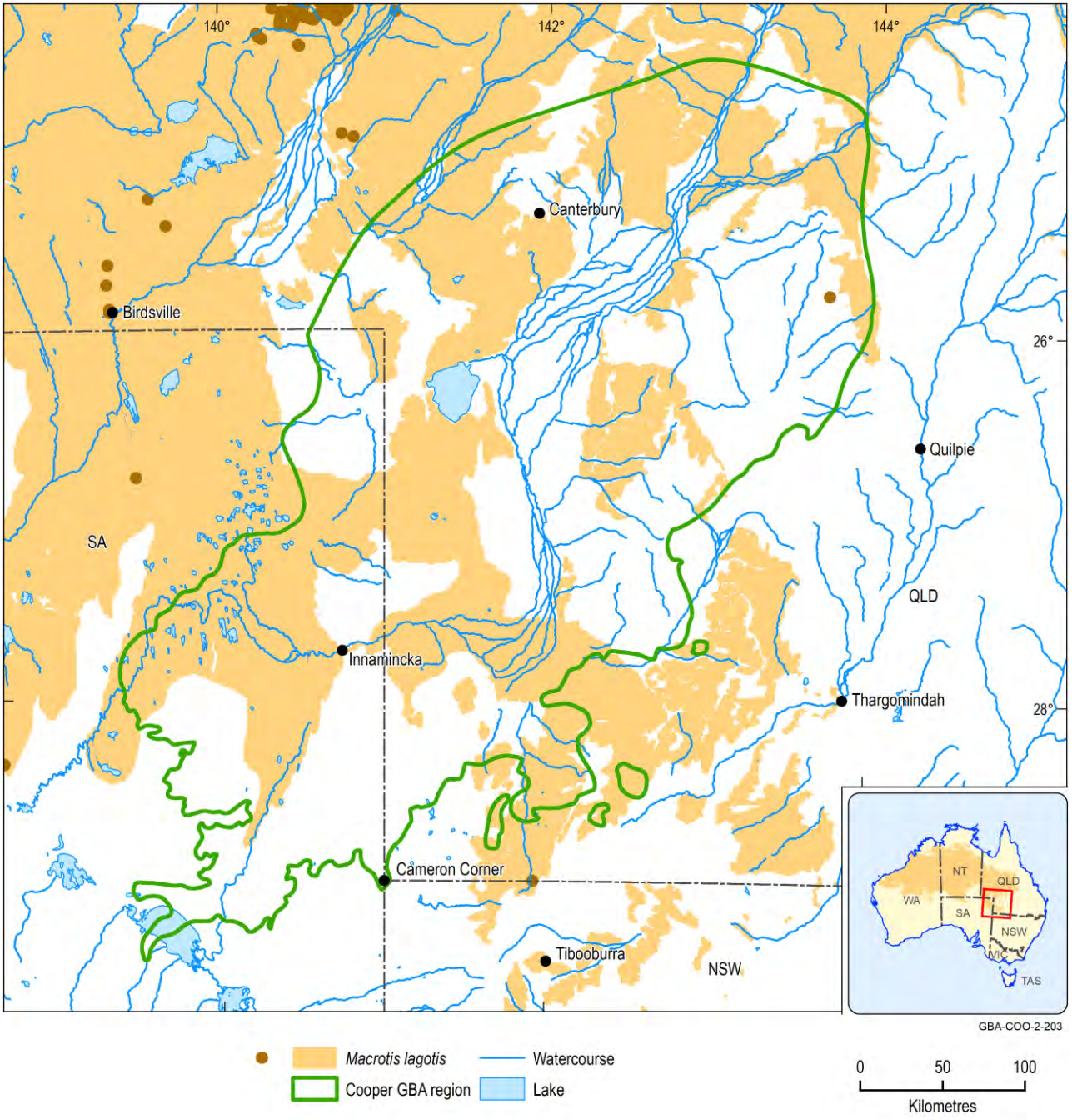

Figure 4 Distribution and Atlas of Living Australia observations of the greater bilby, *Macrotis lagotis*

Data: Atlas of Living Australia (2019); Department of the Environment and Energy (2018a)
Element: GBA-COO-2-203

Water dependency

The greater bilby in south-west Queensland occupies deep clay soils and gibber plains on loam soils. This habitat supports open tussock grasslands of grasses and forbs. Reliance on water is thus expected to be from run-on of local rainfall.

Shale and tight gas development activities with potential to impact species

The key areas of the landscape are likely to be deep clay soils.

Impacts from shale gas development are likely to occur during the following activities:

- habitat loss and fragmentation;
- introduction of invasive species;
- increased competition and predation;
- reduced soil productivity;
- exposure to soil, groundwater and/or surface water contamination;
- changed surface water quality and/or flows.

Dusky hopping-mouse (*Notomys fuscus*)

Status: Vulnerable

Overview

The dusky hopping-mouse is a moderate-sized (mean body mass of 32 g, (Pavey et al., 2016)) endemic rodent that occupies sand dunes and sand plains in north-east SA, south-west Queensland and western NSW (Figure 5). The species has irruptive population dynamics; when populations irrupt during favourable conditions the range of habitats the species occupies increases and includes rocky ranges and gibber plains. The species is nocturnal and occupies burrows during the day.

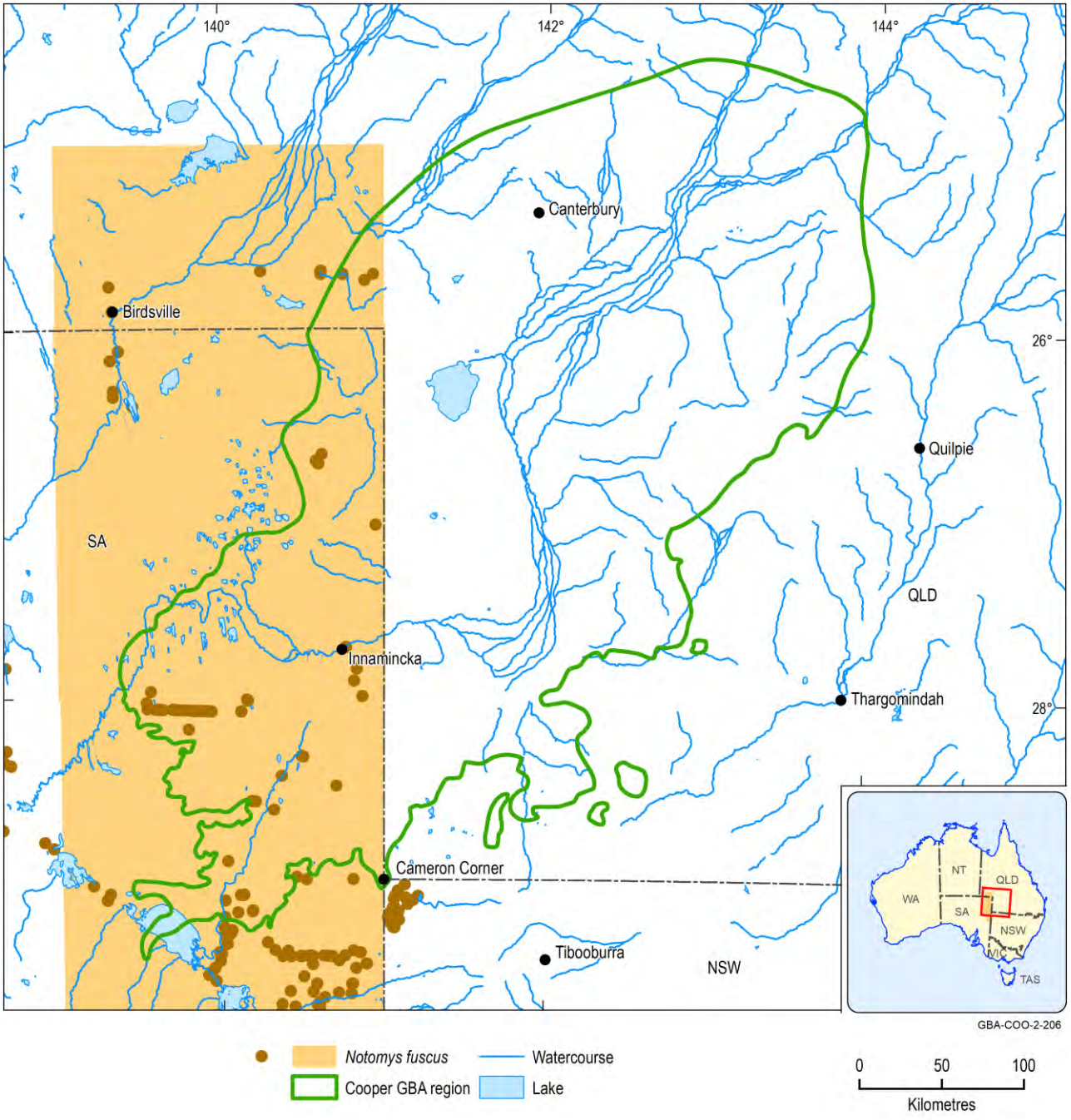

Figure 5 Distribution and Atlas of Living Australia observations of the dusky hopping-mouse, *Notomys fuscus*

Data: Atlas of Living Australia (2019); Department of the Environment and Energy (2018a)
Element: GBA-COO-2-206

Water dependency

No water dependency has been identified for this species.

Shale and tight gas development activities with potential to impact species

Impacts from shale gas development are likely to occur during the following activities:

- habitat loss and fragmentation;
- introduction of invasive species;
- increased competition and predation;
- reduced soil productivity;
- exposure to soil, groundwater and/or surface water contamination;
- changed surface water quality and/or flows.

Kowari (*Dasyuroides byrnei*)

Status: Vulnerable

Overview

The kowari is a marsupial micropredator (body mass of 70 to 175 g) that is endemic to the stony deserts of north-east SA and south-west Queensland (Figure 6). Although relatively small in size it is the largest remaining marsupial predator in arid Australia. It captures a wide range of prey including a diversity of insects, scorpions, spiders, centipedes and vertebrates, mostly mammals. Kowaris have been recorded taking prey as large as the long-haired rat *Rattus villosissimus* (body mass: 54 to 280 g) and European rabbit *Oryctolagus cuniculus* (body mass: 960 to 2420 g). The kowari is nocturnal and shelters during the day in burrows that are usually dug in to sand mounds that occur interspersed in the gibber and cracking clay dominated environments that it occupies.

A recent population viability assessment indicates that the two populations of the species with long-term monitoring data are in decline (Greenville et al., 2018).

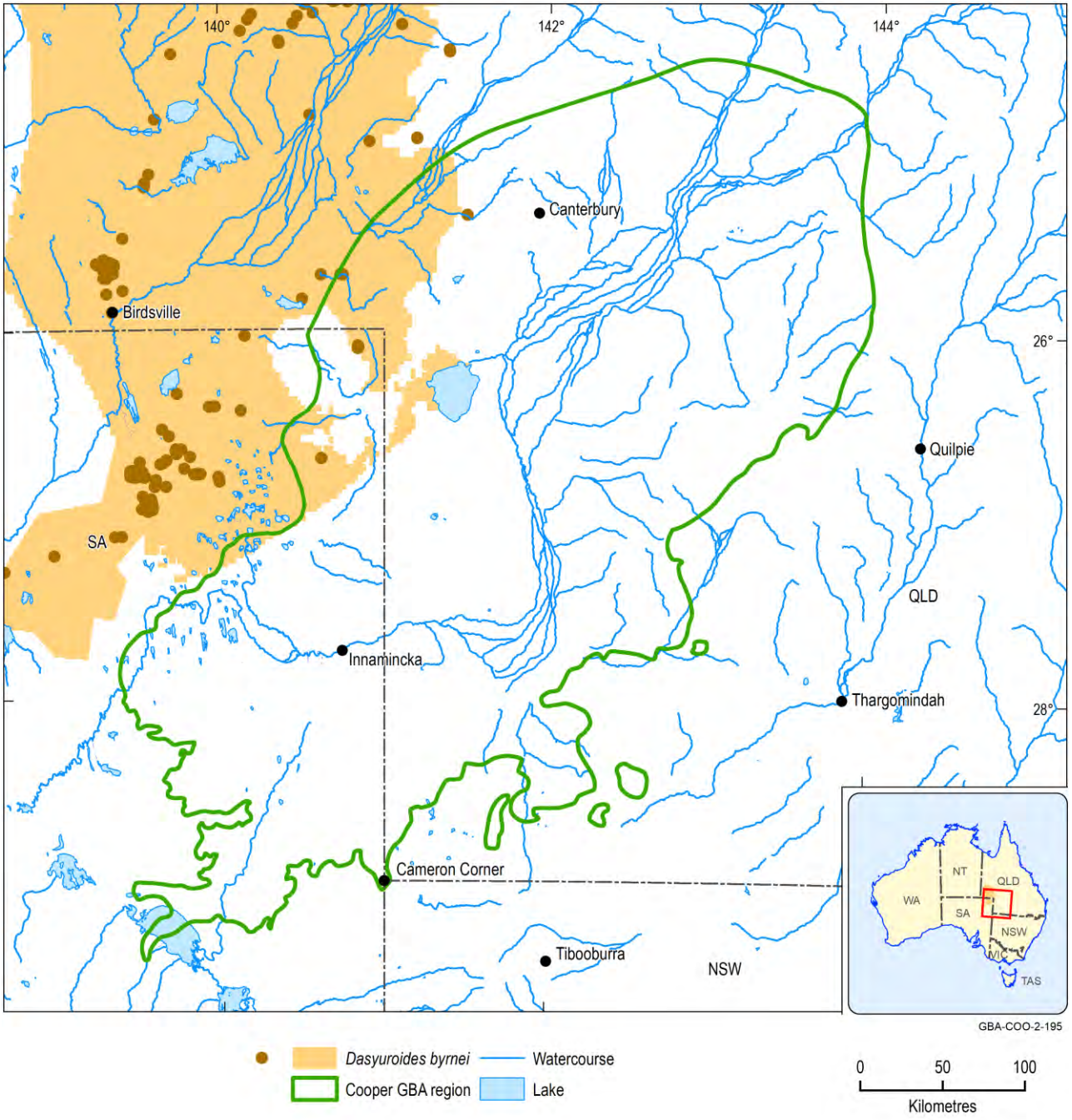

Figure 6 Distribution and Atlas of Living Australia observations of the kowari, *Dasyuroides byrnei*

Data: Atlas of Living Australia (2019); Department of the Environment and Energy (2018a)
Element: GBA-COO-2-195

Water dependency

No water dependency has been identified for this species.

Shale and tight gas development activities with potential to impact species

Impacts from development are likely to occur during the following activities:

- habitat loss and fragmentation;
- introduction of invasive species;
- increased competition and predation;
- erosion;
- exposure to soil, groundwater and/or surface water contamination;
- changed surface water quality and/or flows.

Koala (*Phascolarctos cinereus* (combined populations of Queensland, NSW and the ACT))

Status: Vulnerable

Overview

Koalas that occur in Queensland, NSW and the ACT are considered as a combined management unit that is listed nationally as vulnerable under the EPBC Act. Koalas in the remainder of Australia are not listed as threatened. Potential distribution of the koala intersects with the extreme north-east boundary of the Queensland portion of the Cooper GBA region (Figure 7).

Koalas in semi-arid environments inhabit forest and woodland dominated by *Eucalyptus* species in riparian and non-riparian areas. In non-riparian areas *Acacia*-dominated forest, woodland and shrubland are also occupied. In semi-arid Queensland, riparian vegetation along drainage lines is considered to be an important refuge area during droughts. Important food and habitat trees for koalas in semi-arid Queensland include *Eucalyptus camaldulensis*, *E. populnea*, *E. crebra*, *E. tereticornis*, *E. melanophloia*, *E. tessellaris* and *Melaleuca bracteate* (Gordon et al., 1988; Ellis et al., 2002).

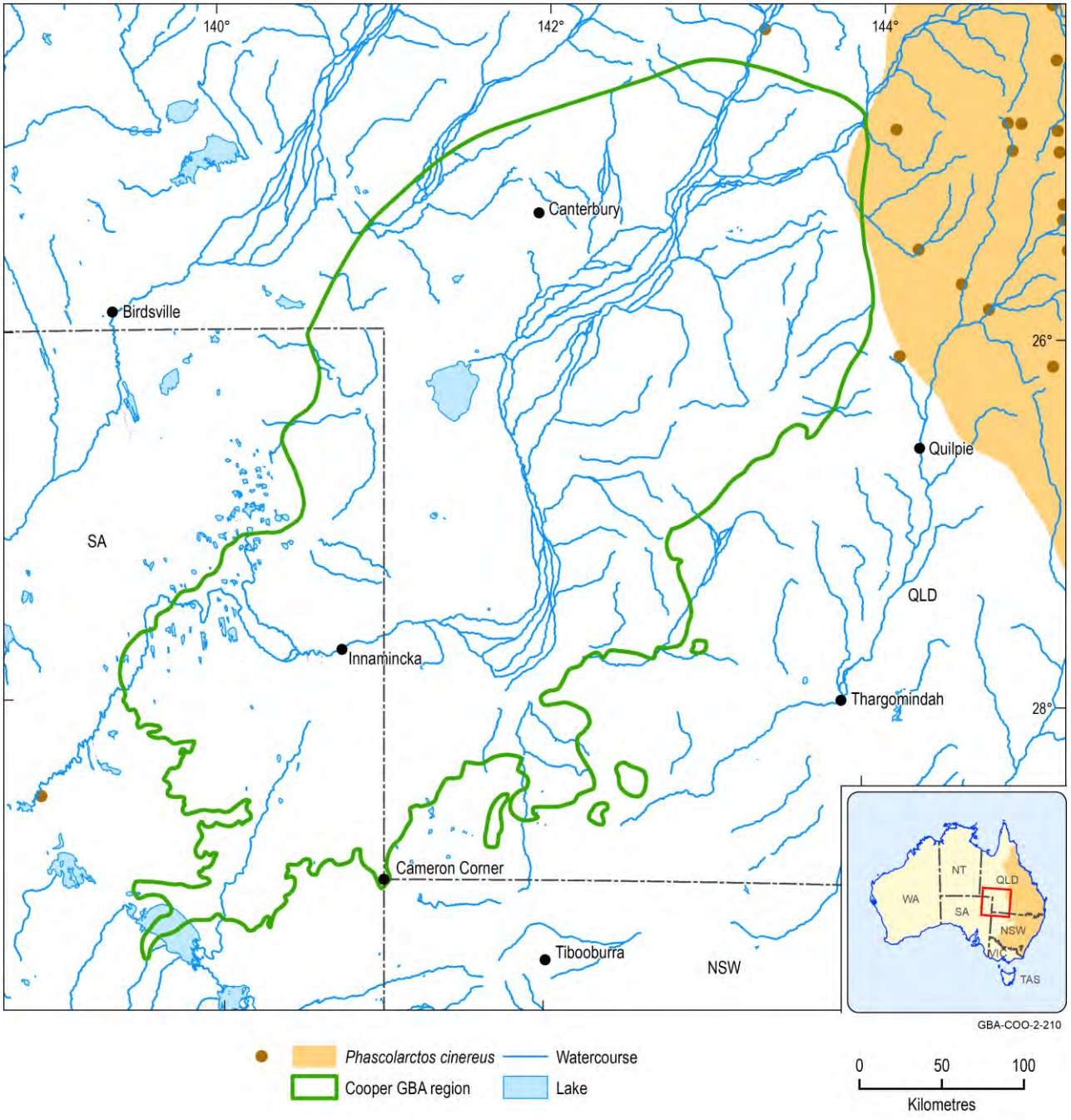

Figure 7 Distribution and Atlas of Living Australia observations of the koala, *Phascolarctos cinereus*

Data: Atlas of Living Australia (2019); Department of the Environment and Energy (2018a)
Element: GBA-COO-2-210

Water dependency

The koala occurs in riverine habitat and in groundwater-dependent ecosystems that are both on floodplain and non-floodplain areas of the landscape. Several important feed trees of the koala in semi-arid Queensland are dependent on groundwater.

Shale and tight gas development activities with potential to impact species

Impacts from shale gas development are likely to occur during the following activities:

- habitat loss and fragmentation;
- exposure to soil, groundwater and/or surface water contamination;
- changed surface water quality and/or flows.

Yellow-footed rock-wallaby (*Petrogale xanthopus celeris* (central-western Queensland))

Status: Vulnerable

Overview

The yellow-footed rock-wallaby is a medium-sized macropod. The subspecies *celeris* has a restricted distribution in central and south-west Queensland to the north and north-west of the town of Adavale (Figure 8). It is a nocturnal animal and shelters during the day in rock crevices. It occupies rocky areas along the edges of hills and tablelands. The vegetation here is *Acacia* woodland or shrubland.

The yellow-footed rock-wallaby occurs in the Queensland portion of the Cooper GBA region.

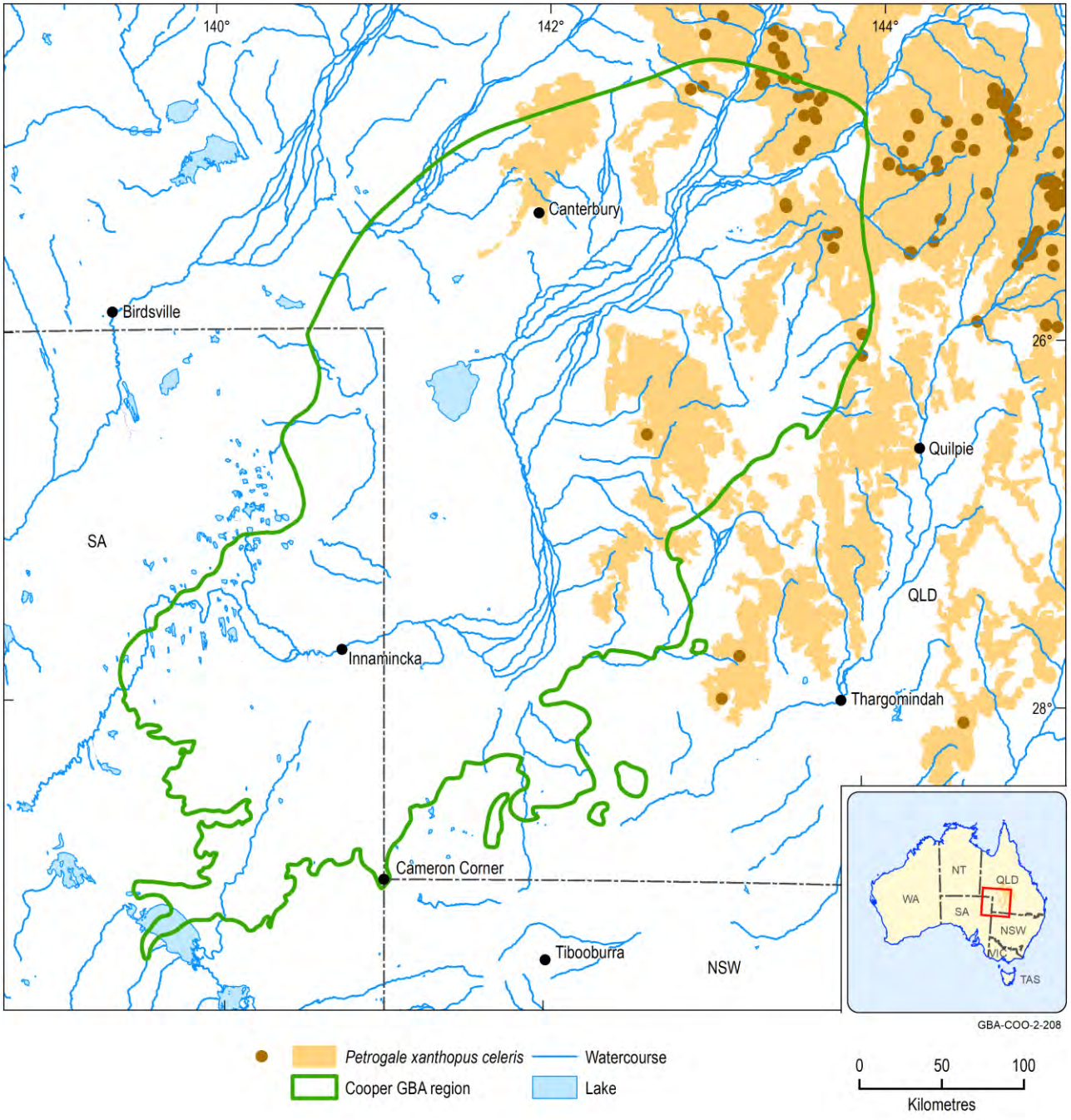

Figure 8 Distribution and Atlas of Living Australia observations of the yellow-footed rock-wallaby (central-western Queensland), *Petrogale xanthopus celeris*

Data: Atlas of Living Australia (2019); Department of the Environment and Energy (2018a)
Element: GBA-COO-2-208

Water dependency

No water dependency has been identified for this species.

Shale and tight gas development activities with potential to impact species

Impacts from shale gas development are likely to occur during the following activities:

- habitat loss and fragmentation;
- introduction of invasive species;
- increased competition and predation;
- exposure to soil, groundwater and/or surface water contamination;
- changed surface water quality and/or flows.

Julia Creek dunnart (*Sminthopsis douglasi*)

Status: Vulnerable

Overview

The Julia Creek dunnart is a carnivorous marsupial that is endemic to inland Queensland (Figure 9). It has a body mass of up to 70 g making it the largest species of the 19 species of dunnart (members of the genus *Sminthopsis*) in the world. The Julia Creek dunnart occurs in grasslands with cracking clay soils. The dominant grasses are Mitchell grass (species of *Astrebla*) and Flinders grass (species of *Iseilema*). The species is nocturnal and shelters during the day in cracks in the soil. It has a home range of 0.25 to 7 ha.

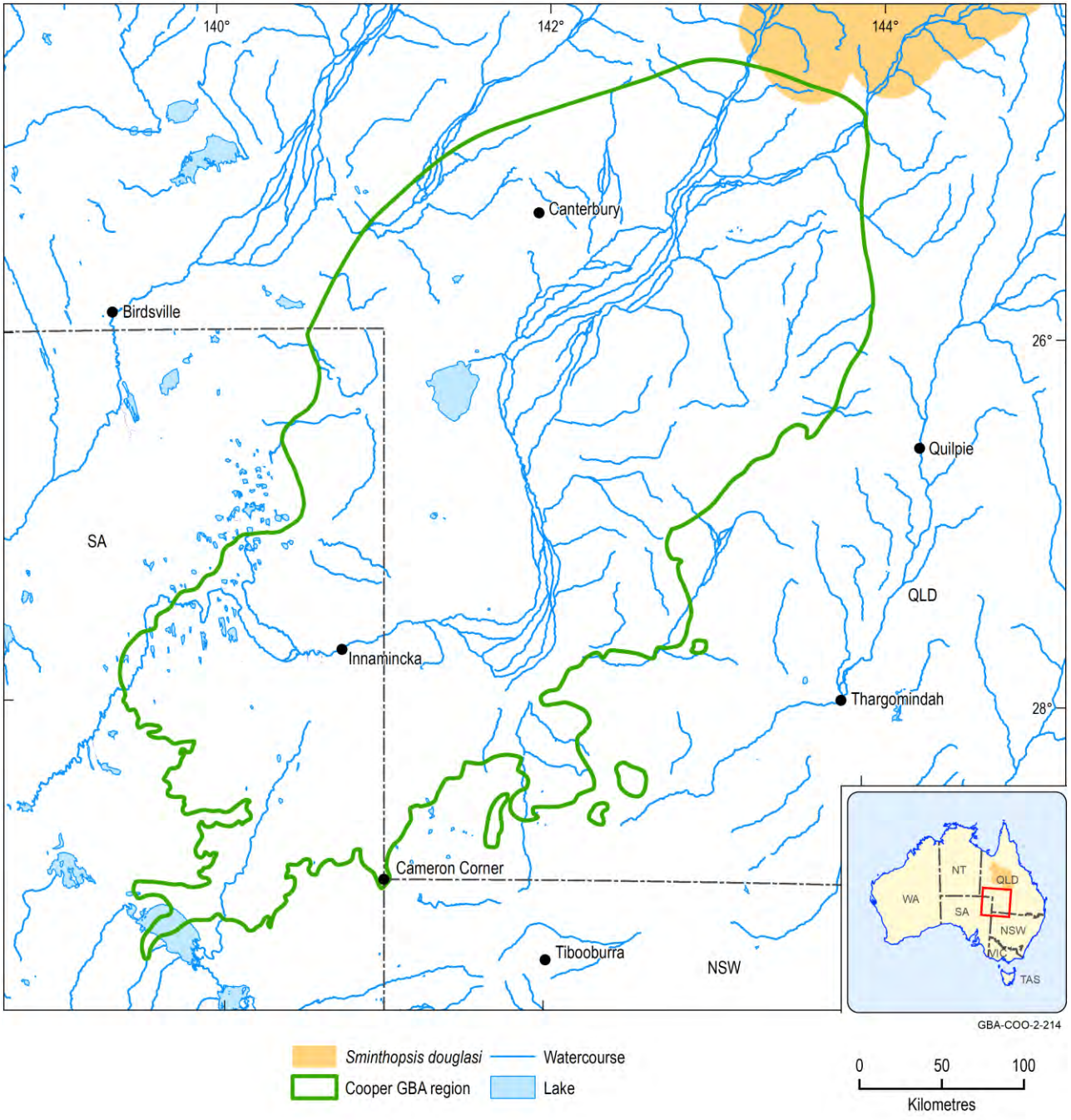

Figure 9 Distribution of the Julia Creek dunnart, *Sminthopsis douglasi*

Data: Department of the Environment and Energy (2018a)
Element: GBA-COO-2-214

Water dependency

Reliance on water is expected to be from run-on of local rainfall.

Shale and tight gas development activities with potential to impact species

The key areas of the landscape are determined by the presence of cracking clay soils.

Impacts from shale gas development are likely to occur during the following activities:

- habitat loss and fragmentation;
- increased competition and predation;
- erosion;
- reduced soil productivity;
- exposure to soil, groundwater and/or surface water contamination;
- changed surface water quality and/or flows;

Plants

Acacia peuce

Status: Vulnerable

Overview

This species is a slow-growing and long-lived arid tree species that grows up to 18 m high. It occurs as three highly disjunct populations on the fringe of the Simpson Desert in arid central Australia. Two populations are located in south-west Queensland and one in the NT. The closest population to the Cooper GBA region is located north-west of Birdsville on the Roseberth pastoral lease (Figure 10). It consists of many discontinuous stands covering a total area of about 50 km^2 (Nano et al., 2007).

At each site, *Acacia peuce* is the only tree to reach any great size, and it therefore functions as a keystone species, providing roosting and nesting sites for birds (including resident and nomadic raptors) as well as establishment sites for subordinate plant species (Nano et al., 2012).

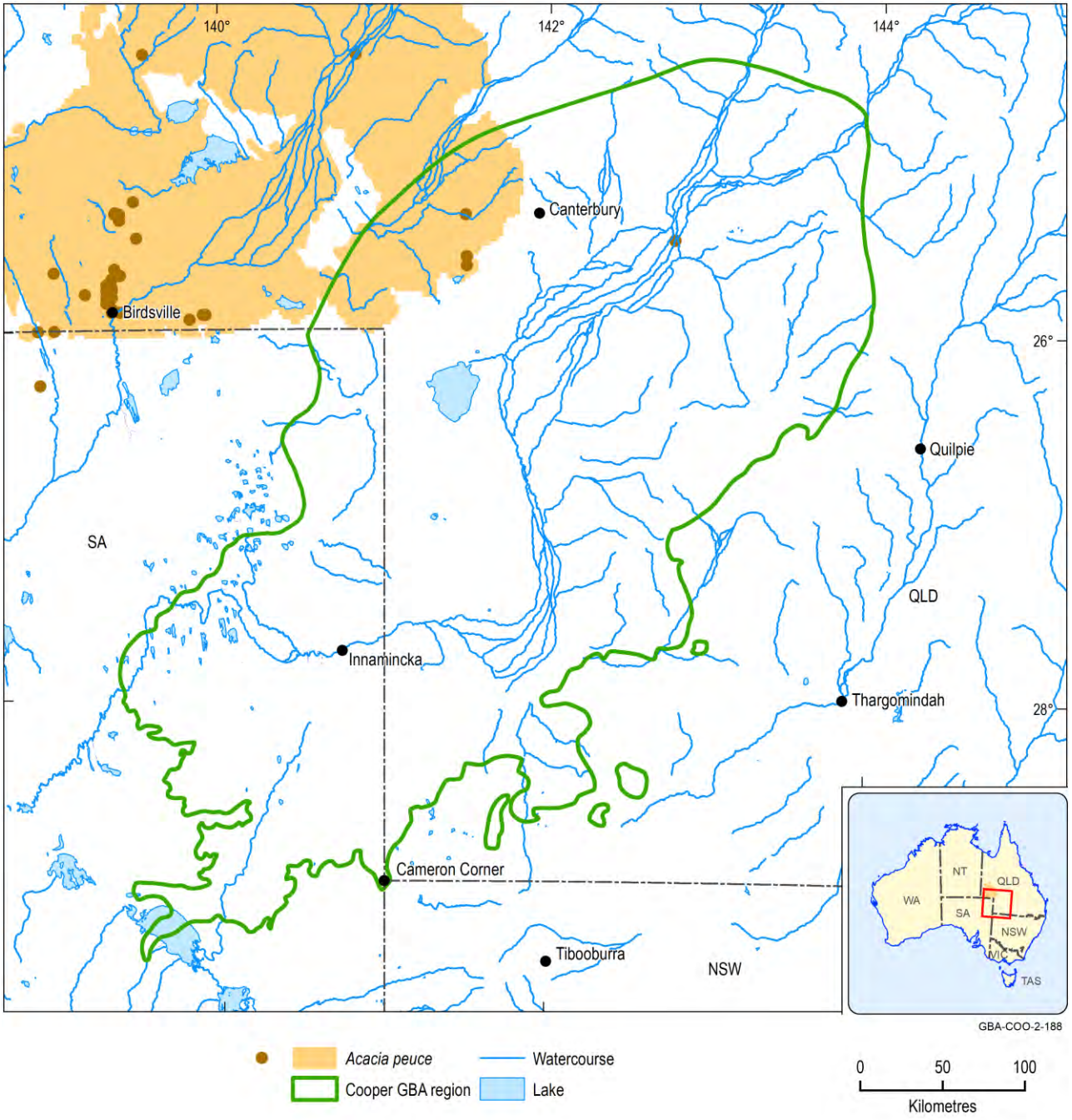

Figure 10 Distribution and Atlas of Living Australia observations of *Acacia peuce*

Data: Atlas of Living Australia (2019); Department of the Environment and Energy (2018a)
Element: GBA-COO-2-188

Water dependency

The presence of a large tree up to 18 m in height in areas that are moisture limited has resulted in the conclusion that *Acacia peuce* is groundwater dependent. However, this has not been conclusively established.

Impacts from shale gas development

Impacts from shale gas development are likely to occur during the following activity:

- erosion;
- reduced soil productivity;
- exposure to soil, groundwater and/or surface water contamination;
- changed surface water quality and/or flows;
- changed groundwater levels and/or quality.

Frankenia plicata

Status: Endangered

Overview

This species is a small shrub that occurs in either an erect or prostrate growth form and has stems that are up to 25 cm long. It occurs in a range of environments including small hillside drainage lines. *Frankenia plicata* has been found growing predominantly in swales with loamy sands to clay soils. Little is known about the ecology of this species. It is likely to be widespread within the Cooper Basin (Figure 11).

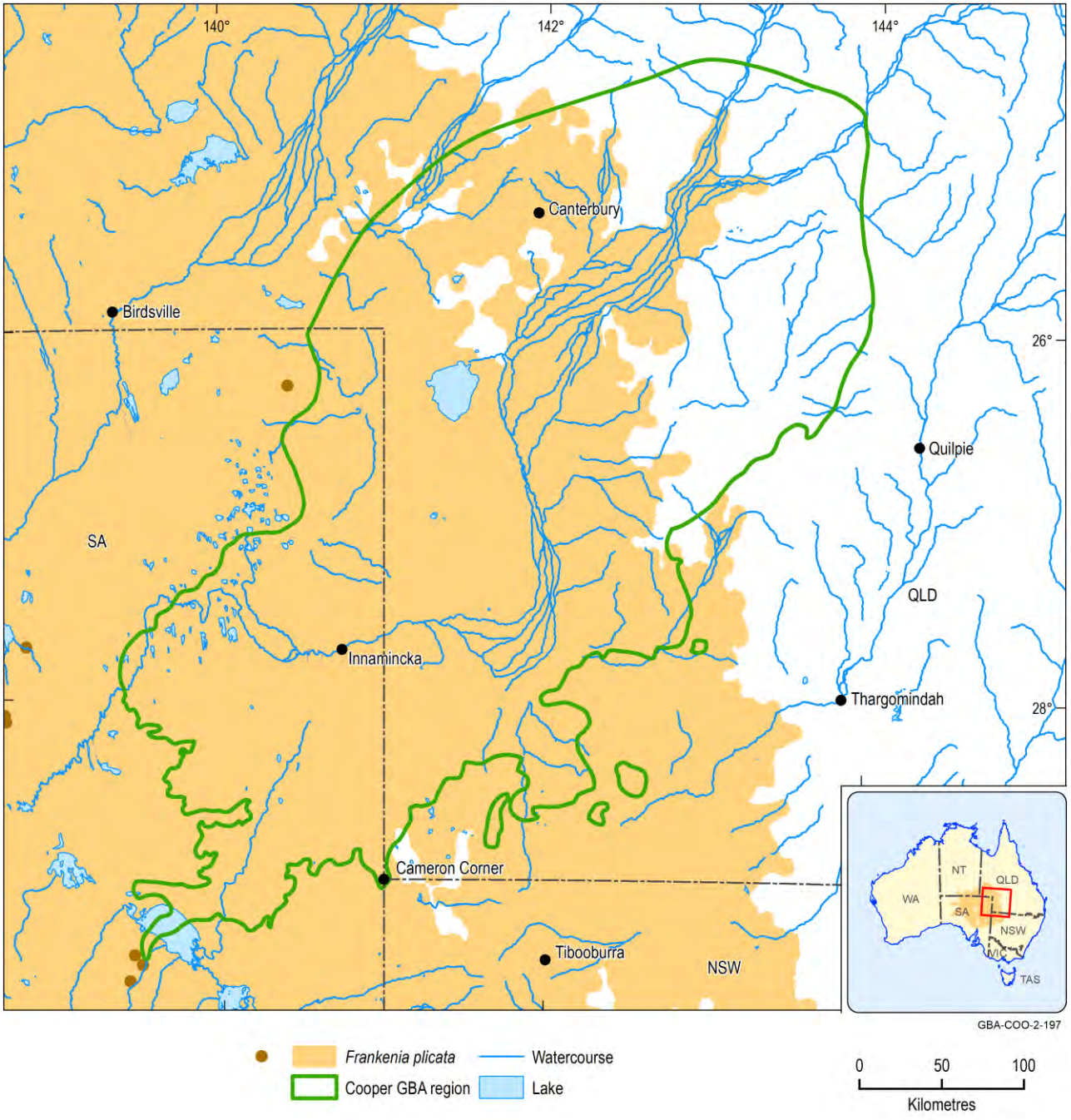

Figure 11 Distribution and Atlas of Living Australia observations of *Frankenia plicata*

Data: Atlas of Living Australia (2019); Department of the Environment and Energy (2018a)
Element: GBA-COO-2-197

Water dependency

No water dependency has been identified for this species. However, its association with drainage lines and dune swales suggests a dependence on surface water or localised runoff.

Shale and tight gas development activities with potential to impact species

Impacts from shale gas development are likely to occur during the following activities:

- habitat loss and fragmentation;
- erosion;
- reduced soil productivity;
- exposure to soil, groundwater and/or surface water contamination;
- changed surface water quality and/or flows.

Sclerolaena walkeri

Status: Vulnerable

Overview

This species is a small shrub that grows to a height of about 30 cm. It has slender, cylindrical leaves. The species occurs on the floodplains of rivers such as the Paroo and Bulloo and in riverine channels and flats. Little is known about the ecology of this species. It occurs widely within the Cooper Basin especially the Queensland portion (Figure 12).

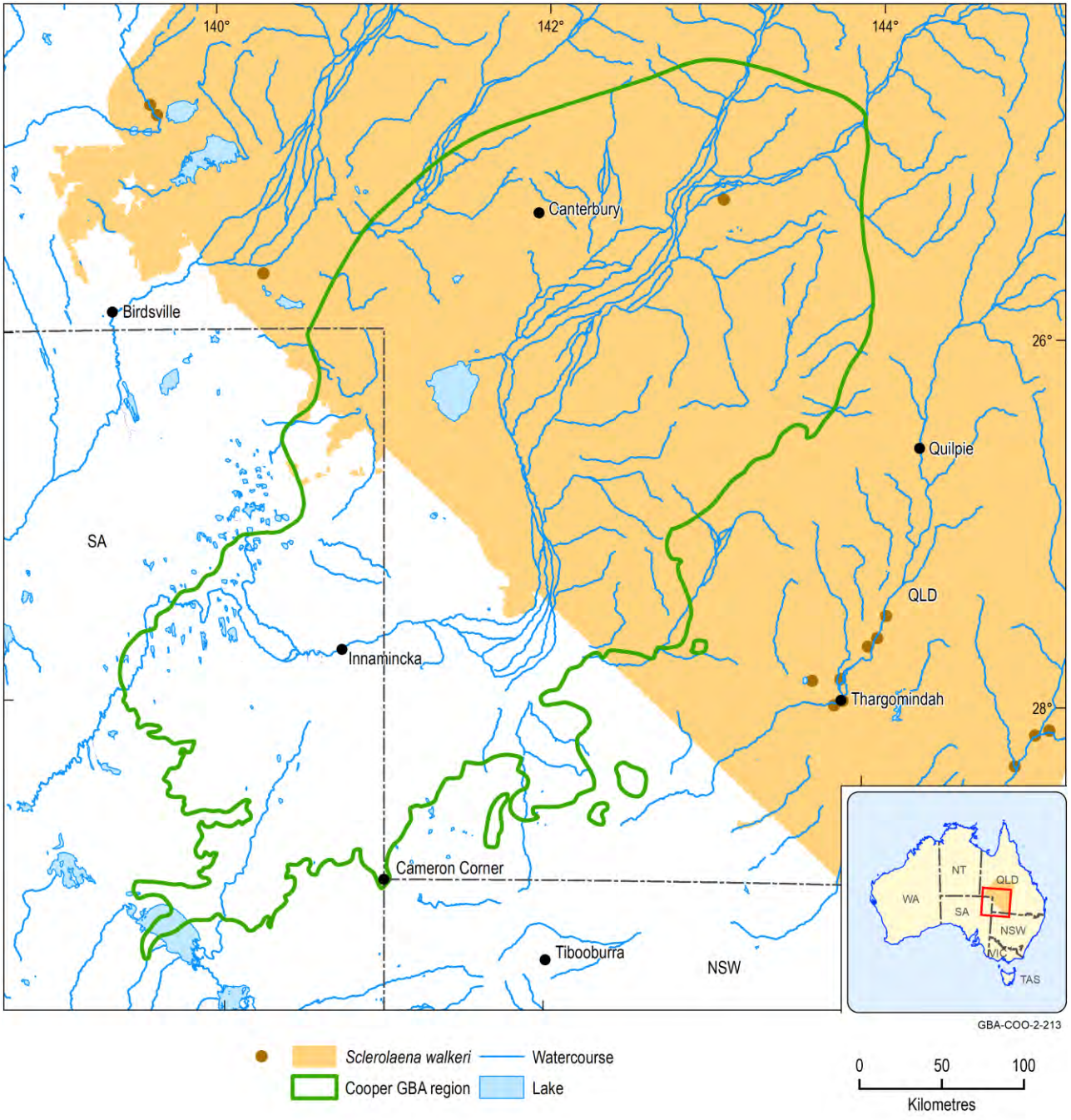

Figure 12 Distribution and Atlas of Living Australia observations of *Sclerolaena walkeri*

Data: Atlas of Living Australia (2019); Department of the Environment and Energy (2018a)
Element: GBA-COO-2-213

Water dependency

No water dependency has been identified for this species. However, its association with floodplains and riverine channels suggests a dependence on surface water or localised runoff.

Shale and tight gas development activities with potential to impact species

Impacts from shale gas development are likely to occur during the following activities:

- habitat loss and fragmentation;
- reduced soil productivity;
- exposure to soil, groundwater and/or surface water contamination;
- changed surface water quality and/or flows;
- changed groundwater levels and/or quality.

Hakea maconochieana

Status: Vulnerable

Overview

This species is an erect or spreading shrub that grows to a height of 0.5 to 1.5 m. It produces inflorescences that are 3.0 to 3.5 cm long with about 100 red flowers each. The species is endemic to a small area of south-west Queensland in the vicinity of the Ambathala Range and Grey Range (Figure 13). It occurs as localised populations that grow on the tops of stony tablelands at elevations above 300 m. *Hakea maconochieana* occupies shallow clay soils.

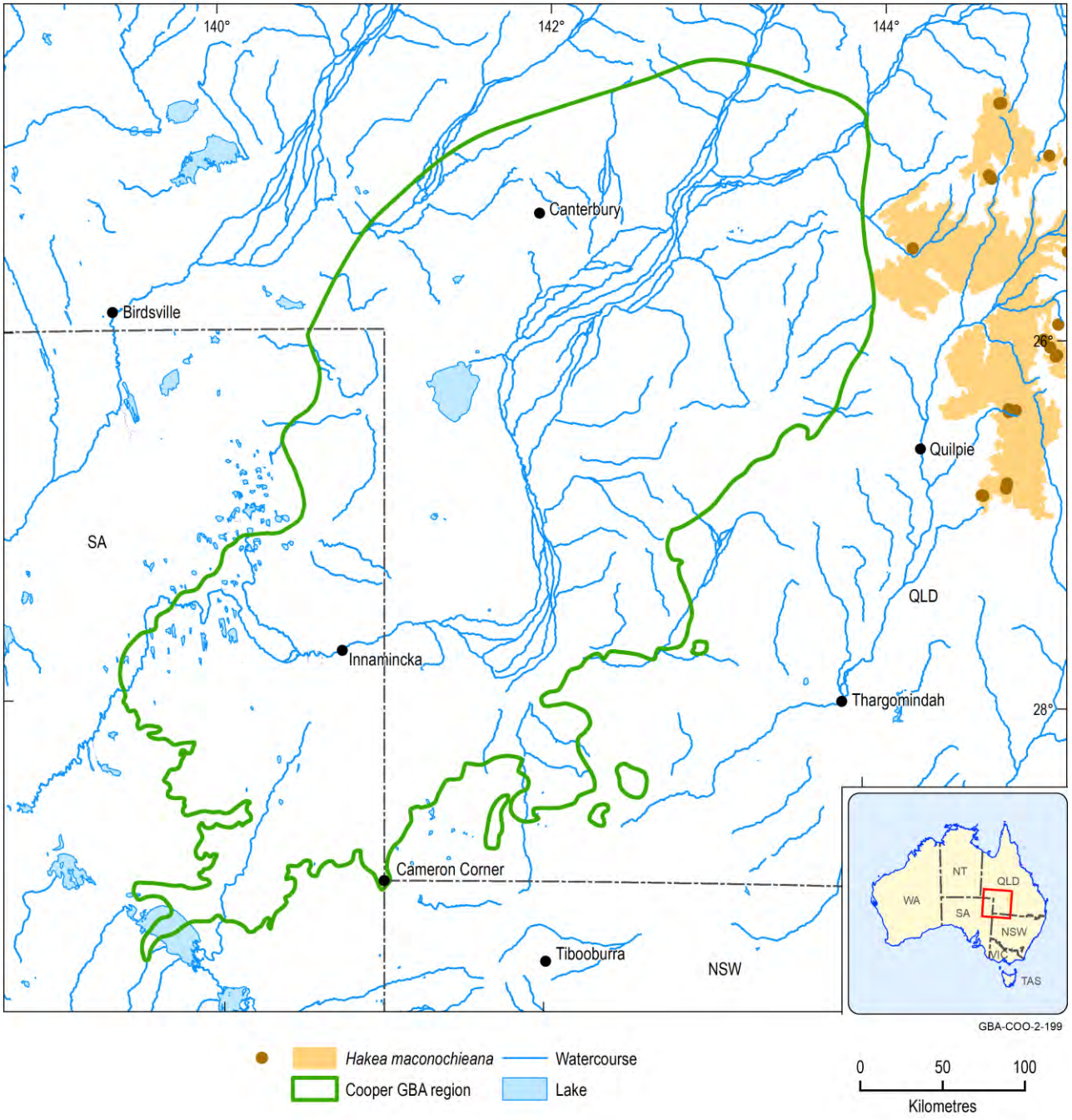

Figure 13 Distribution and Atlas of Living Australia observations of *Hakea maconochieaena*

Data: Atlas of Living Australia (2019); Department of the Environment and Energy (2018a)
Element: GBA-COO-2-199

Water dependency

No water dependency has been identified for this species.

Shale and tight gas development activities with potential to impact species

Impacts from shale gas development are likely to occur during the following activities:

- habitat loss and fragmentation;
- reduced soil productivity;
- exposure to soil, groundwater and/or surface water contamination;
- changed surface water quality and/or flows;
- changed groundwater levels and/or quality.

Xerothamnella parvifolia

Status: Vulnerable

Overview

This species is a shrub that grows to a height of 1 m. The flowers are white with red spots and comprise a tube and widely spreading lobes. The species is endemic to a dryland Australia and occurs in south-west Queensland, the Flinders Ranges of SA and a single collection site in north-west NSW (Figure 14). The species grows on stony ridges and on the lower slopes of rocky escarpments and is often associated with mesas. It occupies variable soil types including sandy loams, sandy clay loams, fine sandy clays and reddish clays.

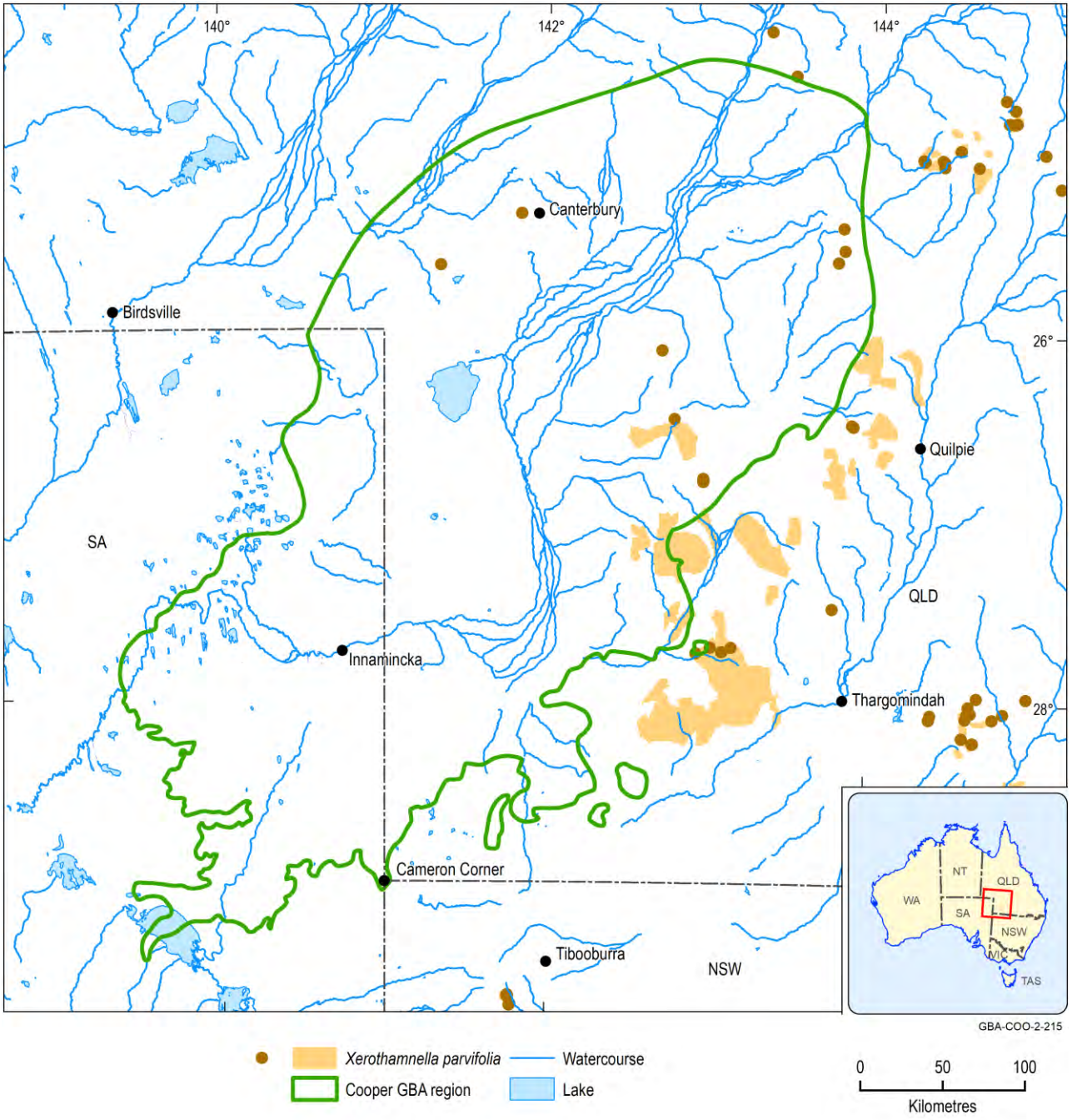

Figure 14 Distribution and Atlas of Living Australia observations of *Xerothamnella parvifolia*

Data: Atlas of Living Australia (2019); Department of the Environment and Energy (2018a)
Element: GBA-COO-2-215

Water dependency

No water dependency has been identified for this species.

Shale and tight gas development activities with potential to impact species

Impacts from shale gas development are likely to occur during the following activities:

- habitat loss and fragmentation;
- reduced soil productivity;
- exposure to soil, groundwater and/or surface water contamination;
- changed surface water quality and/or flows;
- changed groundwater levels and/or quality.

Birds

Grey grasswren (Bulloo) (*Amytornis barbatus barbatus*)

Status: Endangered

Overview

The grey grasswren (Bulloo) is one of two subspecies of the grey grasswren (subspecies *barbatus*). It is endemic to the floodplain of the Bulloo River on the Queensland/NSW border, although unconfirmed records in the Atlas of living Australia has it occurring on the Diamantina River floodplain (Figure 15). In Queensland, it appears to be restricted to Bulloo Downs Station. A cryptic passerine, it occurs on floodplains specifically in swamps, overflow channels and pans that are dominated by dense tall lignum (*Muehlenbeckia florulenta*) with associated sandhill canegrass (*Zygochloa paradoxa*) and sedges. It is largely sedentary and occurs in territorial pairs when breeding. Breeding territories range from 0.5 to 2 ha. The grey grasswren feeds on arthropods, especially insects, and seeds. It is a ground forager.

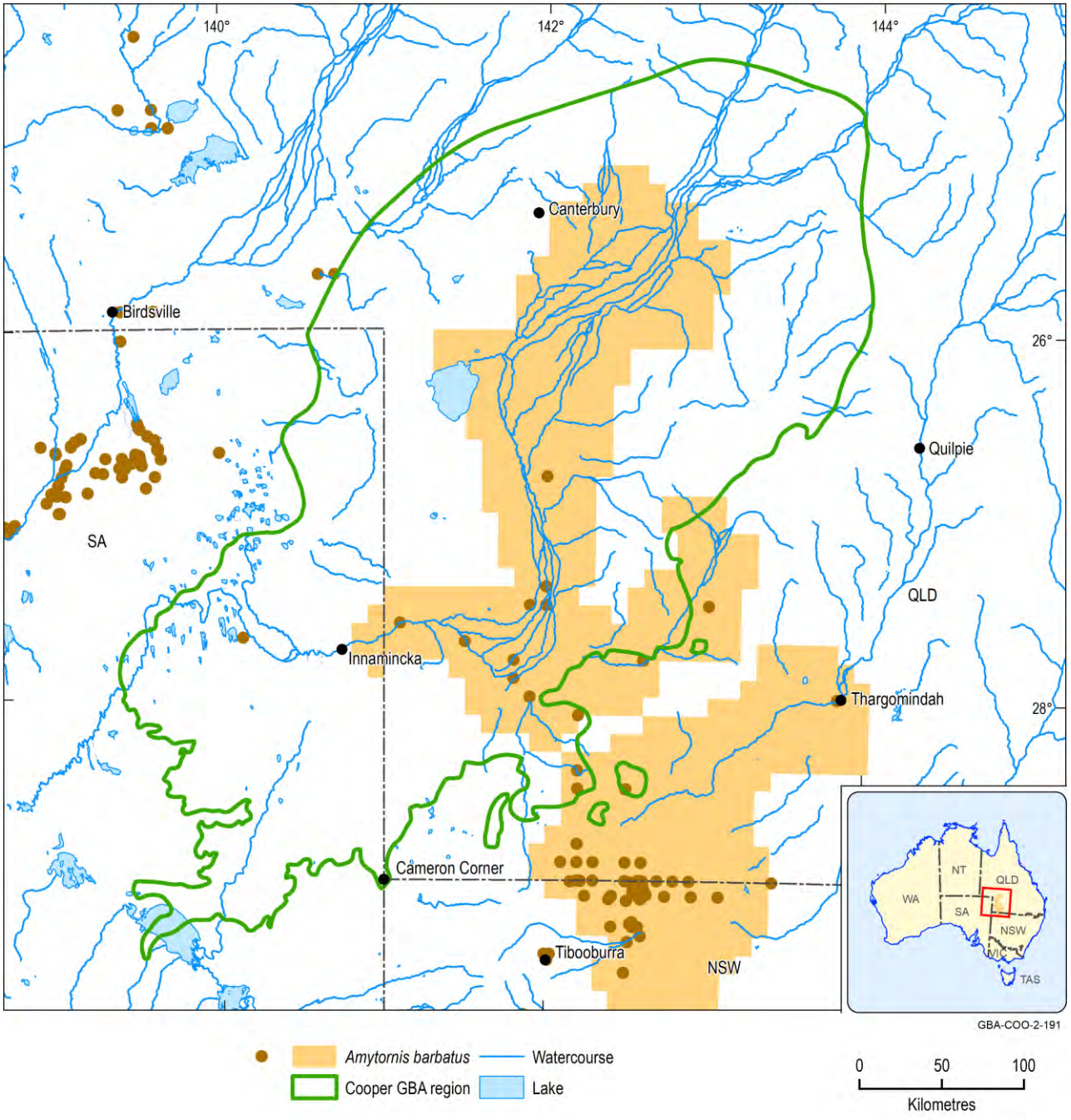

Figure 15 Distribution and Atlas of Living Australia observations of the grey grasswren (Bulloo), *Amytornis barbatus barbatus*

Data: Atlas of Living Australia (2019); Department of the Environment and Energy (2018a)
Element: GBA-COO-2-191

Water dependency

The grey grasswren appears to depend on swamps and other wetlands that support dense tall lignum stands for its persistence in an area (Hardy, 2002). These lignum swamps function as a refuge habitat during periods of climatic extremes. They provide food and shelter to serve as a refuge for a high density of grey grasswrens during dry periods. The integrity of this habitat and its periodic inundation from local rainfall and/or floodwater appears to be essential for the grey grasswren to persist.

Shale and tight gas development activities with potential to impact species

The key areas of the landscape are refuges consisting of lignum-dominated swamps on floodplains.

Impacts from shale gas development are likely to occur during the following activities:

- habitat loss and fragmentation;
- introduction of invasive species;
- increased competition and predation;
- exposure to soil, groundwater and/or surface water contamination;
- changed surface water quality and/or flows.

Thick-billed grasswren (*Amytornis modestus indulkana*)

Status: Vulnerable

Overview

The thick-billed grasswren is endemic to dryland Australia. The subspecies *A. m. indulkana*, one of six described subspecies, occurs within the Cooper Basin. It occupies an area west of Lake Eyre and Lake Torrens in SA, close to the border with the NT (Figure 16). The subspecies occupies chenopod shrublands, particularly those dominated by saltbush and bluebush. It appears to favour patches of thicker and taller vegetation along drainage lines. Thick-billed grasswrens occur as pairs or small groups and occupy a home range of up to 5 ha. This grasswren is a ground forager, feeding on seeds and arthropods.

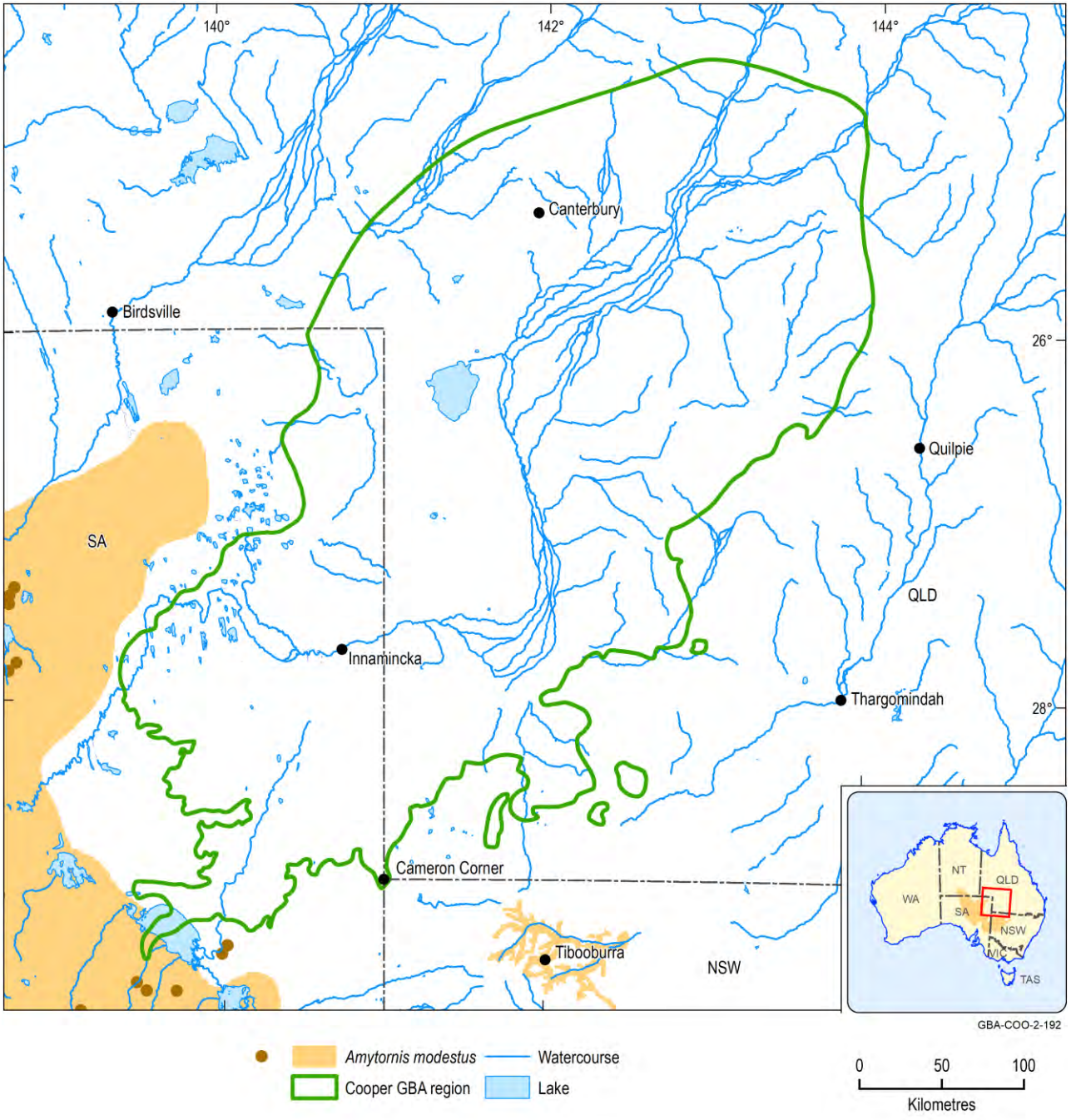

Figure 16 Distribution and Atlas of Living Australia observations of the thick-billed grasswren, *Amytornis modestus indulkana*

Data: Atlas of Living Australia (2019); Department of the Environment and Energy (2018a)
Element: GBA-COO-2-192

Water dependency

The thick-billed grasswren occupies chenopod shrubland in run-on areas of the landscape. It does not appear to depend on water apart from local rainfall.

Shale and tight gas development activities with potential to impact species

The key areas of the landscape for the thick-billed grasswren are chenopod shrublands.

Impacts from shale gas development are likely to occur during the following activities:

- habitat loss and fragmentation;
- introduction of invasive species;
- increased competition and predation;
- exposure to soil, groundwater and/or surface water contamination;
- changed surface water quality and/or flows.

Australian painted snipe (*Rostratula australis*)

Status: Endangered

Overview

The Australian painted snipe (*Rostratula australis*) is a species endemic to Australia that occupies shallow freshwater wetlands. It is listed as endangered and as a marine species under the EPBC Act. Although the species has been recorded across the Australian continent, the area of occupancy is comparatively small and was estimated at about 2000 km^2 by Garnett et al. (2011) (Figure 17). Suitable habitat is likely to be present for the species within the Cooper Basin only during high rainfall years.

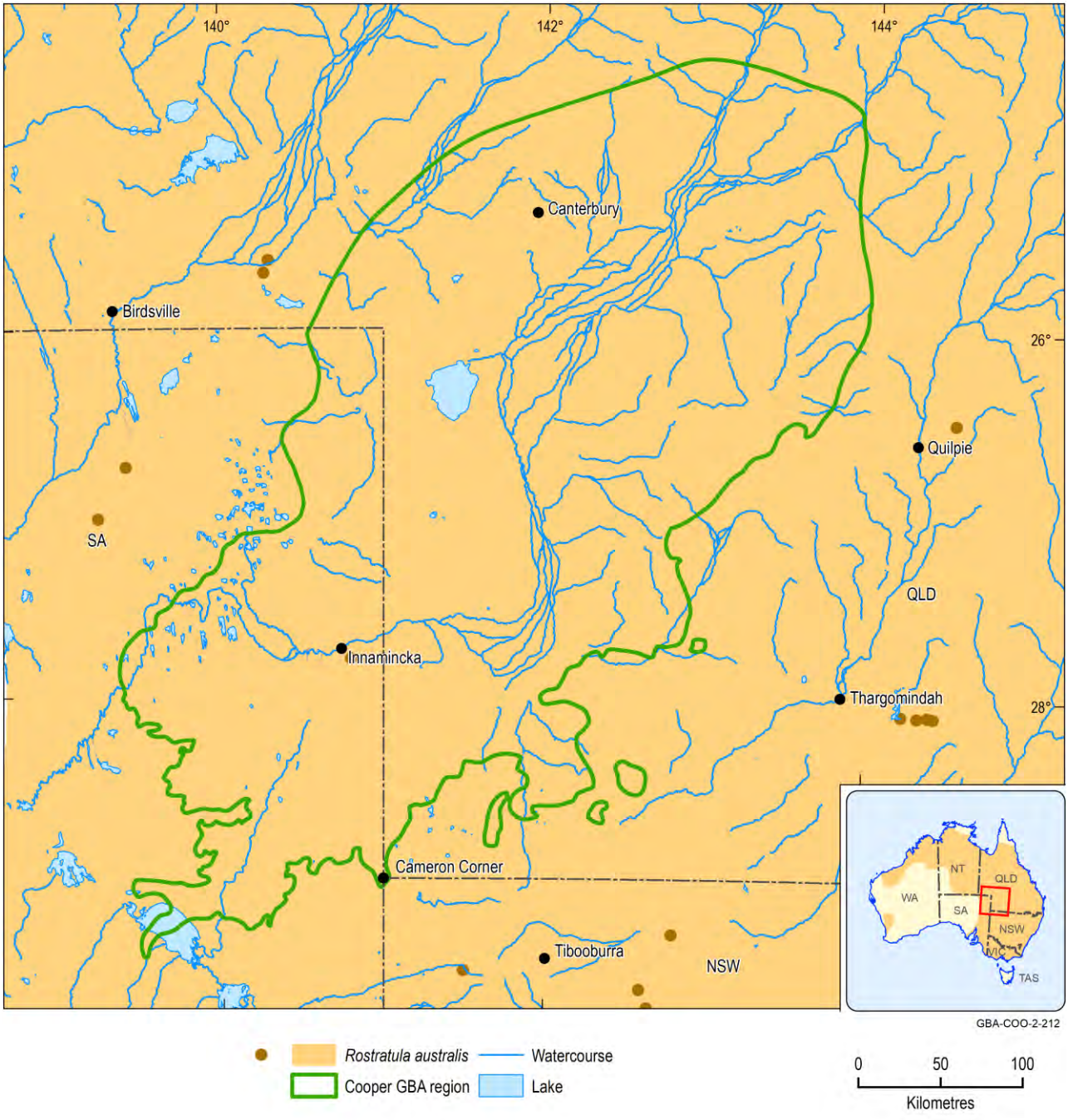

Figure 17 Distribution and Atlas of Living Australia observations of the Australian painted snipe, *Rostratula australis*

Data: Atlas of Living Australia (2019); Department of the Environment and Energy (2018a)
Element: GBA-COO-2-212

Water dependency

The Australian painted snipe is a water-dependent species. The main habitat of this species is shallow freshwater wetlands. Suitable habitat includes lakes, swamps, claypans, inundated or waterlogged grassland and saltmarsh, and artificial wetlands including dams, rice crops, sewerage farms and bore drains.

Shale and tight gas development activities with potential to impact species

The key areas of the landscape are shallow freshwater wetlands.

Impacts from shale gas development are likely to occur during the following activities:

- introduction of invasive species;
- increased competition and predation;
- exposure to soil, groundwater and/or surface water contamination;
- changed surface water quality and/or flows.

Star finch (eastern) (*Neochmia ruficauda ruficauda*)

Status: Endangered

Overview

The eastern/southern subspecies of the star finch (*Neochmia ruficauda ruficauda*) is classified as endangered nationally. However, an assessment of the conservation status of all Australian bird taxa in 2010 concluded that its status should be critically endangered (possibly extinct) (Garnett et al., 2011). The star finch (eastern) may previously have occurred in the Queensland section of the Cooper Basin; however, there are no confirmed records (Figure 18). It occupies grassland and grassy woodland close to freshwater in particular in riverine habitat (Garnett et al., 2011).

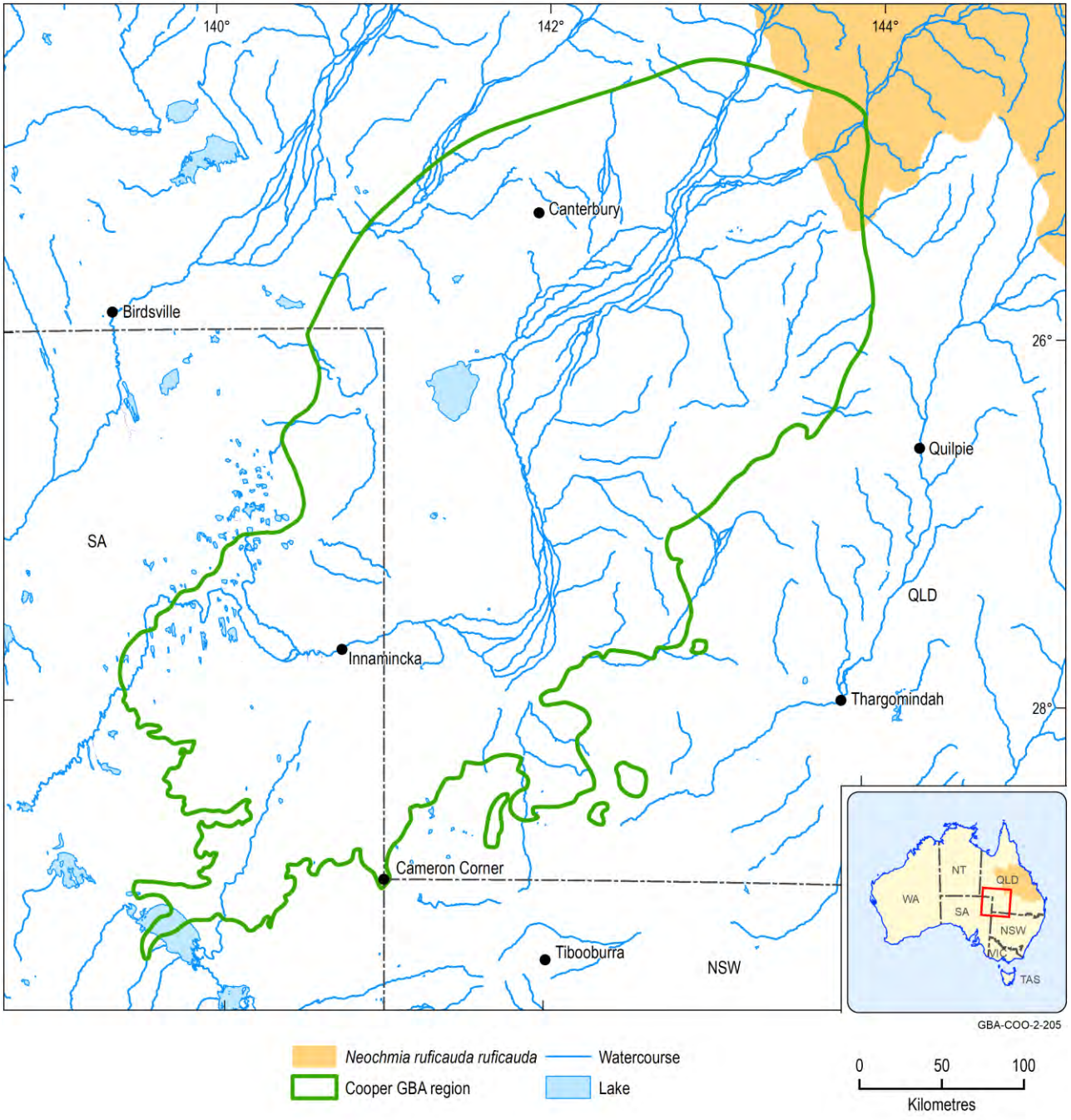

Figure 18 Distribution of the star finch (eastern) *Neochmia ruficauda ruficauda*

Data: Department of the Environment and Energy (2018a)
Element: GBA-COO-2-205

Water dependency

The star finch needs surface water from which it drinks daily.

Shale and tight gas development activities with potential to impact species

The key areas of the landscape are likely to be grassland and grassy woodland close to freshwater in particular in riverine habitat.

Impacts from shale gas development are likely to occur during the following activities:

- habitat loss and fragmentation;
- exposure to soil, groundwater and/or surface water contamination;
- changed surface water quality and/or flows.

Plains wanderer (*Pedionomus torquatus*)

Status: Critically endangered

Overview

The plains wanderer is a phylogenetically distinct species belonging to its own family. It is endemic to Australia where it has a scattered distribution in inland regions of Queensland, SA, NSW and Victoria (Figure 19). Here, the species occupies spare, treeless plains that support native grassland. The plains wanderer is a small bird weighing 40 to 80 grams and looks similar to a quail. Females are more brightly coloured than males.

The Cooper Basin contains important habitat for the species in the vicinity of Astrebla Downs National Park and Diamantina Lakes National Park (Commonwealth of Australia, 2016).

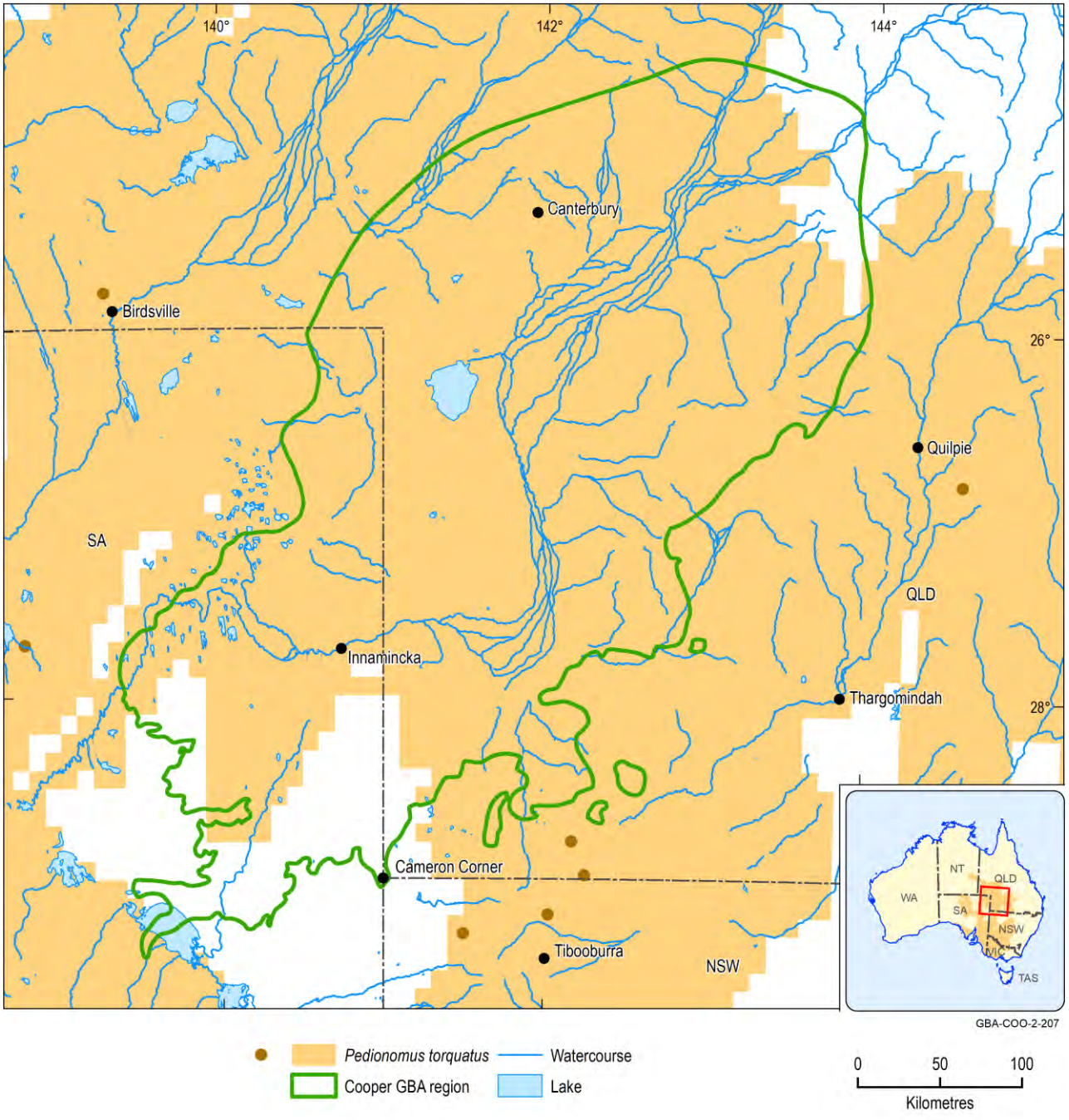

Figure 19 Distribution and Atlas of Living Australia observations of the plains wanderer, *Pedionomus torquatus*

Data: Atlas of Living Australia (2019); Department of the Environment and Energy (2018a)
Element: GBA-COO-2-207

Water dependency

The plains wanderer does not appear to have a specific dependency on water. It does not require daily access to surface water to drink.

Shale and tight gas development activities with potential to impact species

The key areas of the landscape are native grasslands on hard, red-brown clay soils.

Impacts from shale gas development are likely to occur during the following activities:

- habitat loss and fragmentation;
- invasive species;
- increased competition and predation;
- erosion;
- reduced soil productivity;
- exposure to soil, groundwater and/or surface water contamination;
- changed surface water quality and/or flows.

Night parrot (*Pezoporus occidentalis*)

Status: Endangered

Overview

The night parrot is a ground-dwelling bird that has a body mass of about 100 g. It is an enigmatic species that has been irregularly sighted since 2013. The night parrot is endemic to the Australian arid zone where it occurs in south-west Queensland, north-east SA and WA (Figure 20). In Queensland it occurs in the vicinity of Diamantina Lakes National Park and further to the north. It is cryptic and nocturnal. It shelters during the day in mature spinifex (*Triodia*) hummocks and flies up to 10 km to nearby feeding grounds soon after dusk. The diet is likely to be dominated by short-lived herbs and grasses. The species is currently listed as endangered.

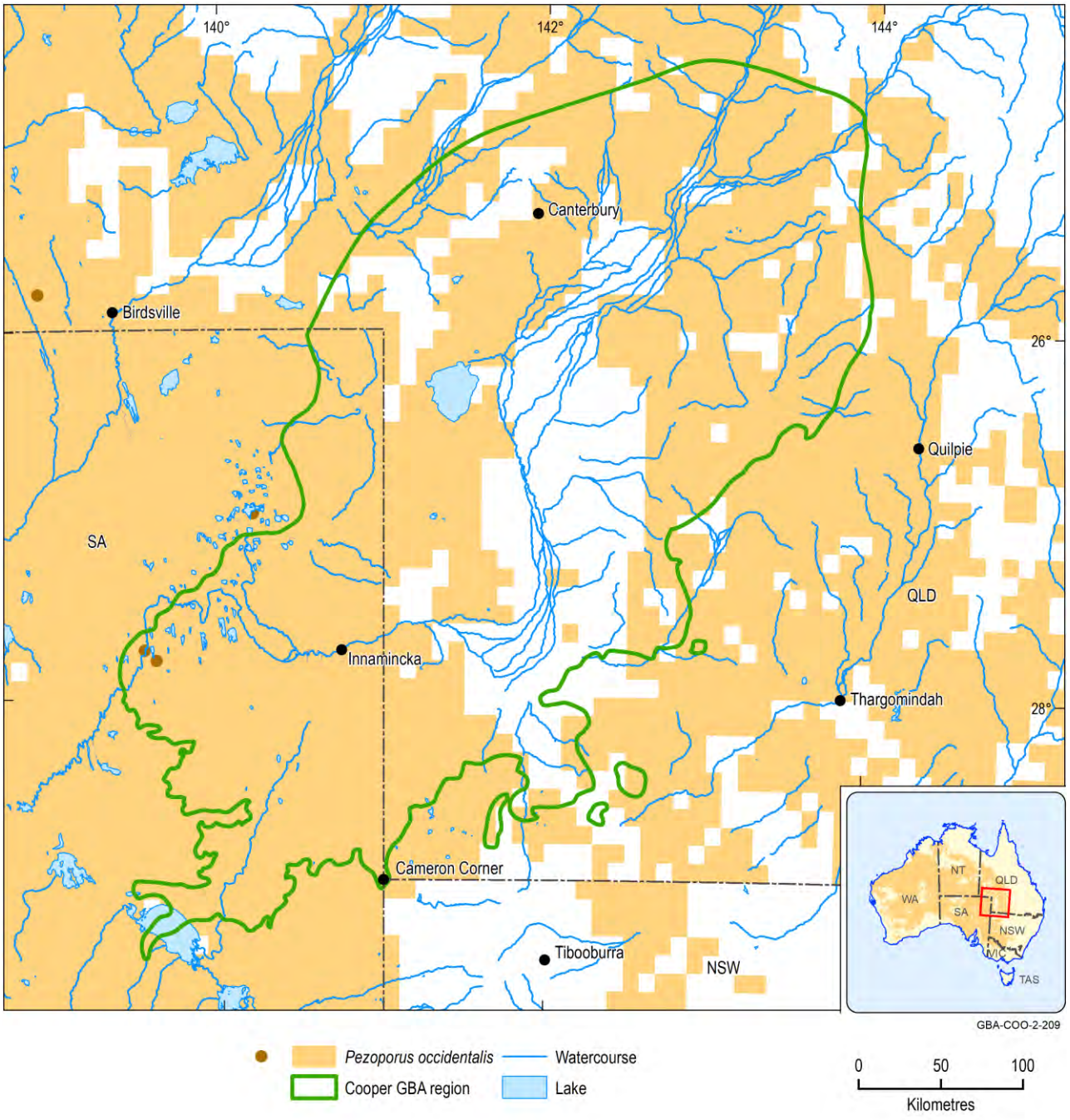

Figure 20 Distribution and Atlas of Living Australia observations of the night parrot, *Pezoporus occidentalis*

Data: Atlas of Living Australia (2019); Department of the Environment and Energy (2018a)
Element: GBA-COO-2-209

Water dependency

The night parrot is a species that is not well understood in terms of its foraging ecology. Research on this topic is ongoing. However, initial information contained in an article by Murphy et al. (2017) show that its foraging habitat includes floodplains and broad, shallow depressions that are fed from local runoff. These areas occur on cracking clay soils and support mixed-herb grasslands (Murphy et al., 2017).

Shale and tight gas development activities with potential to impact species

The key areas of the landscape are likely to include areas of cracking clay soil on alluvial plains and adjacent hillslopes.

Impacts from shale gas development are likely to occur during the following activities:

- habitat loss and fragmentation;
- introduction of invasive species;
- increased competition and predation;
- reduced soil productivity;
- exposure to soil, groundwater and/or surface water contamination;
- changed surface water quality and/or flows.

Painted Honeyeater (*Grantiella picta*)

Status: Vulnerable

Overview

The painted honeyeater is a relatively small species of bird that has a wide distribution across eastern Australia extending to the tropics in north-west Queensland and north-east Northern Territory (Figure 21). It is a specialised bird feeding mainly on the fruit of mistletoes and exhibits seasonal movements in response to food availability. The painted honeyeater occupies acacia-dominated woodlands showing a preference for those with mature trees (Garnett et al., 2011). Many birds move to semi-arid regions in northern Australia following the completion of breeding in late summer/early autumn.

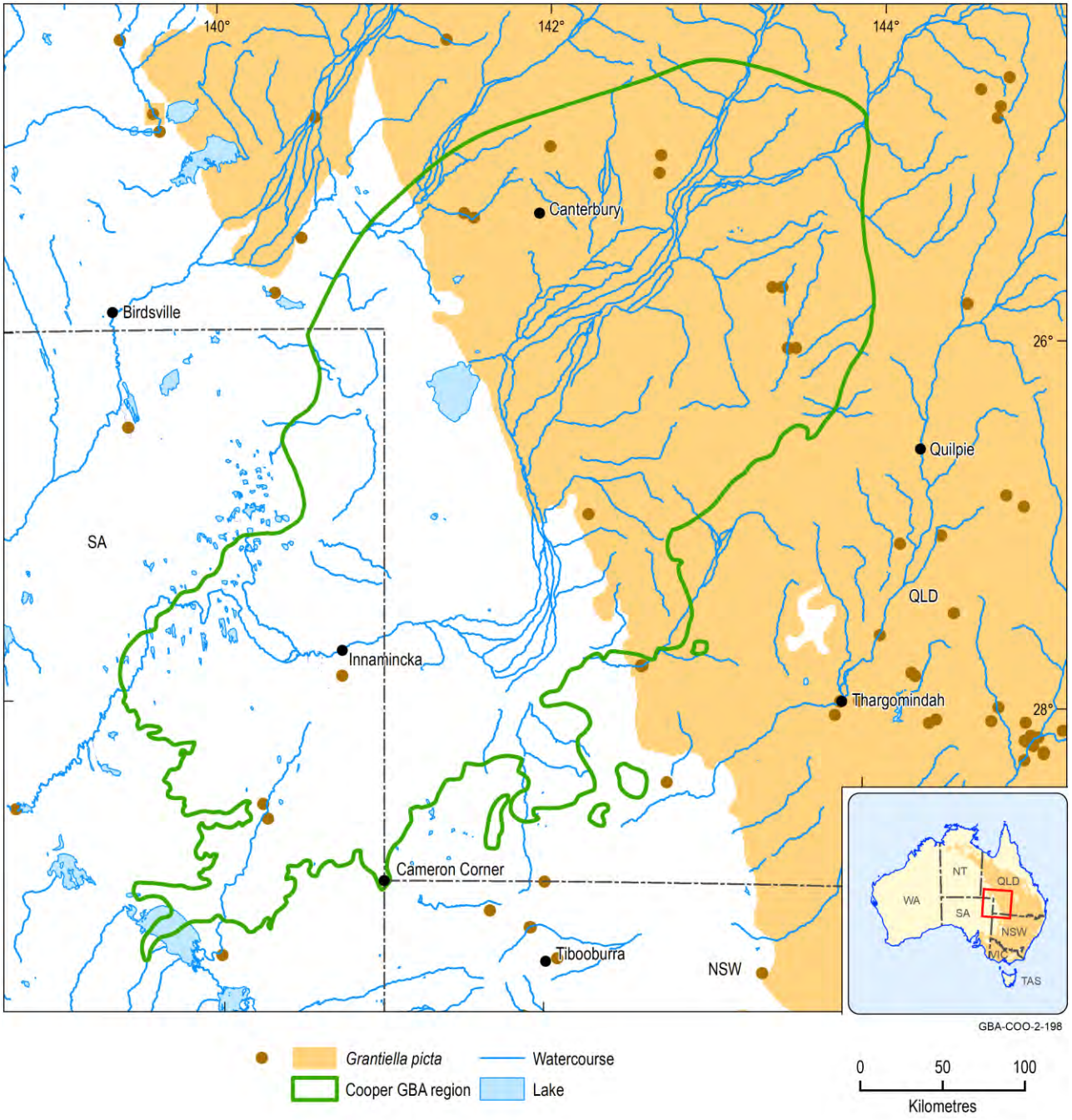

Figure 21 Distribution and Atlas of Living Australia observations of the painted honeyeater, *Grantiella picta*

Data: Atlas of Living Australia (2019); Department of the Environment and Energy (2018a)
Element: GBA-COO-2-198

Water dependency

The painted honeyeater is likely to be dependent on daily access to surface water to drink.

Shale and tight gas development activities with potential to impact species

The key areas of the landscape for the species are those that support mature trees with good numbers of mistletoes. The species is likely to be sensitive to tree clearance and habitat fragmentation. Impacts from shale gas development may occur during the following activities:

- habitat loss and fragmentation;
- reduced soil productivity;
- exposure to soil, groundwater and/or surface water contamination;
- changed surface water quality and/or flows.

Curlew sandpiper (*Calidris ferruginea*)

Status: Critically endangered

Overview

The curlew sandpiper is listed as critically endangered and as a migratory and marine species under the EPBC Act. The curlew sandpiper is a migratory shorebird that breeds mainly in the Arctic region of northern Siberia and spends the Austral summer in a non-breeding phase distributed across Africa, Asia and Australasia (Figure 22). The species does not breed in Australia but significant numbers spend the non-breeding season here. In Australia the curlew sandpiper mainly occurs on the coast particularly intertidal mudflats in sheltered coastal areas such as estuaries, bays, inlets and lagoons. Non-tidal coastal areas include swamps, lakes and lagoons and ponds in sewage farms and saltworks. The curlew sandpiper occurs less commonly inland. Here, it occupies lakes, dams and bore drains.

The global population of the curlew sandpiper is estimated to number between 1.085 and 1.285 million (IUCN, 2019).

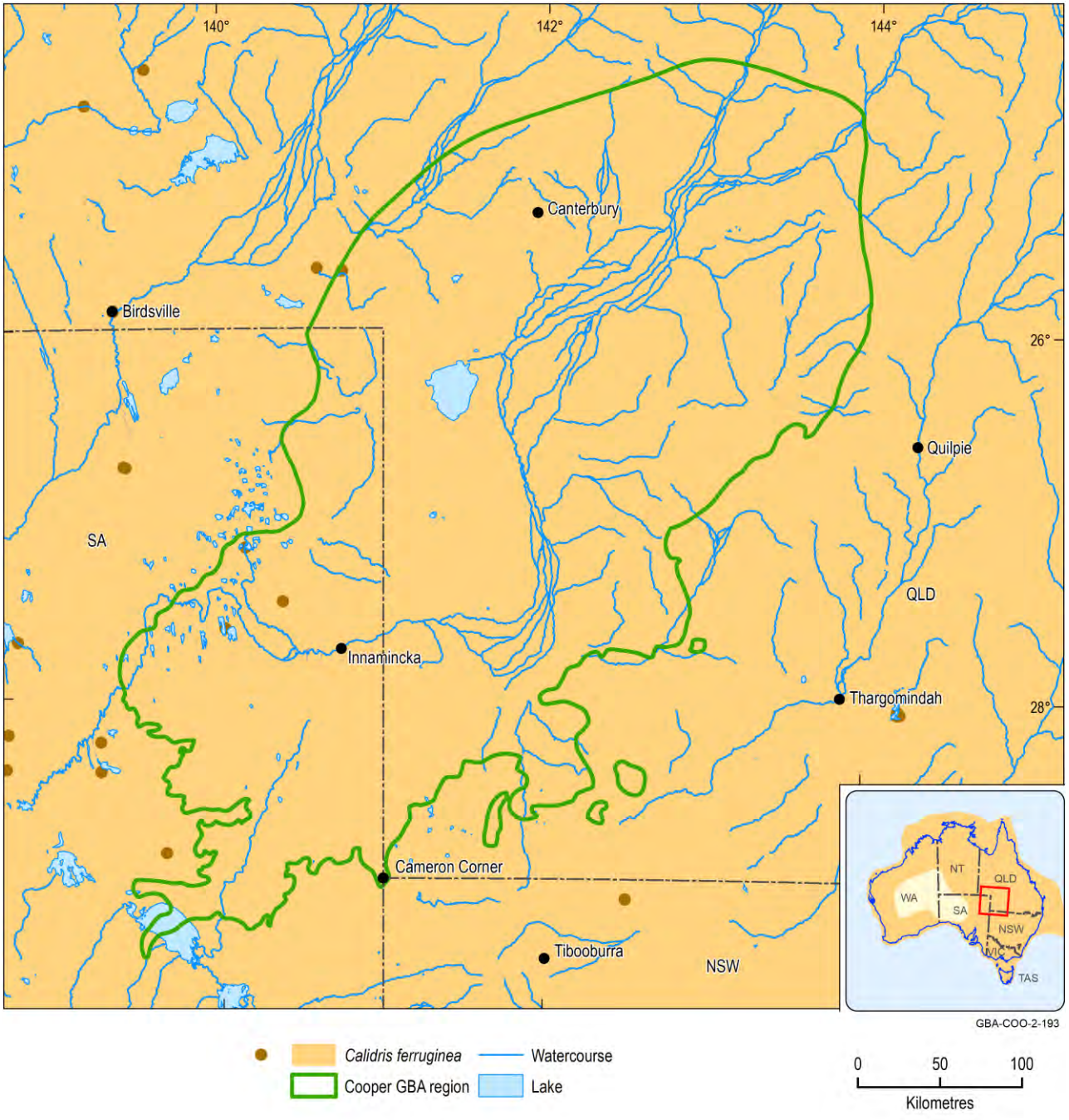

Figure 22 Distribution and Atlas of Living Australia observations of the curlew sandpiper, *Calidris ferruginea*

Data: Atlas of Living Australia (2019); Department of the Environment and Energy (2018a)
Element: GBA-COO-2-193

Water dependency

The curlew sandpiper is water dependent. It will not occur in an area unless suitable foraging habitat in the form of wetlands with bare edges of mud or sand with water to a depth up to 60 mm is available.

Shale and tight gas development activities with potential to impact species

The key areas of the landscape are shallow freshwater wetlands.

Impacts from shale gas development are likely to occur during the following activities:

- exposure to soil, groundwater and/or surface water contamination;
- changed surface water quality and/or flows.

Bar-tailed godwit (*Limosa lapponica*)

Status: *Limosa lapponica baueri*,Vulnerable; *Limosa lapponica baueri,* Critically endangered

Overview

The bar-tailed godwit is listed as threatened and as a migratory and marine species under the EPBC Act. Two subspecies of the bar-tailed godwit occur in Australia; *L. l. baueri* and *L. l. menzbieri*. The bar-tailed godwit is a migratory shorebird that breeds in the north of Scandinavia and Russia and in north-west Alaska. It spends the Austral summer in a non-breeding phase distributed across western Europe, Africa, Asia, islands of the Pacific Ocean and Australia. The species does not breed in Australia, but significant numbers spend the non-breeding season here. Here the bar-tailed godwit mainly occurs on the coast, particularly intertidal mudflats and sandflats in sheltered coastal areas such as estuaries, bays, inlets and lagoons. It is rarely found on inland wetlands. It has been recorded only from the SA portion of the Cooper Basin (IUCN, 2019) (Figure 23 and Figure 24).

The subspecies *L. l. baueri* breeds in north-east Siberia and west Alaska. In Australia, it occurs mainly along the north and east coast. The subspecies *L. l. menzbieri* breeds in northern Siberia. In Australia it occurs mainly in the north of WA (IUCN, 2019).

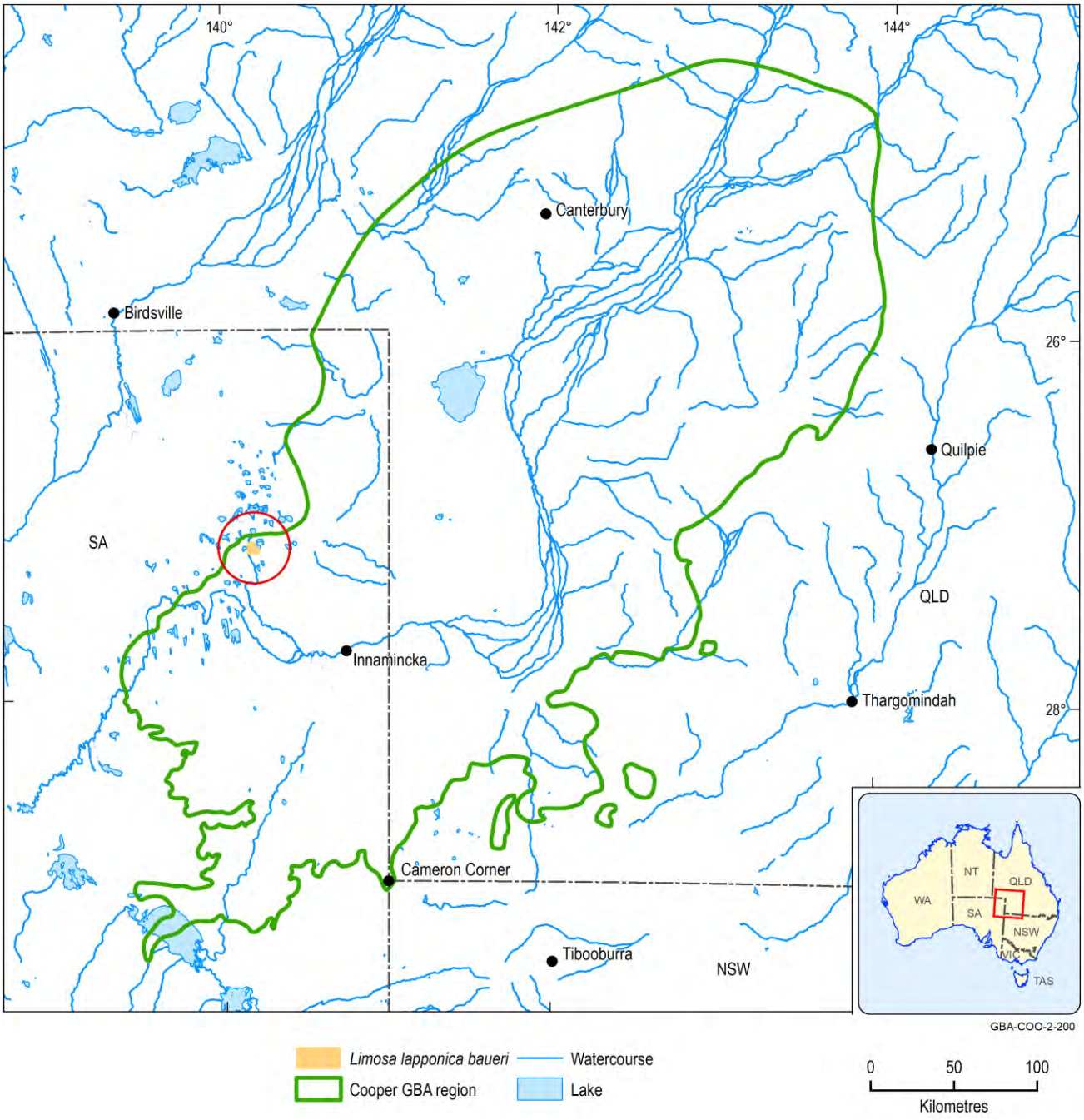

Figure 23 Distribution of *Limosa lapponica baueri*

The distribution of *Limosa lapponica baueri* can be located within the red circle on the map.
Data: Department of the Environment and Energy (2018a)
Element: GBA-COO-2-200

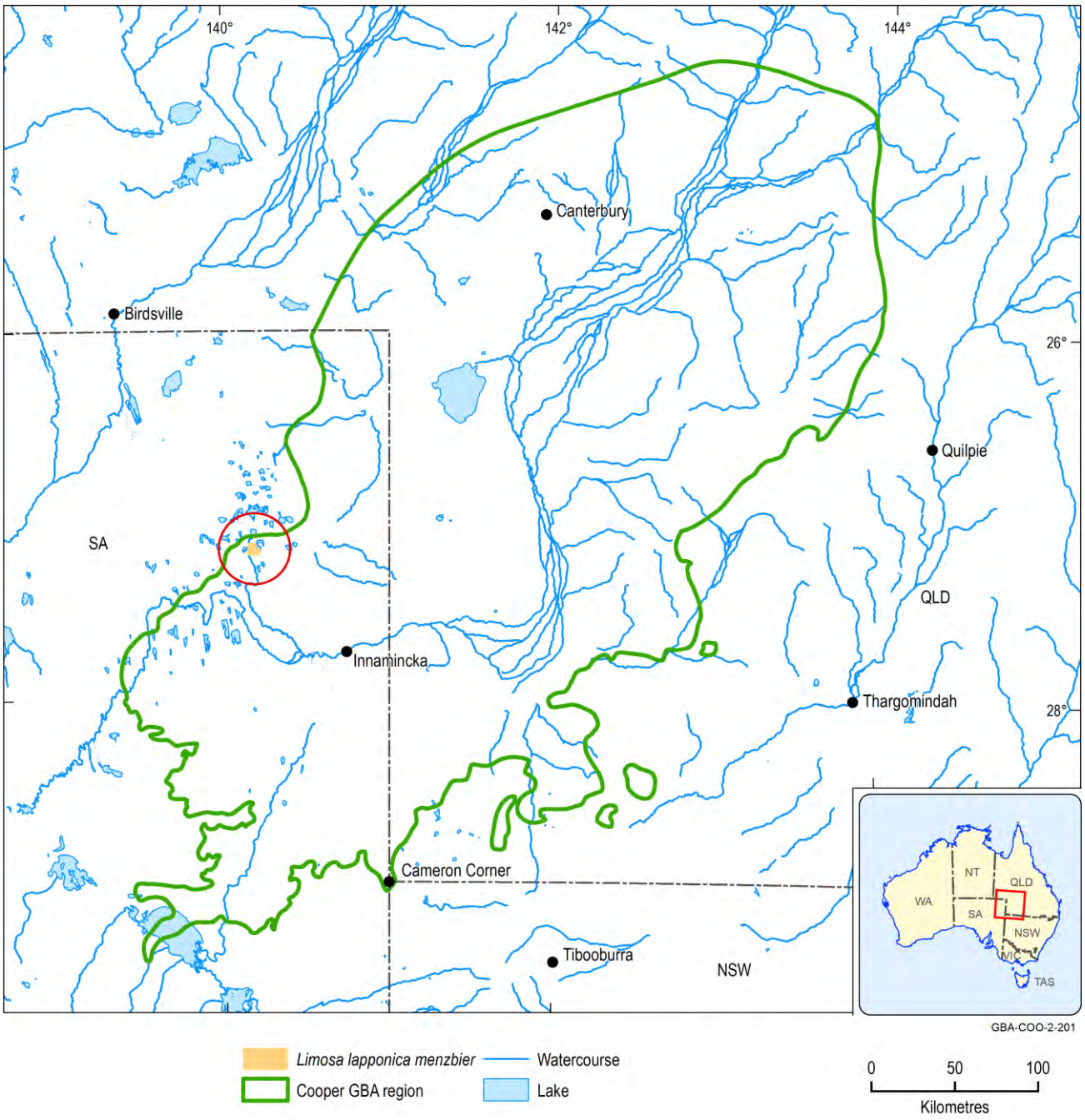

Figure 24 Distribution of *Limosa lapponica menzbieri*

The distribution of *Limosa lapponica menzbieri* can be located within the red circle on the map.
Data: Department of the Environment and Energy (2018a)
Element: GBA-COO-2-201

Water dependency

The bar-tailed godwit is water dependent. It will not occur in an area unless suitable foraging habitat in the form of wetlands with bare edges of mud are available.

Impacts from shale gas development

The key areas of the landscape are shallow freshwater wetlands.

Impacts from shale gas development are likely to occur during the following activities:

- exposure to soil, groundwater and/or surface water contamination;
- changed surface water quality and/or flows.

Reptiles

Yakka skink (*Egernia rugosa*)

Status: Vulnerable

Overview

The yakka skink is a solidly built species of diurnal skink. The distribution of the species is eastern Queensland from Cape York Peninsula south to the Queensland–NSW border. It occurs inland as far as the eastern edge of the Cooper Basin in Queensland (Figure 25). The species is currently listed as vulnerable under the EPBC Act. The species occurs in woodland and open forest dominated by a range of trees including *Acacia*, *Eucalyptus*, *Casuarina* and *Callitris*. Yakka skinks are burrowing animals that occur in colonies or small groups (Chapple, 2003). The species shows a strong preference for friable loamy or sandy soil types (clay loam, sandy; loam; loamy sand; sandy clay loam; sandy loam) and avoids clay or silt soils. Important microhabitat variables leading to occupancy of the species include a high proportion of canopy tree cover and a high volume of logs.

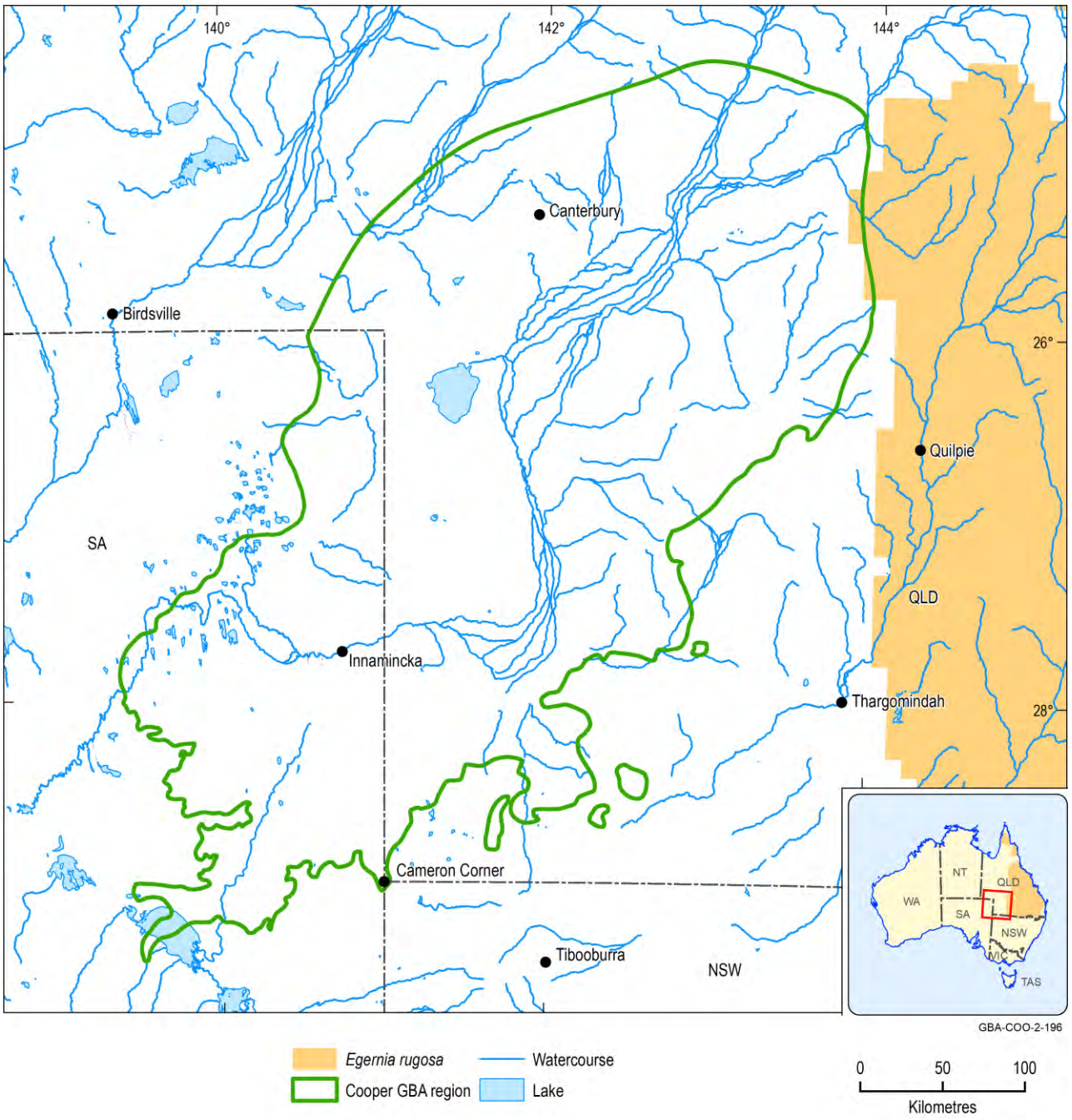

Figure 25 Distribution of the yakka skink, *Egernia rugosa*

Data: Department of the Environment and Energy (2018a)
Element: GBA-COO-2-196

Water dependency

The water-dependency of the species is poorly understood.

Shale and tight gas development activities with potential to impact species

The key areas of the landscape for the yakka skink are likely to be woodland and open forest on sandy or loamy soil with a high volume of fallen logs.

Impacts from shale gas development are likely to occur during the following activities:

- habitat loss and fragmentation;
- introduction of invasive species;
- increased competition and predation;
- exposure to soil, groundwater and/or surface water contamination;
- changed surface water quality and/or flows.

Plains death adder (*Acanthophis hawkei*)

Status: Vulnerable

Overview

The plains death adder is a relatively small (body length of about 0.6 m), stout-bodied terrestrial snake. In occurs across northern Australia from the extreme north-east of Western Australia, across the Top End and Barkly Tableland of the Northern Territory/Queensland border and the Mitchell Grass Downs in south-west Queensland (Figure 26). The plains death adder occurs on floodplains that have cracking clay soils. The conservation status of this species is vulnerable. Populations have declined as a consequence of cane toad invasion into northern Australia; the species readily captures toads but is highly susceptible to the toad's toxins (Ward and Phillips, 2012).

The plains death adder feeds on reptiles, frogs and small mammals especially rodents. Reptiles and frogs are taken when the snakes are young. The species is similar to other death adders in being an ambush predator.

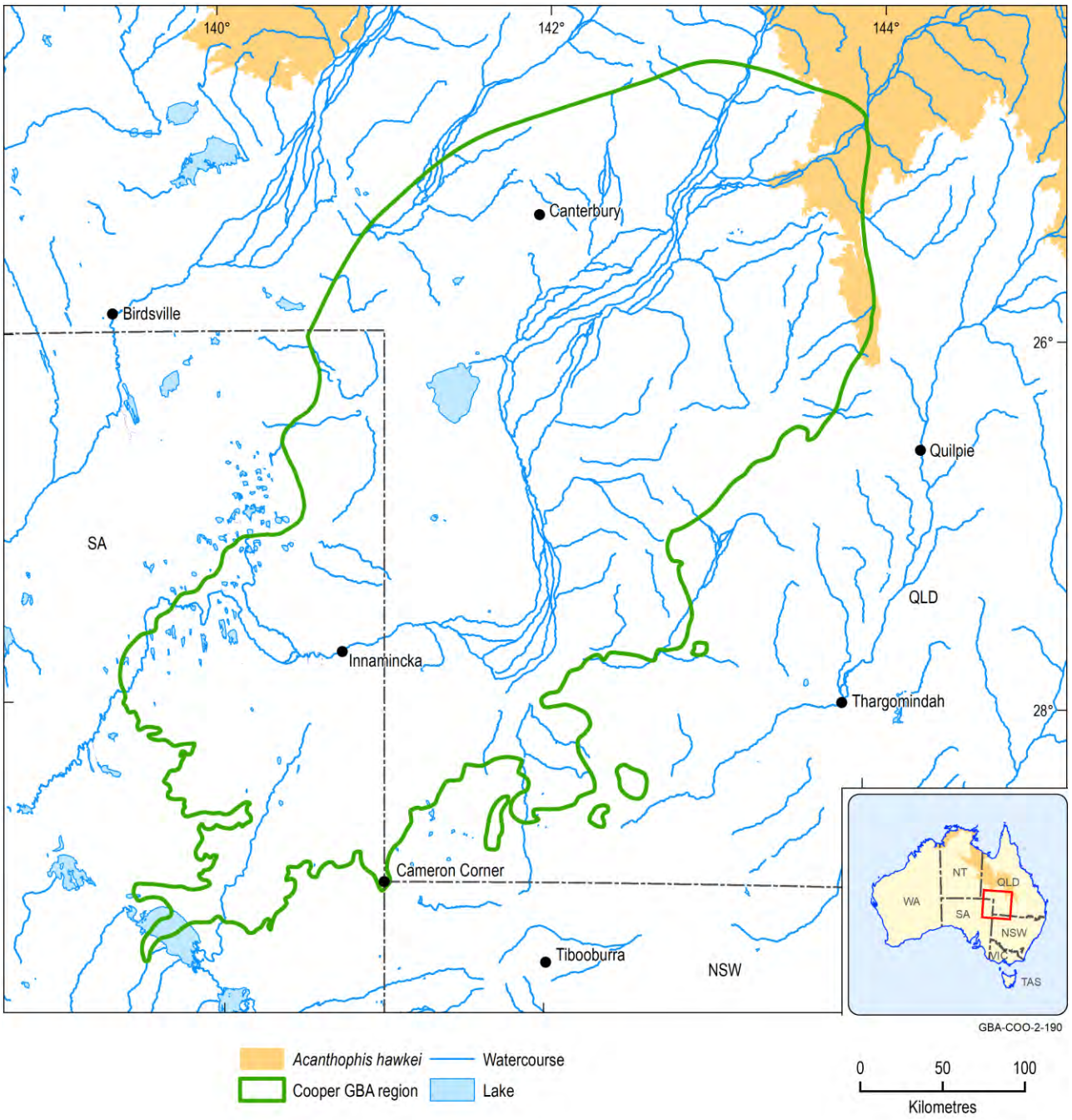

Figure 26 Distribution of the plains death adder, *Acanthophis hawkei*

Data: Department of the Environment and Energy (2018a)
Element: GBA-COO-2-190

Water dependency

The water-dependency of the species is poorly understood. However, its association with floodplains and diet comprising aquatic fauna (frogs) suggests that there may be a surface water dependence.

Shale and tight gas development activities with potential to impact species

The key areas of the landscape for this species are likely to be floodplains that have cracking clay soils.

Impacts from shale gas development are likely to occur during the following activities:

- habitat loss and fragmentation;
- exposure to soil, groundwater and/or surface water contamination; and
- changed surface water quality and/or flows.

1.1.5 Nationally listed threatened ecological communities

There were no nationally listed threatened ecological communities identified within the Cooper GBA region. Springs belonging to the threatened ecological community 'The community of native species dependent on the natural discharge of groundwater from the Great Artesian Basin threatened ecological community' occur at Lake Blanche, outside of the Cooper GBA region, but are likely to be hydrologically connected to groundwater in the region (Sparrow et al., 2015); therefore, they are considered herein.

1.1.6 Nationally listed threatened migratory and marine species

A total of 13 species occur or potentially occur in the Cooper GBA region and are listed under the EPBC Act but are not threatened (Table 3). This includes nine species that are listed as both migratory and marine and four species that are listed as marine.

Each of the 13 species that is migratory and marine or marine but not threatened has an IUCN Red List of Threatened Species classification of ‘least concern’. Many of these species have both a large global population size and a large population size in Australia and are unlikely to be significantly impacted by resources development in the Cooper GBA region.

Table 3 Distribution and habitat of listed migratory and/or marine birds that occur within the Cooper GBA region. Only those species that are not also listed as threatened (refer Table 1) are covered here

Scientific name	Common name	Listing in EPBC Act and IUCN Red List	Distribution and habitat
Actitis hypoleucos	Common sandpiper	EPBC Act: migratory and marine IUCN: least concern	Migratory shorebird. Global population estimated at 2.6 to 3.2 million birds. Breeds in Europe and Asia; non-breeding birds occur in summer in large numbers along all coastlines and in many inland areas of Australia. Mapped extent of potential habitat covers entire continent.
Apus pacificus	Fork-tailed swift	EPBC Act: migratory and marine IUCN: least concern	A migratory swift. Breeds in south-east China and adjacent countries; non-breeding birds occur in summer across Australia. An exclusively aerial species. Mapped extent of potential habitat covers majority of continent.
Calidris acuminata	Sharp-tailed sandpiper	EPBC Act: migratory and marine IUCN: least concern	Migratory shorebird. Breeds in northern Siberia; non-breeding birds occur in summer in large numbers along all coastlines and in many inland areas of Australia where population estimated at up to 140,000 birds (global population estimate is >160,000 birds). Mapped extent of potential habitat covers entire continent.

Scientific name	Common name	Listing in EPBC Act and IUCN Red List	Distribution and habitat
Calidris melanotos	Pectoral sandpiper	EPBC Act: migratory and marine IUCN: least concern	Migratory shorebird. Global population estimate is 25,000 to 100,000 birds. Breeds in northern Russia and North America; non-breeding birds occur in summer in low numbers along coastlines and inland areas of Australia. Mapped extent of potential habitat covers entire continent.
Charadrius veredus	Oriental plover	EPBC Act: migratory and marine IUCN: least concern	Migratory shorebird. Breeds in Mongolia and adjacent Russia. ~90% of global population migrates to Australia in summer occupying coastal and inland areas. 144,000 birds at Eighty Mile Beach, WA in February 2010. Occupies a wide range of marine, freshwater and terrestrial habitats.
Gallinago hardwickii	Latham's snipe	EPBC Act: migratory and marine IUCN: least concern	Migratory shorebird. Global population estimate is 25,000 to 100,000 birds. Breeds in Japan and eastern Russia; passage migrant through northern Australia and non-breeding migrant in summer in south-east Australia (where most of global population overwinters). Occupies permanent and ephemeral wetlands.
Motacilla cinerea	Grey wagtail	EPBC Act: migratory and marine IUCN: least concern	Passerine bird. Widespread in Northern Hemisphere and tropics with some populations breeding in Europe and Asia and migrating to tropical Africa and Asia as non-breeding. Global population estimate of 6.9 to 19.8 million birds. A vagrant in Australia. Occupies riverine areas.
Motacilla flava	Yellow wagtail	EPBC Act: migratory and marine IUCN: least concern	Passerine bird. Extremely large range: Europe to Siberia to west Asia and China south to Egypt. Global population estimate of 64 to 107 million birds. A vagrant in Australia. Occupies terrestrial and freshwater habitat.
Tringa nebularia	Common greenshank	EPBC Act: migratory and marine IUCN: least concern	Migratory shorebird. Global population estimated at 440,000 to 1.5 million birds. Breeds in Scandinavia and across Russia; non-breeding birds occur in summer in small numbers along most coastlines and in many inland areas of Australia. Australian population estimated at 18,000 to 19,000 birds. Occupies a range of coastal and inland wetlands.
Ardea alba	Great egret	EPBC Act: marine IUCN: least concern	A waterbird with a massive global distribution including North and South America, Africa, Asia and Europe. Global population estimated at 41.5 to 69.9 million birds. Occupies wide range of inland and coastal wetlands. Mapped extent of potential habitat covers entire Australian continent.

Scientific name	Common name	Listing in EPBC Act and IUCN Red List	Distribution and habitat
Ardea ibis	Cattle egret	EPBC Act: marine IUCN: least concern	A waterbird with a massive global distribution including North and South America, Africa, Asia and Europe. Global population estimated at 4 to 9.85 million birds. Occupies open grassy areas and some wetlands. Mapped extent of potential habitat covers most of Australian continent.
Haliaeetus leucogaster	White-bellied sea-eagle	EPBC Act: marine IUCN: least concern	A raptor with a range including coastal India, Sri Lanka, south-east Asia, Philippines, Indonesia and Papua New Guinea. In Australia, occurs along coast and extends inland along some of the larger rivers. Australian population size estimated at >500 pairs.
Merops ornatus	Rainbow bee-eater	EPBC Act: marine IUCN: least concern	A bee-eater. Outside Australia occurs in Indonesia, Timor-Leste, Papua New Guinea and Solomon Islands. The population is estimated to number at least 1 million birds. Mapped extent of potential habitat covers entire Australian continent.

1.1.7 Listed threatening processes

In addition to potential impacts of development activities, a number of the key threatening processes identified under the EPBC Act are relevant to the Cooper GBA region, including:

- Competition and land degradation by rabbits;
- Competition and land degradation by unmanaged goats;
- Land clearance;
- Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases;
- Novel biota and their impact on biodiversity (e.g. feral horse, donkey, camel);
- Predation by European red fox;
- Predation by feral cats;
- Predation, habitat degradation, competition and disease transmission by feral pigs;
- The biological effects, including lethal toxic ingestion, caused by cane toads (*Rhinella marina*).

1.2 Other Matters not protected by the EPBC Act

1.2.1 Wetlands of national significance

The Cooper Creek system including the Thomson and Barcoo rivers and their tributaries are identified in the Lake Eyre Basin Intergovernmental Agreement. The Lake Eyre Basin agreement recognises that future prosperity in the Cooper GBA region is contingent on the continued health and functioning of this system, which is internationally recognised as an outstanding example of an unregulated, low gradient, dry-land river system (Kingsford et al., 1999).

The Directory of Important Wetlands lists eight wetlands within the Cooper GBA region (Department of the Environment and Energy, 2010). These include Bulloo Lakes, Coongie Lakes,

Cooper Creek, Cuddapan and Yamma Yamma Lake, and Strzelecki Creek Wetland systems. Table 4 provides areas of the listings in the Cooper GBA region and Figure 27 shows their location. There is much area overlap between the nationally, internationally and state listed wetlands.

Table 4 Wetlands listed in the Directory of Important Wetlands that occur in the Cooper GBA region

Wetland	Area (km^2)
Bulloo Lake	7.0
Coongie Lakes	12,159.9
Cooper Creek - Wilson River Junction	639.6
Cooper Creek Overflow Swamps - Windorah	1,248.9
Cooper Creek Swamps - Nappa Merrie	1,063.8
Lake Cuddapan	17.1
Lake Yamma Yamma	866.1
Strzelecki Creek Wetland System	586.1
Total	16,588.6

Data: Department of the Environment and Energy (2010)

Listed nationally and internationally important wetlands in the Cooper GBA region are all hydrologically connected to the Cooper Creek system (Figure 27).

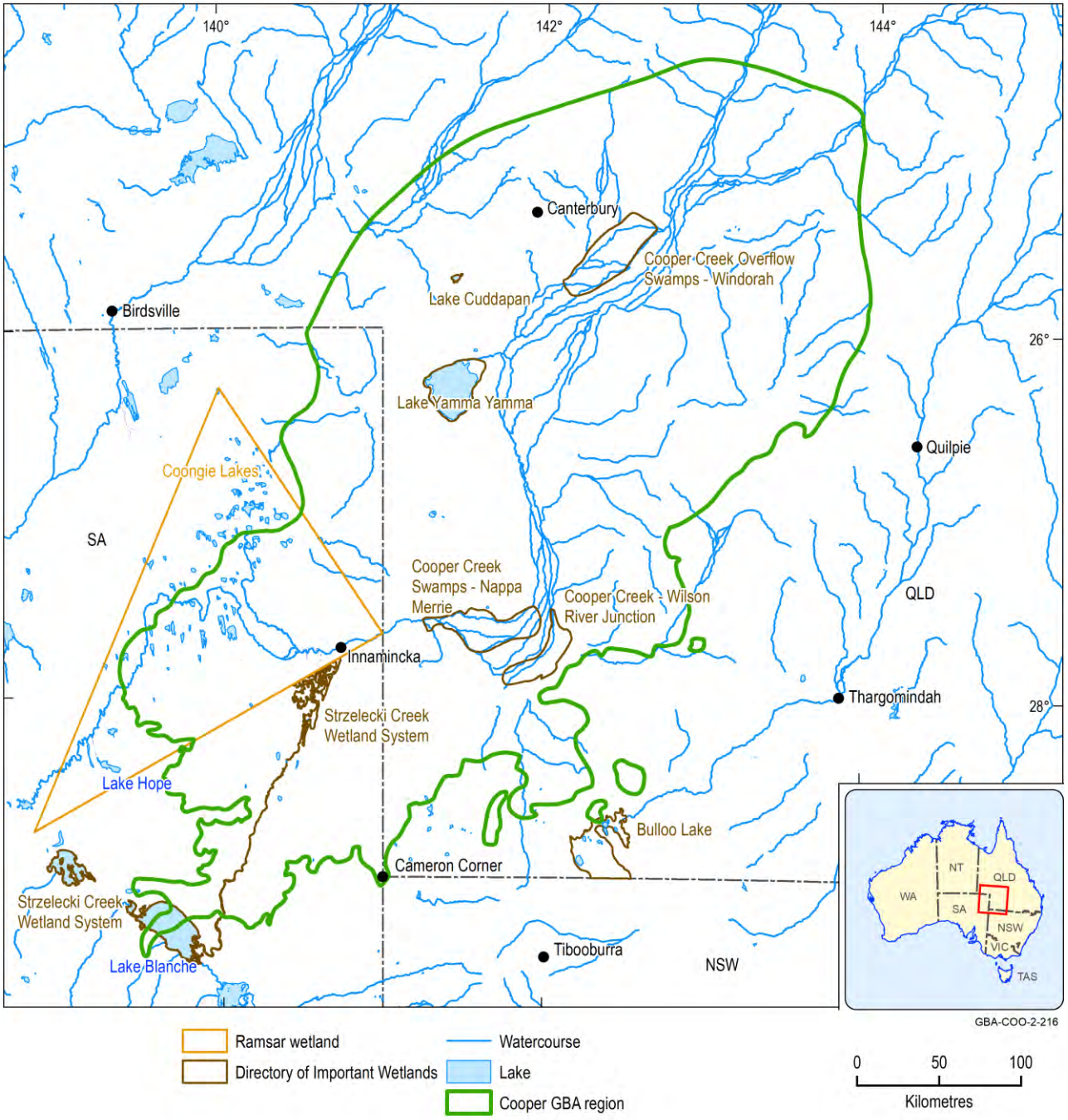

Figure 27 Wetlands of international and national significance in the Cooper GBA region

Source: Department of the Environment and Energy (2018b, 2010)
Element: GBA-COO-2-216

1.3 Matters of state environmental significance

The processes to identify matters of state environmental significance varies between Queensland and South Australia. Queensland's state planning policy July 2017 (The State of Queensland (Department of Infrastructure Local Government and Planning), 2017) lists a range of matters of environmental significance such as important wetlands and ecologically important habitats and threatened wildlife that are relevant to the Cooper GBA region. These matters include:

- Protected area estates (e.g. national parks)
- Strategic environmental areas

- Regional ecosystems listed as 'of concern' or 'endangered'
- Threatened species
- High ecological significance wetlands and high ecological value waters
- Cultural heritage areas including Queensland heritage places, archaeological state heritage places, places of local cultural heritage significance and heritage areas (see Section 2 of this report).

The process for identifying matters of environmental significance in South Australia, followed closely the process for identifying state matters of environmental significance outlined for Queensland.

1.3.1 Protected area estates

Welford National Park is the only national park in the Cooper GBA region. It was gazetted in 1994 and is situated 30 km south-east of Jundah, on the Barcoo River and is approximately 124,000 ha. The national park supports landscape features and biological communities of the Mulga Lands, Mitchell Grass Downs and Channel Country Bioregions (State of Queensland, 2011).

Two regional reserves occur on the South Australian side of the Cooper GBA Region, the Innamincka Regional reserve (135 km^2) and the Strzelecki regional reserve (81.4 km^2).

1.3.2 Strategic environmental area

Strategic environmental areas (SEA) contain regionally significant attributes (e.g. biodiversity, water catchments or ecological functions). There is 24,806 km^2 of the Channel Country Strategic Environmental Area within the Cooper GBA region. The overarching management objective of the SEA is to ensure that development does not jeopardise the ecological integrity of the region.

1.3.3 Important regional ecosystems

The Queensland Government uses the biodiversity status of remnant vegetation for land management under the *Vegetation Management Act* 1999 to determine environmentally sensitive areas in the mining regulation context under provisions in the *Environmental Protection Act 1994*. The biodiversity status has 4 classes (Queensland Government, 2017a).

Endangered, which relates to the amount of vegetation relative to its pre-clearing extent (less than 10%), patch size (10,000 ha, 10-30% of pre-clearing extent), degradation, biodiversity loss, rarity and exposure to a threatening process.

Of concern, which relates 10-30% of pre-clearing vegetation extent, patch size (10,000 ha, more than 30% pre-clearing) or degradation/biodiversity loss affects 70-90% of pre-clearing.

Least concern, which is vegetation above 10,000 ha patch size and is over 30% of its pre-clearing extent.

No concern at present, which includes all remnants that are not subject to the degradation criteria defined under endangered or of concern.

There are 81 regional ecosystems within the Cooper GBA region. None of these are listed as endangered however 8 are listed as 'of concern' (Table 5). Figure 28 maps the distribution 'of concern' ecosystems in the Cooper GBA region.

Table 5 Regional ecosystems listed as 'of concern' in the Cooper GBA region

Regional Ecosystem	Description
5.5.1	*Acacia aneura* low woodland on Quaternary deposits
5.3.20	*Eucalyptus coolabah* +/- *Eucalyptus camaldulensis* open woodland fringing billabongs, waterholes in major river systems and waterholes in braided channel systems
5.6.3	*Acacia calcicola* +/- *A. aneura* tall shrubland between sand dunes
6.3.11	*Eleocharis pallens* +/- short grasses +/- *Eragrostis australasica* open herbland on clays, associated with ephemeral lakes, billabongs and permanent waterholes
6.3.13	*Atriplex spp.*, *Sclerolaena spp.*, species of Asteraceae and/or short grasses open herbland on alluvial plains
6.3.2	*Eucalyptus camaldulensis* +/- *E. coolabah* +/- *Acacia cambagei* woodland on major drainage lines or rivers
6.3.3	*Eucalyptus camaldulensis* +/- *E. coolabah* +/- *E. populnea*, *Acacia stenophylla* woodland on alluvium
6.6.1	*Atalaya hemiglauca* +/- *Acacia aneura* +/- *Acacia spp.* +/- *Corymbia terminalis* tall open shrubland on low dunes over alluvium

Source: Department of Environment and Science (Qld) (2018d)

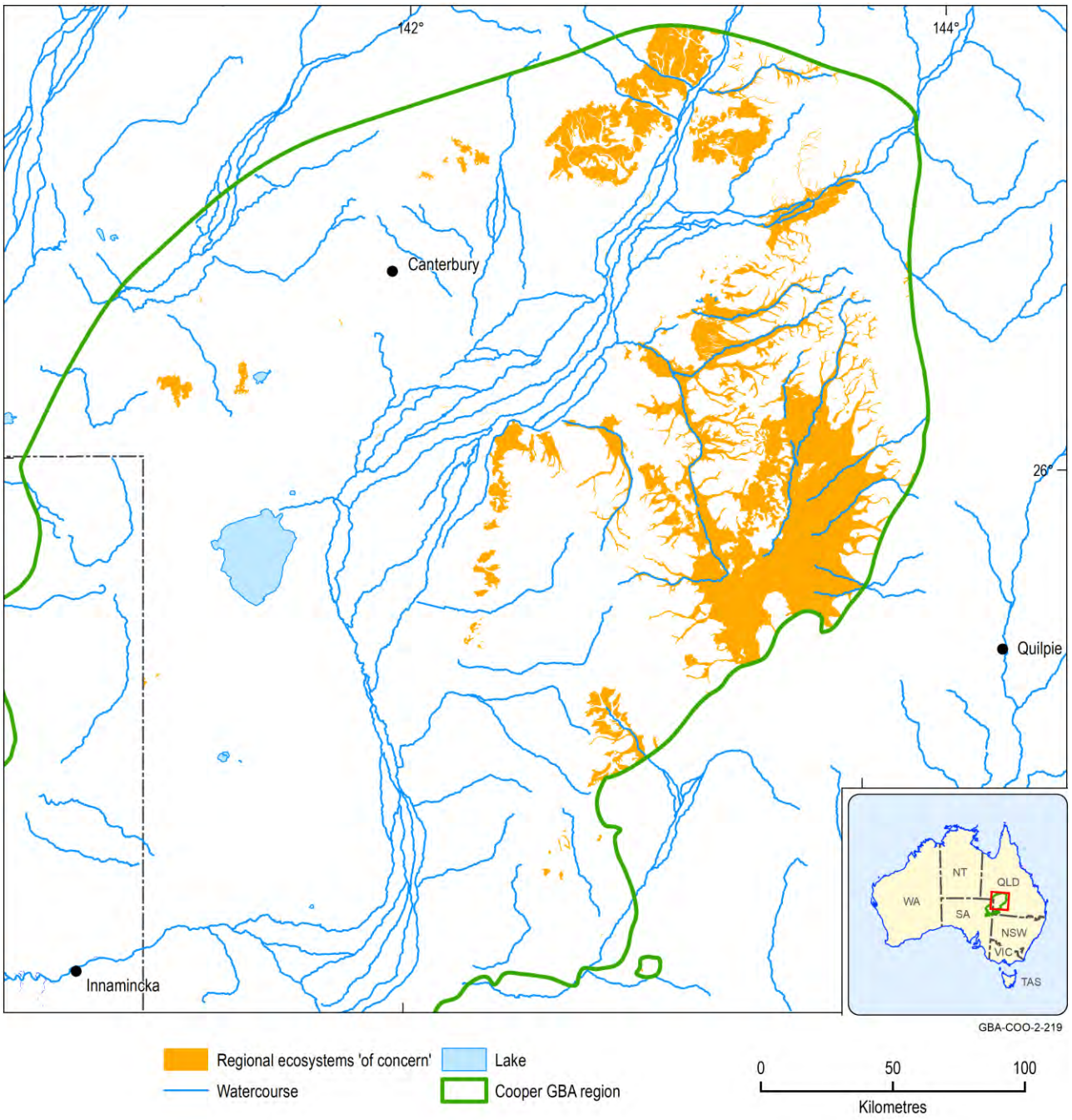

Figure 28 'Of concern' regional ecosystems in the Cooper GBA region

See Table 5 for the list of regional ecosystem classes 'of concern' in the Cooper GBA region.
Data: Department of Environment and Science (Qld) (2018d)
Element: GBA-COO-2-219

1.3.4 State-listed threatened species

Queensland and South Australia have state specific threatened species legislation. In Queensland the *Nature Conservation Act 1992* (includes the *Nature Conservation (Wildlife) Regulation 2006*) identifies wildlife that is 'extinct in the wild', 'endangered', 'vulnerable', 'near threatened' and 'least concern' and 'special least concern' (Queensland Government, 2007). This latter category includes the echidna, the platypus and migratory birds listed under 3 separate agreements between Australia and China, Japan and the convention of Migratory species. Wildnet lists

9259 records of 1300 species for the Cooper GBA region (Geological and Bioregional Assessment Program, 2019a).

In South Australia, the *National Parks and Wildlife Act 1972* (South Australian Government, 2002) identifies wild threatened species in 4 Schedules. These are divided into 'endangered' (Schedule 7), 'vulnerable' (Schedule 8), 'rare' (Schedule 9), and 'unprotected species' (Schedule 10), with the latter not being of concern for a GBA. The ALA data for the Cooper GBA region lists 2155 records of 94 species (Geological and Bioregional Assessment Program, 2019c).

Species listed as least concern, near threatened or special least concern will not be considered further in the GBA Cooper GBA region, as these categories are for the management of species currently not threatened and are subject to re-evaluation and monitoring. Furthermore, species within these categories will not be considered to be nationally threatened species under the common assessment methodology (Department of the Environment and Energy, 2015).

The process of identifying species in the Queensland section of the Cooper GBA region used published WildNet wildlife records, which is a QLD vetted dataset to remove errors and confidential records (to protect sensitive species) and has an accuracy of at least 10 km (Department of Environment and Science (Qld), 2018b). It lists 2 birds and 3 mammals as endangered, 2 near threatened plants, 10 vulnerable species from 4 taxa (plants, mammals, birds, and reptiles) and 11 iconic species classified as special least concern. The special least concern category includes the short-beaked echidna, and 10 migratory birds (Table 6).

The process for identifying threatened species in the SA part of the Cooper GBA region relied on the use of threatened species codes that the SA government provide to the Atlas of Living Australia and matched these with Atlas of Living Australia (ALA) records in the Cooper GBA region (Atlas of Living Australia, 2019; Geological and Bioregional Assessment Program, 2019c). This overlay of the ALA records with the Cooper GBA region identified 3 birds and 1 plant in the extinct or threatened category and 13 vulnerable species including 4 mammals, 4 birds, 1 reptile and 4 plant species (Table 7).

Table 6 Queensland threatened species identified in the Cooper GBA region

Taxon	Scientific Name	Common Name	QLD status	EPBC status
Birds	*Apus pacificus*	Fork-tailed Swift	Special least concern	NI
	Calidris acuminata	Sharp-tailed Sandpiper	Special least concern	NI
	Calidris ferruginea	Curlew Sandpiper	Endangered	Critically Endangered
	Charadrius bicinctus	Double-banded Plover	Special least concern	NI
	Cuculus optatus	Oriental Cuckoo	Special least concern	NI
	Erythrotriorchis radiatus	Red Goshawk	Endangered	NI
	Gelochelidon nilotica	Gull-billed Tern	Special least concern	NI
	Grantiella picta	Painted Honeyeater	Vulnerable	Vulnerable
	Hydroprogne caspia	Caspian Tern	Special least concern	NI
	Lophochroa leadbeateri	Major Mitchell's Cockatoo	Vulnerable	NI
	Monarcha melanopsis	Black-faced Monarch	Special least concern	NI
	Numenius minutus	Little Curlew	Special least concern	NI
	Plegadis falcinellus	Glossy Ibis	Special least concern	NI
	Tringa stagnatilis	Marsh Sandpiper	Special least concern	NI
Mammals	*Dasyuroides byrnei*	Kowari	Vulnerable	Vulnerable
	Macroderma gigas	Ghost Bat	Endangered	NI
	Notomys fuscus	Dusky Hopping-mouse	Endangered	Vulnerable
	Petrogale xanthopus celeris	Yellow-footed Rock-wallaby	Vulnerable	Vulnerable
	Phascolarctos cinereus	Koala	Vulnerable	NI
	Pseudomys australis	Plains Rat	Endangered	Vulnerable
	Tachyglossus aculeatus	Short-beaked Echidna	Special least concern	NI
Reptiles	*Acanthophis antarcticus*	Common Death Adder	Vulnerable	NI
Plants	*Acacia peuce*	Waddy	Vulnerable	Vulnerable
	Eremophila stenophylla	NA	Vulnerable	NI
	Indigofera oxyrachis	NA	Vulnerable	NI
	Nyssanthes impervia	NA	Vulnerable	NI
	Ptilotus maconochiei	NA	Near threatened	NI
	Rhodanthe rufescens	NA	Near threatened	NI

Source: Wildnet (Department of Environment and Science (Qld), 2018b)
NI= Not listed nationally

Table 7 South Australian threatened species identified in the Cooper GBA region from ALA records

Taxon	Scientific Name	Common Name	SA status	EPBC status
Birds	*Anseranas semipalmata*	Magpie Goose	Extinct or Endangered	NI
	Ardeotis australis	Wild Turkey	Vulnerable	NI
	Cladorhynchus leucocephalus	Banded Stilt	Vulnerable	NI
	Lophoictinia isura	Square-tailed Kite	Extinct or Endangered	NI
	Pezoporus occidentalis	Night Parrot	Extinct or Endangered	Endangered
	Rostratula australis	Australian Painted Snipe	Vulnerable	Endangered
	Stictonetta naevosa	Freckled Duck	Vulnerable	NI
Mammals	*Dasyuroides byrnei*	Kowari	Vulnerable	Vulnerable
	Notomys cervinus	Fawn Hopping-mouse	Vulnerable	NI
	Notomys fuscus	Dusky Hopping-mouse	Vulnerable	Vulnerable
	Pseudomys australis	Plains Rat	Vulnerable	Vulnerable
Reptiles	*Emydura macquarii*	Murray Turtle	Vulnerable	NI
Plants	*Bergia occultipetala*	NA	Vulnerable	NI
	Cyperus dactylotes	NA	Vulnerable	NI
	Osteocarpum pentapterum	NA	Extinct or Endangered	NI
	Sauropus ramosissimus	NA	Vulnerable	NI
	Stylidium desertorum	NA	Vulnerable	NI

Source: Department for Environment and Water (SA) (2015)
NI = not listed nationally

1.3.5 High ecological significance wetlands and high ecological value waters

High ecologically significant wetlands located in a wetland protection area and, wetlands of high ecological significance based on referable wetlands under the Queensland *Environmental Protection Regulation 2008* include; Lake Yamma Yamma, Cooper Creek Over Flow swamps near Windorah, Lake Cuddapan, Cooper Creek Swamps - Nappa Merrie, Cooper Creek - Wilson River Junction and Bulloo Lake. It also contains many waterholes including Nockabooka Waterhole, Maapoo Waterhole, Nacowlah Waterhole, Tookabarnoo Waterhole, Owwirree Waterhole, Baryulah Waterhole, Nurra Norah Waterhole.

1.3.6 Groundwater-dependent ecosystems

The Cooper GBA region contains important groundwater-dependent ecosystems (GDEs) that resource development may impact and that fall outside of the matters of environmental significance outline above. This study used a combination spatial data from the QLD and SA states to create a combined Cooper GBA region map of groundwater-dependent ecosystems, which will form the part of subsequent impact analyses. This includes GDE information from the QLD GDE

mapping (Department of Natural Resources, Mines and Energy (Qld), 2019a, 2019b) and the SA GDE classification (Department for Environment and Water (SA), 2010).

The Queensland GDE information, which also incorporates information from the QLD Regional Ecosystem mapping (Department of Environment and Science (Qld), 2018d) lists

- 12 springs (including 2 ephemeral)
- 53 intermittent and 562 ephemeral stream channels mapped within 50 m of permeable sandy plain aquifers with ephemeral groundwater connectivity, indicating a potential for Groundwater dependency
- 12,790 km^2 ephemeral, 160 km^2 episodic and 850 km^2 intermittent surface GDE features in the Cooper GBA region. These include aquifers that recharge via infiltration from porose permeable rocks, sandy dunefields and the alluvium
- 880 km^2 ephemeral surface GDEs at the Lake Yamma wetlands and 37 ha in other shallow alluvial aquifers as well as 1100 km^2 wetlands on bedrock within 100 m of streams including Cooper Creek, Okena Creek, Farrers Creek
- the QLD part of the Cooper GBA region as a potential aquifer GDE.

The SA groundwater-dependent ecosystem list for the Cooper GBA region contains many entries ranging from 1 ha to 4000 km^2. The five largest GDE wetlands include Coongie Lakes (4030 km^2), Lake Blanche (210 km^2), Moonlight Flat (71 km^2), Lake Marrakoonamooka (33 km^2) and Fly Lake (26 km^2) (Figure 29).

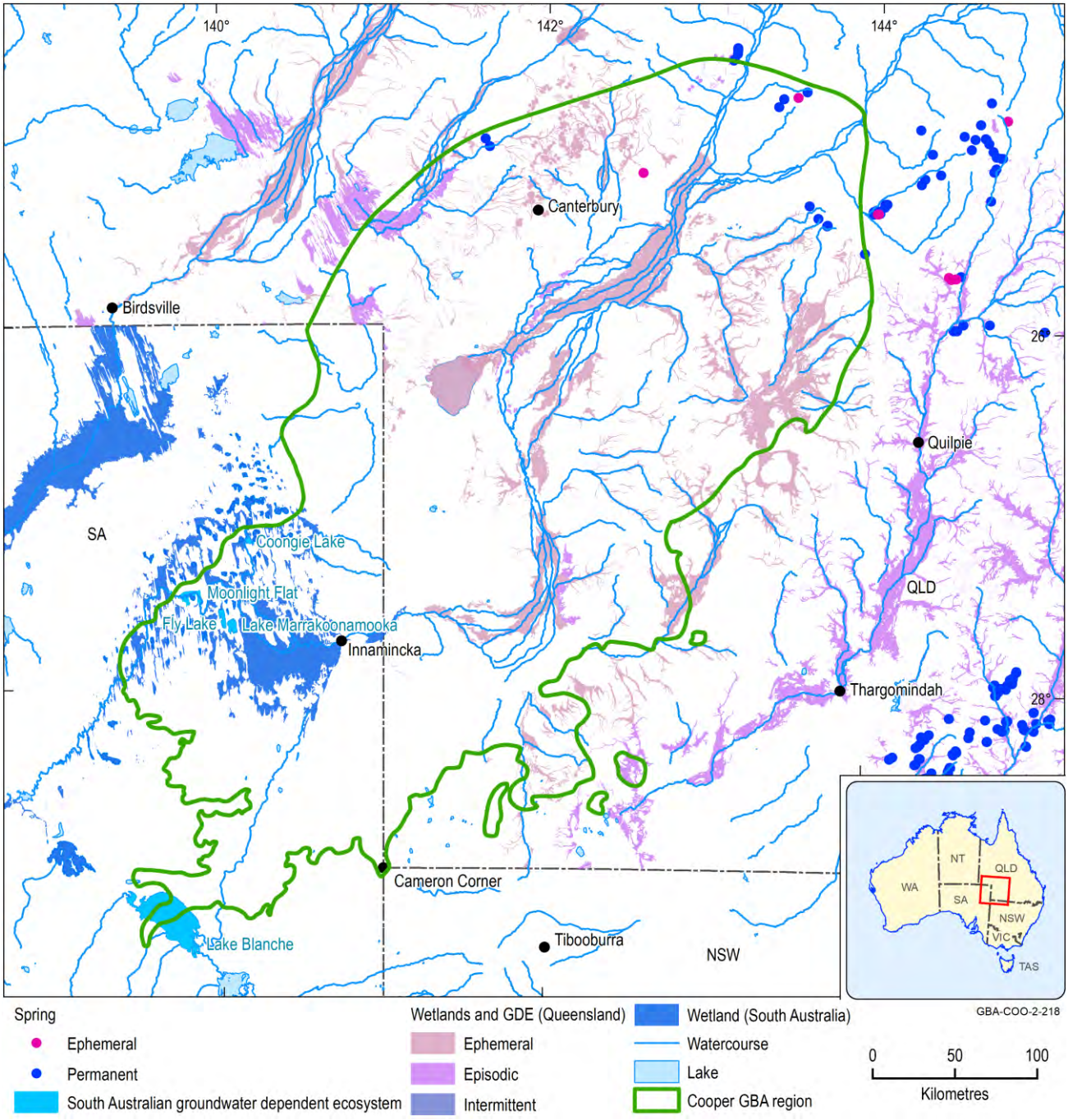

Figure 29 Wetlands and groundwater-dependent ecosystems

Data: Department of Environment and Science (Qld) (2018c); Department for Environment and Water (SA) (2010)
Element: GBA-COO-2-218

1.3.7 Other Queensland Matters of State Environmental Significance

- Regulated vegetation intersecting a watercourse and,
- regulated vegetation within 100 m of a wetland containing areas of Category A, B, C, R vegetation as outlined in the Queensland *Vegetation Management Act 1999*. These categories describe areas of different requirements for assessing development. Category A areas area subject to compliance notices, offsets and voluntary declarations, Category B contain remnant vegetation, Category C contain high-value regrowth vegetation and

Category R describe regrowth vegetation within 50 m of watercourses in priority reef catchment areas

- Regulated vegetation that contains essential (potential) habitat of wildlife that the Queensland *Nature Conservation Act 1992* identifies as endangered or vulnerable.

2 Cultural baseline synthesis

The Burke, Wills, King and Yandruwandha National Heritage Place is the one National Heritage Place is listed as a protected matter in the Cooper GBA region. The sites are located along the course of Cooper Creek and are listed due to their historical significance and tell the story of the Burke and Wills expedition and the support provided to it by the Yandruwandha Aboriginal people.

The Australian Heritage Database lists 9 Indigenous sites, 12 heritage sites and 2 recreational areas located in the Cooper GBA region. The Cooper Creek and its associated waterholes has a long and enduring cultural significance, and is part of traditional trade routes.

There were no world heritage, or Commonwealth heritage places identified for the Cooper GBA region. Only one National Heritage Place is listed as a protected matter in the Cooper GBA region. The Burke, Wills, King and Yandruwandha National Heritage Place (Department of the Environment and Energy, 2019). The sites that make up the National Heritage Place are located along the course of Cooper Creek on either side of the Queensland and the South Australian border (Figure 30). The sites are listed due to their historical significance and tell the story of the Burke and Wills expedition and the support provided to it by the Yandruwandha Aboriginal people. The asset is composed of 4 of sites:

1. The Dig Tree and Fort Wills Site are emblematic of the tragedy of the expedition, the tree inscriptions are now obscured.
2. Burke's tree and Wills' site mark where Burke and Wills respectively died.
3. King's site is marked by a tree inscribed with the name King, blazed years after the expedition as a reminder of King and the role of local aboriginal people the Yandruwandha.
4. Howitt's site marks the camp from where the relief party discovered King.

In addition to the Burke, Wills, King and Yandruwandha National Heritage Place Sparrow et al (2015) recognised a number of socio-cultural assets identified in the Australian Heritage Database, including 9 indigenous sites, 12 heritage sites and 2 two recreational areas listed in the Register of the National Estate that occur in the Cooper GBA region.

There are three heritage sites listed on the Queensland state heritage register (Figure 30):

- Haddon Corner
- Cameron Corner
- Burke and Wills Dig Tree.

On the south Australian side of the Cooper GBA region the Innamincka/Cooper Creek state heritage is a heritage area listed in South Australia. Additionally, there are another six localities listed (Department for Environment and Water (SA), 2019; Department of Planning, Transport and Infrastructure (SA), 2019). The Regional Reserve Headquarters (former Australian Inland Mission [AIM] Elizabeth Symon Nursing Home), is in the Innamincka/Cooper Creek State Heritage Area. The remaining five sites located in the Cooper GBA region (Figure 30) are;

- Tinga Tingana Homestead (Ruin)
- Horse Capstan, Pump & Well, Old Mulga Bore, Merty Merty Station
- Cordillo Downs Station Homestead and Woolshed
- A Tree, possibly marking the burial site of Charles Gray, member of Burke and Wills' 1861 expedition', Lake Massacre, Innamincka Regional Reserve
- Well and Whim, Coochilara Waterhole.

Although the protected matters search did not identify listed Indigenous matters, the Cooper GBA region has supported Aboriginal cultures for many centuries, and communities maintain an ongoing connection to the region. Many of the Cooper Creek waterholes and Cooper Creek itself form part of extensive trading routes throughout Lake Eyre Basin. Cullyamurra waterhole is an important cultural site and the site of grindstone quarries. Innamincka is also an important meeting place as an intersection of a number of trade routes (Lake Eyre Basin Community Advisory Committee, 2018).

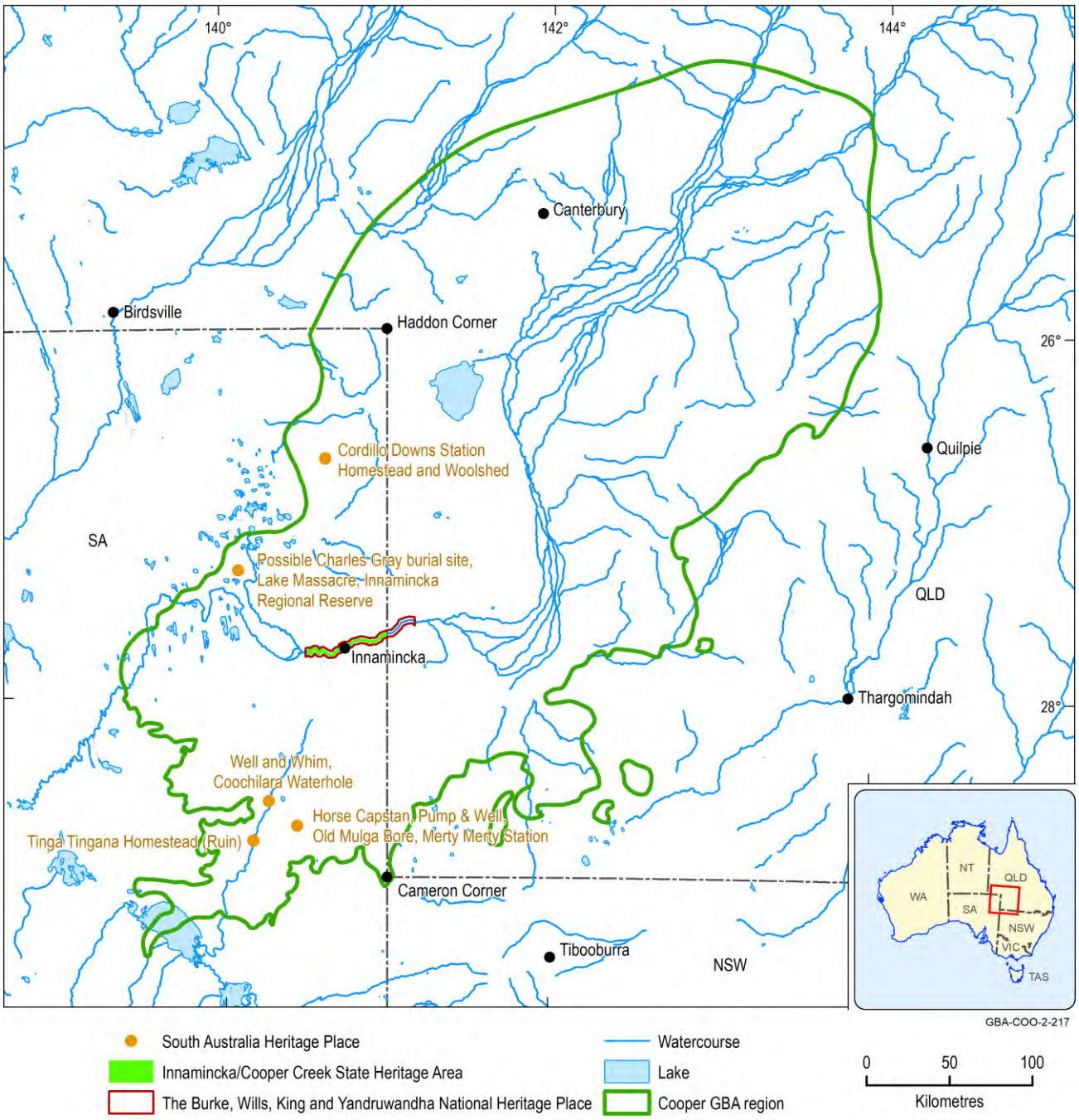

Figure 30 Matters of cultural significance within the Cooper GBA region

Data: Department for Environment and Water (SA) (2019); Department of Planning, Transport and Infrastructure (SA) (2019); Department of the Environment and Energy (2019, 2008)
Element: GBA-COO-2-217

Cultural assets were identified using a protected matters search for the Cooper GBA region on the 9/07/2018. The search identifies matters of national environmental significance and was run separately for the South Australian and Queensland portions of the region and combined to create a unified list of nationally protected matters for the region.

3 Landscape classification and ecohydrological conceptualisation

The Cooper GBA region is dominated by inland dunefields, floodplain and alluvium, and undulating country on fine-grained sedimentary rocks. There are smaller spatial areas of loamy and sandy plains, and tablelands and duricrusts, and only traces of clay plains.

A landscape classification approach was used to determine how hydrological changes due to shale, tight and deep coal gas development may affect ecosystems at a landscape scale in the Cooper GBA region. Seven landscape classes have been identified for the Cooper GBA region.

Conceptually, landscape classes can be considered as bundles of ecosystem assets (Bureau of Meteorology, 2013; United Nations et al., 2014), that produce a flow of ecosystem services that provide benefit to humanity. Landscape classification aims to:

- reduce ecosystem and landscape complexity to a limited number of regional-scale landscape classes that are mutually exclusive and comprehensive
- guide the development and review, including the spatial and temporal scope of conceptual models
- where possible, use existing data sources and existing classifications or typologies
- provide a natural aggregation for reporting potential impacts
- be applicable to data poor regions.

Inputs into the landscape classification were based on existing classification schemes wherever possible and can be purely physical, biological or predictive (Linke et al., 2011). Choice of approach depends on the availability of data at an appropriate scale, as well as the expertise and resources for undertaking the assessment. Landscape classifications should be credible, transparent, logical and consistently applied; where possible, match other classifications (or at least some of their classes); and be feasible within available resourcing.

The landscape classification developed for the Cooper GBA region is a harmonisation of the Queensland Land Zones (Wilson and Taylor, 2012) and South Australian Land Systems (Santos, 1997), reflecting the substantial areas of the Cooper Basin in both states (Figure 31). Consistent with the principles outlined above, it sought to use existing data sources and classifications, and to leverage the extensive effort already expended to develop highly relevant conceptual models at both landscape scale and wetland scale by the Queensland Government as part of its Wetlands Program (Department of Environment and Science (Qld), 2017).

The following description of Queensland Land Zones is taken from Wilson and Taylor (2012):

> Land zones are categories that describe the major geologies and associated landforms and geomorphic processes of the State of Queensland. The differences between land zones result in marked differences in the function of ecosystems and their associated biodiversity and this is due in part to the effects that geology (lithology, structure, alteration) has on landform, hydrology and landscape processes (geomorphology and soil formation).

Detailed land zones (Qld) within the Cooper GBA region were supplied by the Queensland Government (Department of Environment and Science (Qld), 2018a) and assigned to corresponding landscape classes (Table 8). Land systems in South Australia (Santos, 1997) were coarsely mapped in the 1990s; hence, landscape classes for the Cooper Basin within SA were refined from land systems based on land system mapping, detailed (1:100 000) surface geology (Department for Energy and Mining (SA), 2018), elevation (Geoscience Australia, 2008) and landscape position inferred from 30 m Landsat images. Major land zones (Queensland) are described in Table 9 and major land systems (SA) are described in Table 10 for the Cooper Basin.

The total area of the Cooper Basin is 130,006 km^2. This is dominated by floodplain and alluvium, inland dunefields and undulating country on fine grained sedimentary rocks (Table 8). There were lesser areas of loamy and sandy plains, and tablelands and duricrusts, and only traces of clay plains.

Table 8 Landscape classes within the Cooper GBA region, and corresponding Queensland Land Zones and South Australian Land Systems

Landscape class (GBA)	Queensland Land Zones[a]	South Australian Land Systems	Area (km^2)
Floodplain and alluvium	Recent Quaternary alluvial systems	Floodplain	41,244
Inland dunefields	Quaternary inland dunefields	Dunefields	39,752
Undulating country on fine grained sedimentary rocks	Fine grained sedimentary rocks	Gibber plain	25,986
Duricrusts and tablelands	Cainozoic duricrusts	Tableland	11,813
Loamy and sandy plains	Tertiary-early Quaternary loamy and sandy plains and plateaus	na	11,189
Clay plains	Tertiary-early Quaternary clay plains	na	21
Springs	na	na	na
Total			**130,005**

na = not applicable

[a] Typology and punctuation are consistent with Queensland Land Zones (Wilson and Taylor, 2012) who refer to Cainozoic and Tertiary-aged sediments.

Data: Geological and Bioregional Assessment Program (2018); Santos (1997); Department of Environment and Science (Qld) (2018a)

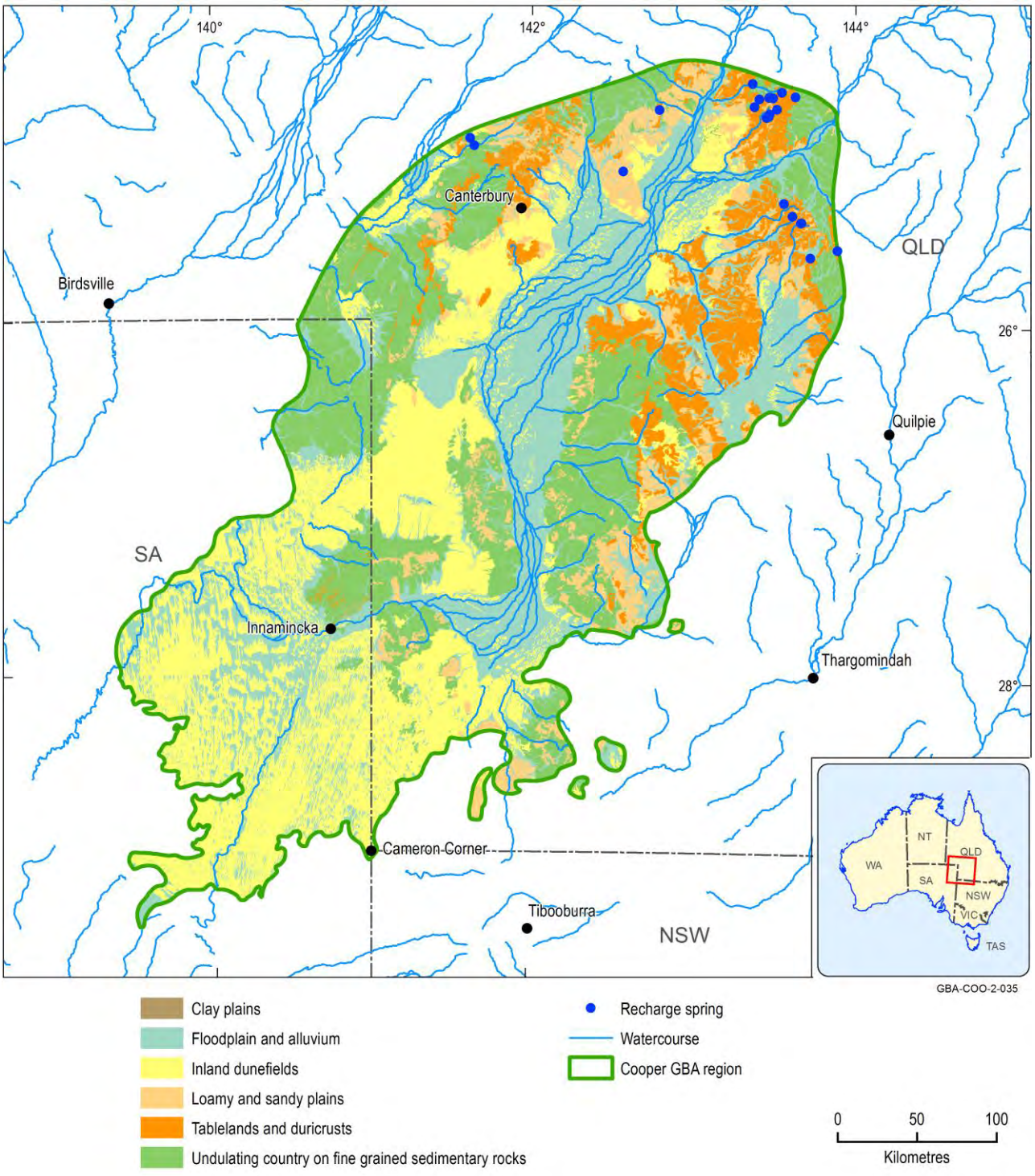

Figure 31 Landscape classification for the Cooper GBA region

Data: Geological and Bioregional Assessment Program (2018)
Element: GBA-COO-2-035

General descriptions of the final landscape classes, along with preliminary ecohydrological conceptual models that describe their structures (e.g. geology, landform, biota) and processes (e.g. hydrology), are described in the following section. The ecohydrological conceptualistion of the Cooper Basin is based on landscape scale and wetland scale conceptual models developed by the Queensland Government as part of its Wetlands Program (Department of Environment and

Science (Qld), 2017), with the exception of the 'Springs' landscape class, which is from Fensham et al. (2016).

Table 9 Land zones (Queensland) in the Cooper GBA region

Name	Detailed description
Recent Quaternary alluvial systems	Recent Quaternary alluvial systems, including closed depressions, paleo-estuarine deposits currently under freshwater influence, inland lakes and associated wave-built lunettes. Excludes colluvial deposits such as talus slopes and pediments. Includes a diverse range of soils, predominantly Vertosols and Sodosols; also with Dermosols, Kurosols, Chromosols, Kandosols, Tenosols, Rudosols and Hydrosols; and Organosols in high rainfall areas.
Tertiary-early Quaternary clay plains	Tertiary-early Quaternary clay deposits, usually forming level to gently undulating plains not related to recent Quaternary alluvial systems. Excludes clay plains formed in-situ on bedrock. Mainly Vertosols with gilgai microrelief but includes thin sandy or loamy surfaced Sodosols and Chromosols with the same paleo-clay subsoil deposits.
Tertiary-early Quaternary loamy and sandy plains and plateaus	Tertiary-early Quaternary extensive, uniform near level or gently undulating plains with sandy or loamy soils. Includes dissected remnants of these surfaces. Also includes plains with sandy or loamy soils of uncertain origin, and plateau remnants with moderate to deep soils usually overlying duricrust. Excludes recent Quaternary alluvial systems, exposed duricrust, and soils derived from underlying bedrock. Soils are usually Tenosols and Kandosols, also minor deep sandy surfaced Sodosols and Chromosols. There may be a duricrust at depth.
Quaternary inland dunefields	Quaternary inland dunefields, interdune areas, degraded dunefields, and associated aeolian sandplains. Excludes recent Quaternary alluvial systems, which may traverse this zone, and intermittent lakes and claypans. Soils are predominantly Rudosols and Tenosols, some Kandosols and minor Calcarosols.
Cainozoic duricrusts	Cainozoic duricrusts formed on a variety of rock types, usually forming mesas or scarps. Includes exposed ferruginous, siliceous or mottled horizons and associated talus and colluvium, and remnants of these features, for example low stony rises on downs. Soils are usually shallow Rudosols and Tenosols, with minor Sodosols and Chromosols on associated pediments, and shallow Kandosols on plateau margins and larger mesas.
Fine grained sedimentary rocks	Fine grained sedimentary rocks, generally with little or no deformation and usually forming undulating landscapes. Siltstones, mudstones, shales, calcareous sediments, and labile sandstones are typical rock types although minor interbedded volcanics may occur. Includes a diverse range of fine textured soils of moderate to high fertility, predominantly Vertosols, Sodosols, and Chromosols.

Source: adapted from Wilson and Taylor (2012)

Table 10 Land systems (SA) in the Cooper GBA region

General term	Detailed description
Dunefields	The Cooper Basin dunefields are characterised by parallel dunes of red, yellow or white aeolian sands of the Simpson Sand, dominated by single crested linear sand ridges and separated by flat interdune corridors (swales), which usually consist of claypans. Dunes range in height from 5 to 35 m and trend approximately north-east. Sand cover rarely exceeds 30 m and a stony base may be exposed in interdune areas. The dunefields are extremely arid and generally lack any permanent surface water. In some areas good quality groundwater can be found at shallow depths in dunefield areas adjacent to major watercourses (for example the Strzelecki and Cooper creeks). This water is non-artesian and contained within unconfined aquifers that are recharged primarily from surface stream flows.

General term	Detailed description
Floodplain	The Cooper Creek and Strzelecki floodplains consist of intricately braided channels, swamps and extensive outwash plains. Floodplain topography is relatively flat and consists of an extensive and extremely variable system of rivers and creeks. Soils are characterised by deep, grey, self-mulching clays which are derived from fluvial mudstone and siltstone, and occasional fluvial sand and conglomerates in river and creek beds. The floodplains of the Cooper Basin are primarily associated with the Cooper Creek drainage system. The Cooper Creek originates in the moister catchments of south-west Queensland and channels water through the basin to Lake Eyre. Cooper Creek still has the hydrologic character of an unregulated arid zone river with an extremely variable flow regime. Upper catchments of the Cooper Creek provide virtually all flows to the South Australian section of the Cooper Basin floodplain, as local rainfall makes only a small contribution to the hydrology of the region.
Wetland	Wetlands may be perennial or ephemeral and are considered to contain water more often, or be subjected to more frequent inundation, than surrounding areas of floodplain. The Cooper Creek intermittently discharges into a vast area of swamps, lakes and overflows. Most wetlands in the basin receive flows from this system which carries floodwaters throughout the basin and occasionally, during major flooding events, to Lake Eyre. Wetlands are also filled intermittently by heavy rainfall. Flooding is considered to be the most crucial factor in the recharge of many wetlands in the basin area.
Salt lake	The basin is dotted with numerous salinas, or salt lakes and salt pans, of varying sizes. In these lakes, excess evaporation in interior basins leads to the concentration of soluble salts as a surface crust. Salt lakes usually have a low topography and dry surface covered with a gypsum (salt) crust. Salt lakes are predominantly dry but are occasionally filled by floodwaters from the major river systems. During flooding, water may remain fresh and can support abundant fish populations. Lakes become increasingly saline as they dry. The frequency of flooding and inundation is highly variable.
Tableland	Tableland areas are commonly known as dissected residuals or breakaways. They are characterised by a silcrete surface that has been eroded to form low but steep escarpments, mesas, buttes and extensive gibber covered foot slopes. Tableland areas generally have moderately deep clay rich soils of aeolian origin, and a fine crystalline gypsum-rich horizon. Permanent surface water is scarce in elevated areas of tablelands. Minor drainage channels occur in lowland plains and can contain permanent waterholes. Temporary surface water can also be found lying in pools after rain in lowland plain areas.
Gibber plain	Gibber plains are extremely flat to undulating plains that were formed during the breakdown and gradual recession of former tablelands. Soils typically consist of red and brown clays that are mantled by stone or gibber (recent deposits of silcrete pebbles). Gibbers form a stable pavement that protects underlying soil from erosion. Gibber plains commonly contain gilgai or low surface relief structures. Permanent surface water sources are generally lacking, but temporary pools of water often form after rain in low depressions or gilgai. Minor drainage channels occur throughout lowland plain areas.

Source: adapted from Santos (2015)

The methodology for defining landscape classes is based on submethodology M03 for assigning receptors to water-dependent assets from the Bioregional Assessment Technical Programme (O'Grady et al., 2016), with modifications that reflect the broader purpose of the Geological and Bioregional Assessment Program to harmonise landscape classifications across the regions. A landscape classification approach was used to systematically define geographical areas into landscape classes that are similar in physical and/or biological and hydrological character.

3.1 Description of landscape classes

3.1.1 Floodplain and alluvium

Floodplain and lowland riverine areas derived from Quaternary alluvial deposits are widely distributed across the Cooper GBA region. Floodplains are areas of the landscape that occur between a river system and the enclosing valley walls and are exposed to inundation or flooding during periods of high discharge (Rogers, 2011). Within the Lake Eyre Basin, floodplains are considered to be alluvial plains that experience channelled or overbank streamflow at least every 50 years (Aquatic Ecosystems Task Group, 2012). The floodplain of the Cooper Creek exceeds 60 km at its widest point and is very broad on the Cooper Plain from Windorah to its entrance into the east of the Innamincka Dome. This complex, anastomosing system of channels is known as 'Channel Country'.

In South Australia this landscape class corresponds to the following surface geologies: Q\gy (Undifferentiated Quaternary gypcrete), Qa (Undifferentiated Quaternary alluvial/fluvial sediments), Qa2 (Quaternary high angle alluvial fan/talus sediments), Qha (Undifferentiated Holocene alluvial/fluvial sediments), Qha1 (Present day Holocene alluvium; current bedload), Qha2 (Holocene alluvium), Qhat (Tingana Clay), Qhl (Undifferentiated Holocene lacustrine/playa sediments), Qhl1 (Holocene playa sediments), Qhl2 (Holocene playa margin/beach sediments), Qpa3 (Pleistocene high-level alluvial fan gravel), Qplc (Coomb Spring Formation), Taee (Eyre Formation), Tmpc (Cadelga Limestone), Tmpd (Doonbara Formation), Topn (Namba Formation) and TpQay (Yandruwantha Sand).

While much of the floodplain supports terrestrial vegetation that is not groundwater dependent and relies on rainfall and local runoff, there are also extensive areas of palustrine and lacustrine wetlands on floodplains in south-west Queensland and west of Innamincka in SA. Especially prevalent are salt lakes, which are terminal lakes or pans of various sizes that result from excess evaporation and the concentration of soluble salts as a surface crust (Santos, 2015). Smaller pans may be interconnected and coalesce during floods. Water levels of the lakes fluctuate with episodic flooding of the river systems, but the lakes are predominantly dry. The lakes are typically fringed by chenopod shrubland but may also be bare. Lake Blanche and Lake Gregory in the far south of the Cooper GBA region make up most of this landscape class, although smaller salt lakes are scattered throughout the Cooper Basin in SA. Lunettes may be found along parts of their eastern shores.

Within the Cooper Basin, the alluvium can be broadly divided into four sections from north-east to south-west: the lower Thomson River from Stonehenge to confluence of the Thomson and Barcoo rivers, the Cooper Plain from the Thomson/Barcoo confluence to the Nappa Merrie, the Cooper Creek within the Innamincka Valley from Nappa Merrie to Innamincka, and the Cooper Fan from Innamincka to Lakes Blanche and Gregory.

The lower Thomson River

The physical characteristics of the valleys of the lower Thomson River differ from those of the Cooper Plain. The alluvial valley of the lower Thomson River is relatively narrow (3 to 10 km) and, although less well studied than the Cooper Creek, has been described by Wakelin-King (2015). The

valley contains floodplain bars, floodways, channels and waterholes that are strongly confined by steeply sloping hills of erosion-resistant rock of the Eromanga Lowlands physiographic unit, which are capped with gibber and silcrete. Swamps are absent from the lower Thomson River. The anastomosing network of floodways contains one to several main channels and numerous minor channels. Waterholes are channel segments located along primary flow paths that are notably wider and deeper than the primary channels. Channel width is generally less than 30 m but waterholes may be up to 75 m wide and several kilometres long. Water hole depth varies but waterholes that act as key refugia are typically deeper than 4m.

The Cooper Plain

Similarly to the lower Thomson River, most of the Cooper Plain is flanked by gibber and silcrete mantled hillslopes, and has a small gradient (0.015% to 0.019%). However, along the Cooper Plain the river valley is very wide (8 to 60 km). In addition to floodplain bars, floodways, channels and waterholes, the Cooper Plain also contains numerous swamps. The dominant channel network is an anabranching system of one to four primary channels, together with secondary and minor channels (Knighton and Nanson, 1994). In general, the channels are narrow and deep, with moderate to steeply dipping banks that lack levees. Waterholes can be wider and longer than in the lower Thomson River, in the order of 70 to 150 m wide and 1 to 17 km long (Wakelin-King, 2015) and vary from shallow (3m at cease to flow) to quite deep, 26 m. After the channels and floodplains have dried out, the waterholes provide a long-term reservoir of water; hence, they are both ecologically and culturally important (Silcock, 2009). They tend to have steep banks of cohesive muddy sediments and are crowned by tree-covered levees (Knighton and Nanson, 1994, 2000).

Riparian vegetation, particularly trees and lignum, plays an important role in maintaining waterhole depth, in trapping bank top sediments, and also in reducing stream power and flow velocity with increasing flow stage (Knighton and Nanson, 2000; Wakelin-King, 2010 (unpublished), 2015). Lignum is not present on all channel/waterhole banks, but where present clumps of lignum extend from the bank lip down to a level below that of the bank trees.

Away from the main channels, along the floodplain of the Cooper Plain, the great width of the alluvium allows for the development of swampy areas, where there is a dense and complex network of reticulate channels (Fagan and Nanson, 2004). These occur in locations where inundation frequency is sufficient to develop prominent microtopography from gilgai heave, but where flow energy is not strong enough to move the soil particles. Linear depressions in the gilgai microtopography locally concentrate flow, creating and maintaining the reticulate channels (Fagan and Nanson, 2004). The reticulate channels can occur on higher as well as lower floodplain surfaces. Swamps typically have dense vegetation dominated by lignum.

Where inundating flows have sufficiently high energy to erode and redistribute floodplain sediment, gilgai microtopography is suppressed (Fagan and Nanson, 2004) and a braided floodplain results. This consists of alternating floodplain bars (elongate landforms of slightly higher elevation) and floodways (wide shallow swales). The elevation difference between swales and floodplain bars is generally less than 1 m (Wakelin-King, 2015). Floodplain vegetation is an important roughness element that promotes sediment deposition and maintains valley-floor

integrity (e.g. Bull, 1997). Dryland river trees (e.g. black box, coolabah, red gum, *Acacia*) have different requirements for period of inundation, groundwater salinity or duration of waterlogging. Within the swales, perennial floodplain vegetation that acts to trap sediment includes waterlogging-resistant species such as blue bush, rats-tail couch, sedges and lignum. The floodplain bars are very sparsely vegetated, low-relief surfaces. Unchannelled floodplain surfaces are always at higher elevations, and flood records demonstrate that these surfaces are rarely inundated. As a result these both braided channels and gilgai are absent from these surfaces (Fagan and Nanson, 2004).

The Innamincka Valley

Between Nappa Merrie and Innamincka, the Cooper Creek valley is confined within the rocky and stony walls and steep slopes created by Cooper Creek cutting through the Innamincka Dome (Wakelin-King, 2013). The higher stream power in this narrow valley carved deeper and longer waterholes than in other parts of the Cooper Creek and the width of the valley is very irregular. There are two very narrow reaches with almost no floodplain at the Cullyamurra Choke and near the Nappa Merrie Waterhole. In other parts, the modern channels are set within a wide floodplain comprising paleochannels and modern floodplain. High elevation terraces and bars may flood in extreme events. The waterholes generally have very steep banks with a levee and are fringed by densely vegetated riparian zones.

The Cooper Creek Fan

West of the Innamincka Dome is the 'Cooper Creek Fan', which rises 40 to 245 m above the Strzelecki Plain (Wakelin-King, 2013). This alluvial fan has its apex located where Cooper Creek exits the Innamincka valley and the Strzelecki Creek begins. The fan forms a complex distributary network of flow paths, lakes and wetland systems as it passes through the Strzelecki Desert on its way to Lake Eyre North (Costelloe, 2013). The overall gradient is very low. The topography of the Cooper Creek Fan is dominated by orange-brown compound sand dunes, broad apparently featureless flat areas of greyish dusty muds, and lakes and swamps. The Cooper Creek Fan is divided into an inner and an outer fan.

The inner fan is a sinuous, large single-thread channel from the apex to the fork of the main and north-west branches of the Cooper Creek (Wakelin-King, 2013). Secondary channels forming anabranches are active in high flows. Channels along the inner fan are generally deep waterholes separated by shallow reaches. Waterholes are relatively deep (>10 m), have steep sides and are lined with various eucalypt trees. The more gently sloping shallow reaches are vegetated with dense lignum and young riparian trees on their banks with larger trees in the channels. Shallow reaches tend to dry out between floods. Distributary channels are created within the inner fan by floodwaters, and carry water and sediments out to flats, depending on their length.

The outer fan consists of anabranching, anastomosing and reticulate channels along the main and north-west branches of the Cooper Creek, with swamps and lakes in the flats (Wakelin-King, 2013). Waterholes are less well developed than in other parts of the Cooper Creek but occur along the main branch in high energy locations. In exceptional circumstances, flows from the Strzelecki Creek can reach Lakes Blanche and Gregory but these terminal lakes are generally dry.

Floodplain and alluvium within the lower Thomson River, Cooper Plain and Innamincka Valley are represented by the 'alluvia—mid-catchment' conceptual model (Queensland Government, 2017b), owing to the substantial development of alluvium and low gradient (0.017%). The section of the landscape class on the Cooper Creek Fan is represented by the 'alluvia—lower-catchment' conceptual model (Queensland Government, 2017b). Other relevant conceptual models include the 'riparian woodland groundwater dependent ecosystems' and 'evaporative influence groundwater dependent ecosystems' from Miles and Costelloe (2015); these are not described here but are cited for reference.

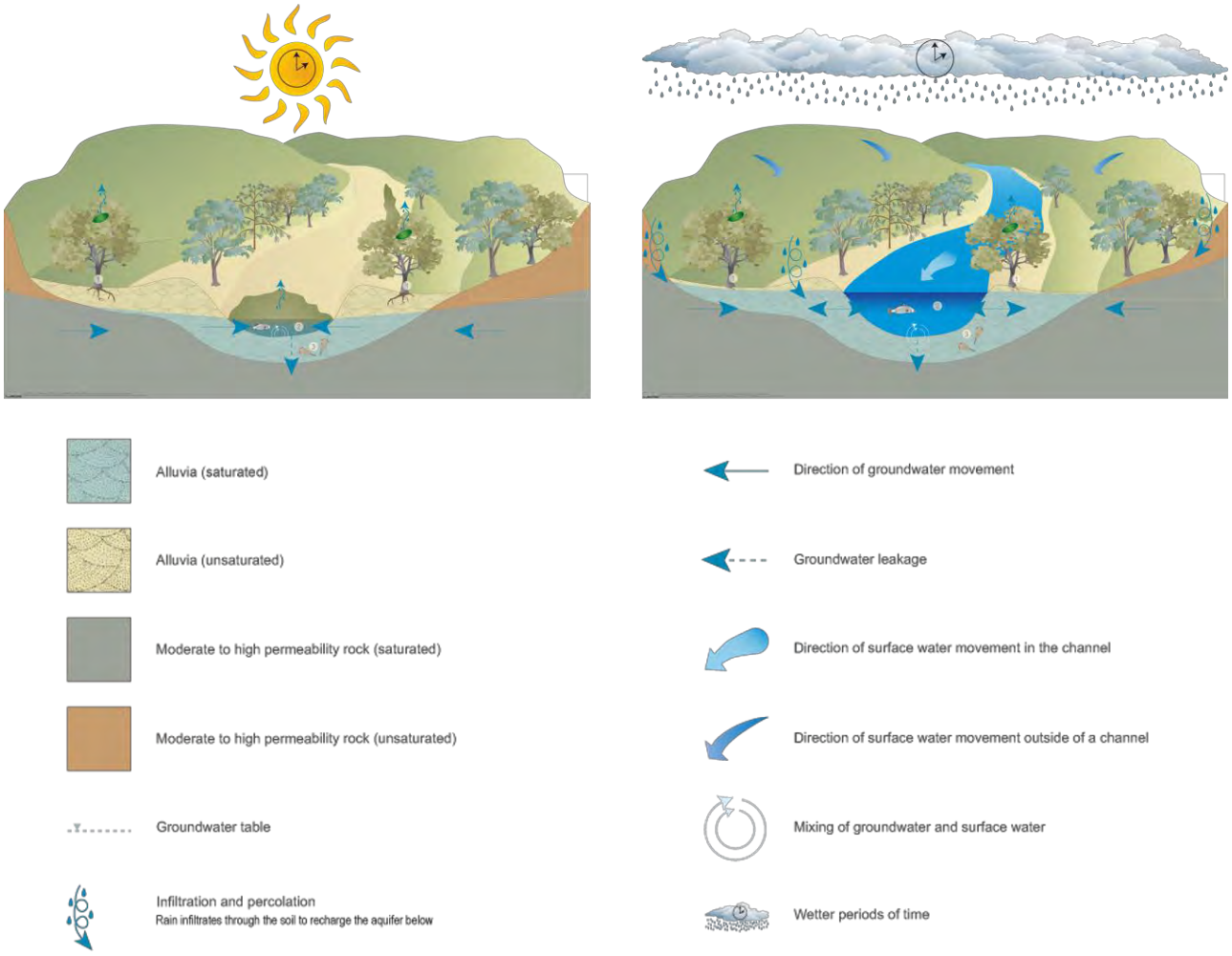

Figure 32 Floodplains and Alluvia ecohydrological conceptual model based on the Alluvia—mid-catchment conceptual model

Note: 1=Terrestrial GDE, 2=Surface expression GDE, 3=Subterranean GDE. Clocks within the clods and sun represent the variable timing of these boom and bust periods.

Source: Pictorial conceptual models, WetlandInfo, Department of Environment and Science, Queensland, viewed 19 March 2019 Element: GBA-COO-2-132

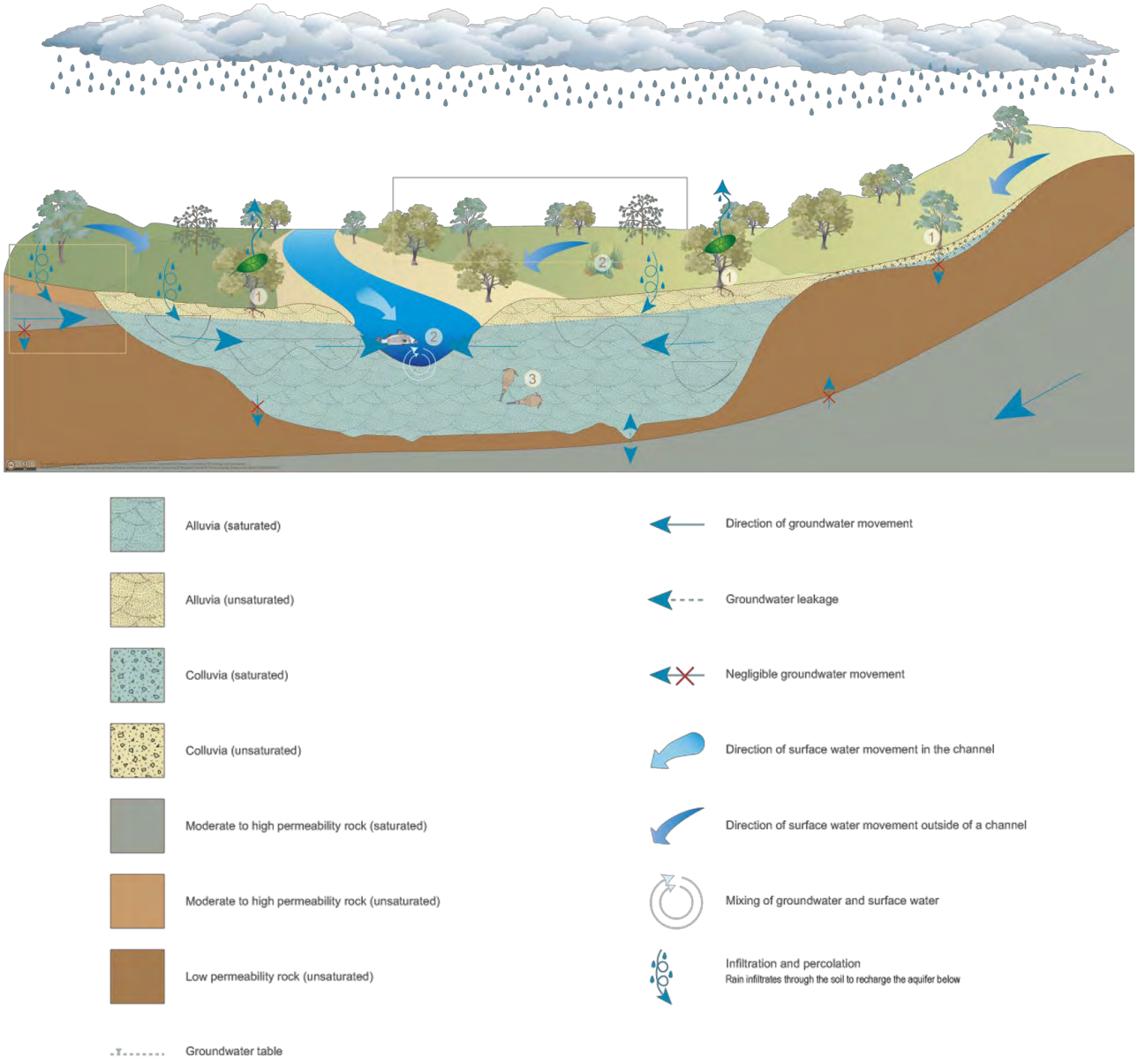

Figure 33 Floodplains and alluvia conceptual model, based on the Alluvia—lower-catchment ecohydrological conceptual model

Note: 1=Terrestrial GDE, 2=Surface expression GDE, 3=Subterranean GDE

Source: Pictorial conceptual models, WetlandInfo, Department of Environment and Science, Queensland, viewed 19 March 2019
Element: GBA-COO-2-133

3.1.2 Inland dunefields

The Strzelecki Plain (the central and western portions of the Strzelecki Desert) in SA is a topographic low, south and west of the Cooper Creek Fan, within which sand dunes have accumulated among river and lake deposits. Dunefields are also prevalent west of the Cooper Creek, north of Lake Yamma Yamma in Queensland, and north of the Innamincka Dome. Dunefields are scattered in other parts of the Cooper GBA region. The Cooper GBA region dunefields are characterised by parallel dunes of red, yellow or white aeolian sands (Rudosols) of the Simpson Sand (Drexel and Preiss, 1995), dominated by single-crested linear sand ridges. Dunes are separated by flat interdune corridors (swales), which usually consist of claypans (Santos, 1997; Twidale and Wopfner, 1990). Dunes range in height from 5 to 35 m and trend approximately

north-east (Twidale and Wopfner, 1990). Sand cover rarely exceeds 30 m and a stony base may be exposed in interdune areas. In those parts of the basin where salt lakes and distributary channels occur in interdune corridors, the soils between dunes are dominantly grey and brown clays. Elsewhere, the common interdune soils are solonised brown soils, calcareous red earths and earthy sands (Wright et al., 1990).

In South Australia this landscape class corresponds to the following surface geologies: Qe3 (Unnamed Quaternary gypsiferous dunes/lunettes), Qe9 (Unnamed Quaternary clay-pellet lunettes), Qec (Coonarbine Formation), Qes1 (Unnamed Longitudinal sand dunes), Qes2 (Unnamed Hummocky sand dunes), Qhe (Unnamed Undifferentiated Holocene aeolian sediments), Qhe2 (Unnamed Holocene sand capping dunes in dunefields) and Qhe8 (Unnamed Holocene quartz sand dunes and spreads).

The dunefields are extremely arid and generally lack any permanent surface water. In some areas good quality groundwater can be found at shallow depths in dunefield areas adjacent to major watercourses (for example the Strzelecki and Cooper creeks). This water is non-artesian and contained within unconfined aquifers that are recharged primarily from surface stream flows.

Vegetation types alternate between the upper slopes and crests of dunes and interdune areas. Dune crests are often sparsely vegetated (depending on seasonal conditions) with sandhill canegrass (*Zygochloa paradoxa*) and ephemeral herbs and shrubs (Santos, 1997). Dune flanks are characterised by marpoo (*Acacia ligulata*), whitewood (*Atalaya hemiglauca*) and grevilleas and hakeas; lobed spinifex grassland is also common on dune flanks in the Strzelecki Desert (Santos, 2015). Vegetation in interdunal areas depends largely on dune spacing. Narrowly spaced areas contain similar vegetation to dune flanks. Widely spaced dune areas, where gibber or floodplain soils are exposed, may contain low shrubland of saltbush or bluebush (Santos, 1997a). In general, interdune vegetation may consist of hummock grassland, chenopod shrubland, open shrubland or low open woodland.

This landscape class is represented by the ‘wind-blown inland sand dunefields’ conceptual model (Queensland Government, 2017c).

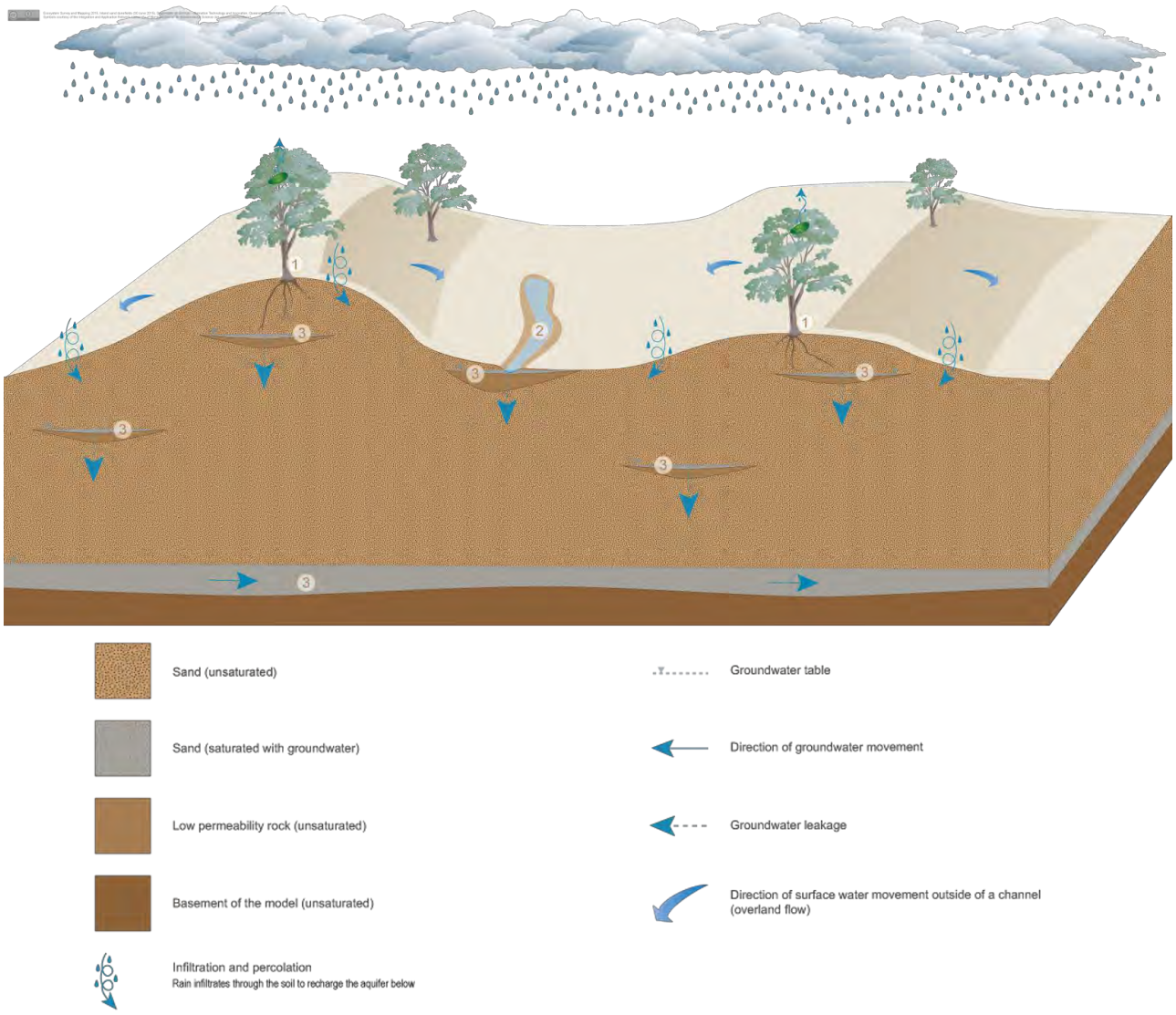

Figure 34 Inland dunefields conceptual model-based on the wind-blown inland sand dunefields ecohydrological conceptual model

Note: 1=Terrestrial GDE, 2=Surface expression GDE, 3=Subterranean GDE
Source: Pictorial conceptual models, WetlandInfo, Department of Environment and Science, Queensland, viewed 19 March 2019
Element: GBA-COO-2-134

3.1.3 Clay plains

Only a small area (21 km^2) of the Cooper GBA region, north-west of Kyabra in Queensland in the east of the Cooper GBA region, is classified as 'clay plain'. The distribution of the clay plains is not clearly indicated in geological mapping. Reference to additional land resource data, particularly the geomorphology in reports, together with interpretation of satellite imagery, aerial photographs and soil information is necessary to identify clay plains, given identification and mapping of this landscape class is uncertain.

Clay plains includes paleo-clay unconsolidated sediments originating from 'old' alluvial processes and aeolian clays forming predominantly level to gently undulating plains, but includes lesser rises and low hills, particularly in arid areas. These paleo-clay deposits are now elevated above and usually isolated from the alluvial valleys and floodplains (Wilson and Taylor, 2012). As a result, this is now an erosional landscape with poorly defined drainage. These clay soils have been extensively

cleared for introduced pastures and cropping in higher rainfall areas due to their relatively high soil moisture availability and high fertility. Soils are dominated by Vertosols with gilgai microrelief. Larger gilgai may provide ephemeral wetland habitat as a result of ponding of rainfall.

Soils usually have restricted rooting depth due to the adverse effects of high sodium levels. They are typically gently undulating plains, with clay soils and texture-contrast soils derived from fine-grained sediments deposited in Tertiary to early Pleistocene lakes, basins and alluvial plains, and from aeolian clays (parna). These support brigalow (*Acacia harpophylla*), gidgee (*A. cambagei, A georginae*), belah (*Casuarina cristata*), blackwood (*A. argyrodendron*), and some box (*Eucalyptus populnea, E. brownii, E. moluccana*) communities, grasslands (*Astrebla pectinata*, various bluegrasses) herblands, and semi-evergreen vine thicket in more favourable areas.

This landscape class is represented by the 'high-level alluvia' conceptual model (Queensland Government, 2017b).

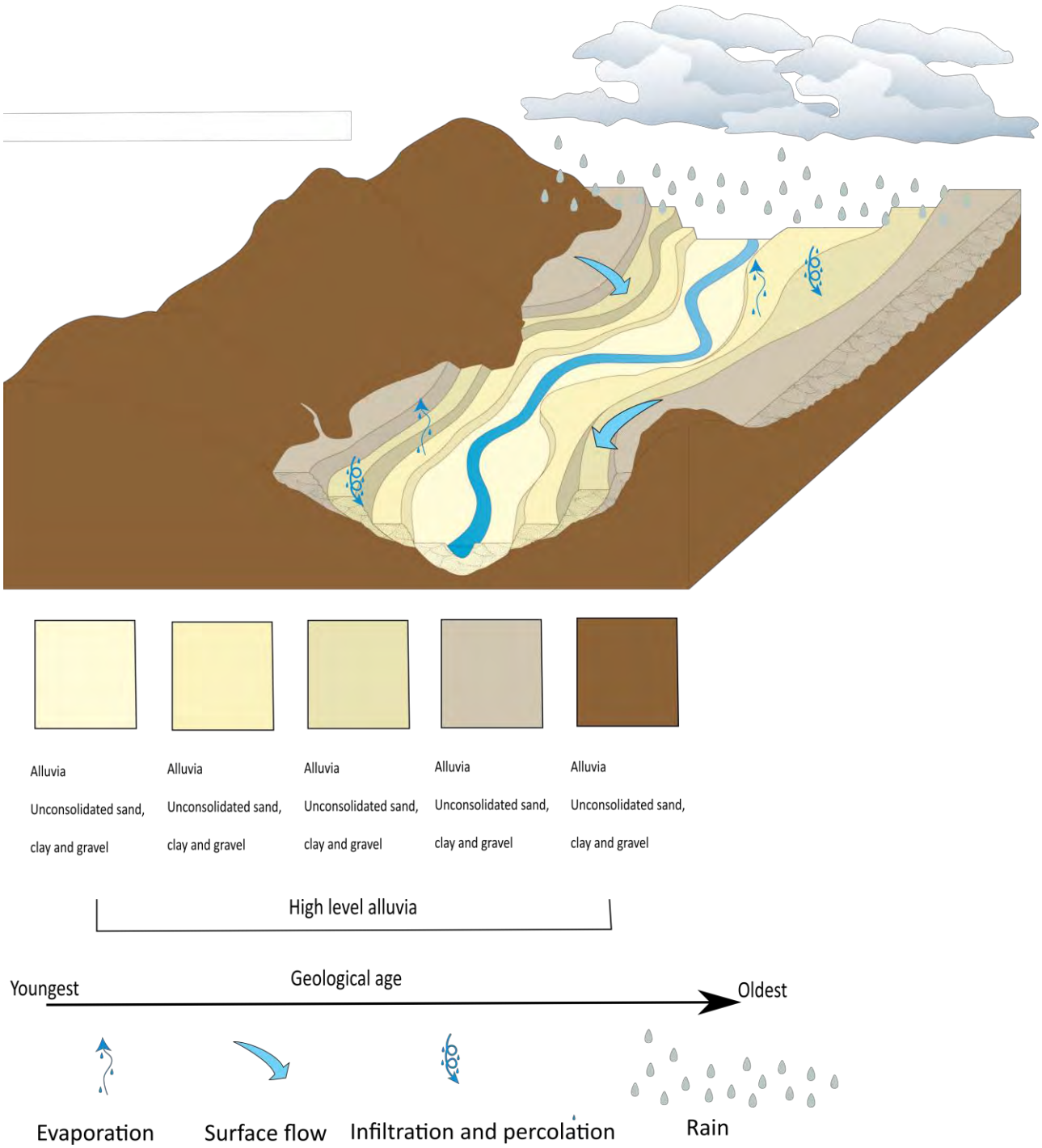

Figure 35 Clay plains conceptual model, based on the high level alluvia conceptual model

Source: Pictorial conceptual models, WetlandInfo, Department of Environment and Science, Queensland, viewed 19 March 2019
Element: GBA-COO-2-135

3.1.4 Loamy and sandy plains

Patches of loamy and sandy plains have been mapped in the Cooper GBA region in Queensland, typically on sloping terrain between uplands and alluvium. The most extensive area of loamy and sandy plains is in the north of the Cooper GBA region, north-west of Windorah and Jundah. There is no corresponding land system in SA and it is possible that limited areas classified as 'Tableland and duricrust' in SA may contain loamy and sandy plains. However, it is likely that this landscape class is very uncommon in the Cooper GBA region in South Australia owing to the great amount of

recent alluvial deposition and its generally low elevation compared to the Cooper GBA region in Queensland. Geological mapping does not reliably show unconsolidated surface layers. Determining the extent and nature of unconsolidated deposits can be problematic as field observation and landscape interpretation may be misleading and can only be accurately determined with the aid of soil cores. Hence, as for clay plains, identification and mapping of this landscape class is uncertain.

Loamy and sandy plains may be formed by redeposition of colluvium or be formed in-situ from 'old' alluvial processes (Wilson and Taylor, 2012). They may also result from prolonged, intense, deep weathering of parent rock material high in iron and/or aluminium oxides and kaolin clays. Landforms are flat to gently undulating plains, plateaus and dissected tablelands. A variety of vegetation communities exist within this landscape class, depending on local climate and soil factors. In semi-arid areas, vegetation generally consists of mulga, other *Acacia* species and poplar box; however, in the arid landscapes within the Cooper Basin *Acacia* species are most common.

This landscape class is represented by the 'sandy plains' conceptual model (Queensland Government, 2017c).

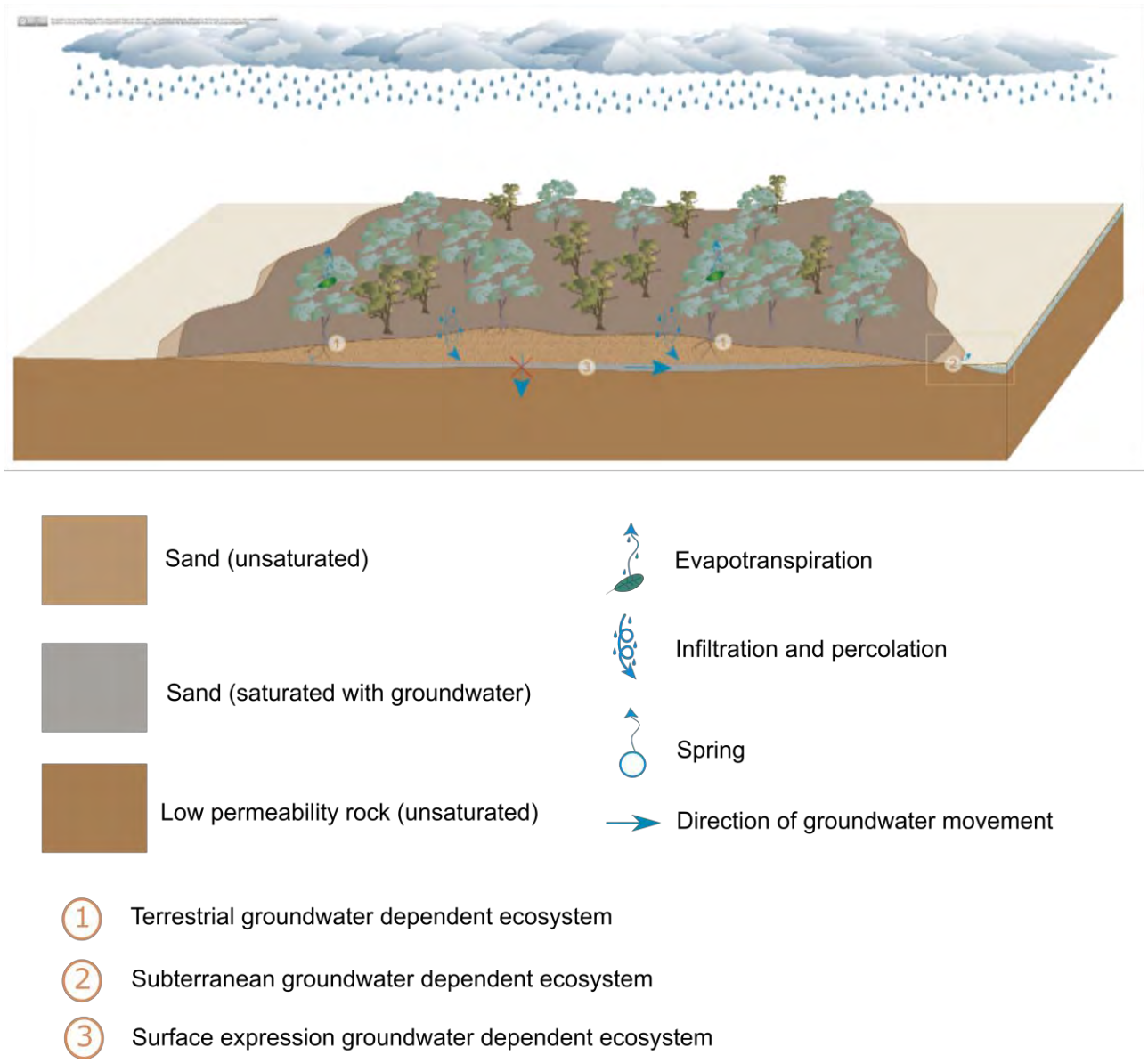

Figure 36 Sandy plains ecohydrological conceptual model (redrawn from 'Sandy Plains' conceptual model Queensland Government 2015)

Source: Pictorial conceptual models, WetlandInfo, Department of Environment and Science, Queensland, viewed 19 March 2019
Element: GBA-COO-2-136

3.1.5 Undulating country on fine-grained sedimentary rocks

Fine-grained sedimentary rocks include siltstones, mudstones and shales that readily weather to form landforms dominated by gently undulating plains and rises with clayey soils or soils with clay subsoils. Coarse-grained sedimentary rocks are included in the fine-grained sedimentary rock group if these rocks also weather to clayey soils. For example, the labile sandstones of the Winton Formation form gently undulating plains with cracking clay soils. Soils are predominantly Vertosols, Sodosols and Chromosols, although Dermosols and Kurosols are also present.

In South Australia this landscape class corresponds to the following surface geologies: K (Unnamed Undifferentiated Cretaceous rocks), Knw (Winton Formation), Knw1 (Unnamed Shale; siltstone; sandstone), Qhr (Unnamed Undifferentiated Holocene colluvial/regolith sediments), Qp\gy

(Unnamed Undifferentiated Pleistocene gypcrete), T (Unnamed Undifferentiated Tertiary rocks) and TQ (Unnamed Undifferentiated Tertiary to Pleistocene rocks).

In places where soil fertility is moderate to high, the undulating plains and rises have been developed or cleared for pasture or, in higher rainfall areas, cropping. The Mitchell grass downs and herbfields of western Queensland have been used traditionally for grazing by sheep and cattle. The vegetation includes a diverse range of eucalypt open forest and woodland, *Acacia* woodlands (gidgee, brigalow), grasslands and herbfields, and some vine forest in more favourable sites.

Within the Channel Country IBRA region, gibber plains are likely to be present. These are extremely flat to undulating plains that were formed during the breakdown and gradual recession of former tablelands (Santos, 2015). Soils typically consist of red and brown clays that are mantled by stone or recent deposits of silcrete pebbles, referred to as 'gibbers'. Where gibbers form a stable pavement they protect the underlying soil from erosion. Similarly for clay plains, permanent surface water sources are generally lacking, but temporary pools of water often form after rain in low depressions or gilgai. Minor drainage channels occur throughout lowland plain areas.

There is a range of vegetation throughout gibber country (Santos, 2015). On the southern and south-western margins, relatively dense low open shrubland of bladder saltbush, low bluebush and cotton bush are common. Further north, much of the area is naturally bare, but Mitchell grass tussock grasslands become more frequent. In other gibber areas, the main cover may be short-lived copperburrs and ephemeral grasses. There is still further variation caused by hills and drop-offs where small trees or tall shrubs, particularly emu bush, may form a tall open shrubland.

This landscape class is represented by the 'exclusion zones' conceptual model (Queensland Government, 2017c).

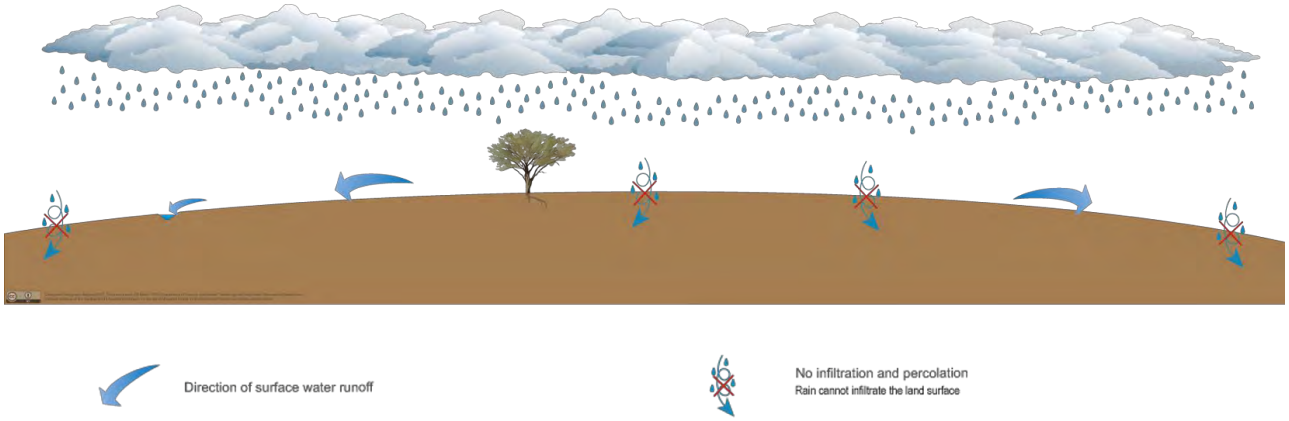

Figure 37 Undulating country on fine grained sedimentary rocks conceptual model based on the exclusion zones ecohydrological conceptual model

Source: Pictorial conceptual models, WetlandInfo, Department of Environment and Science, Queensland, viewed 19 March 2019
Element: GBA-COO-2-137

3.1.6 Tablelands and duricrusts

Tableland and duricrust areas are also known as dissected residuals, breakaways or ironstone jump-ups. They are characterised by a silcrete or ferricrete surface that has been eroded to form low but steep escarpments, mesas and buttes (Santos, 2015) with colluvial slopes (talus)

containing shallow soils (<0.5 m) over deeply weathered rock (Wilson and Taylor, 2012). Soils are either absent (exposed rock) or dominated by shallow (<0.5 m) Rudosols and Tenosols, with Kandosols on plateau and tableland margins. They may have gibber-covered foot slopes. Permanent surface water is scarce in elevated areas of tablelands (Santos, 2015).

In South Australia this landscape class corresponds to the following surface geologies: Knh (Mount Howie Sandstone), T\si (Unnamed Undifferentiated Tertiary silcrete) and Tem\si (Unnamed Regionally older silcrete; approximately late Eocene to mid Miocene).

Vegetation is extremely variable depending on climatic conditions, depth of soil and position in the landscape (Wilson and Taylor, 2012). The absence of vegetation on the bare rock and scarp areas is typical. In western areas, lancewood (*Acacia shirleyi*) and bendee (*A. catenulata*) and Spinifex (*Triodia* spp.) are dominant communities on the edges of the exposed duricrusts. Mulga (*A. aneura*) and bastard mulga (*A. clivicola*) are dominant on shallow soils on the level to gently undulating flat tops. Lower slopes range from *Acacia* shrublands, including gidgee (*A. cambagei*) to various eucalypt communities, including *Eucalyptus normantonensis* and mountain yapunyah (*E. thozetiana*).

This landscape class is represented by the ‘exclusion zones’ conceptual model (Queensland Government, 2017c).

3.1.7 Springs

Springs in the Great Artesian Basin (GAB) have been divided into two broad categories: recharge springs and discharge springs (Fensham et al., 2016). Recharge springs are also known as ‘outcrop’ springs (Fensham and Fairfax, 2003) because they occur within outcrop areas of sandstone formations on the eastern margins of the basin, before the aquifer rocks dip underground. Discharge springs occur remotely from recharge zones, where aquifers abut against impervious basement rocks and the confining bed or aquitard is thin or weak. Discharge springs are not present within the Cooper Basin, although Lake Blanche hosts several discharge springs that lie just outside the Cooper Basin.

Recharge springs emanating from fractures in Tertiary sandstone aquifers occur in clusters throughout semi-arid Queensland (Fensham et al., 2016). Within the Cooper Basin they are primarily located north and south-east of Welford National Park in the north of the Cooper GBA region, with scattered springs further west. They often occur at the base of cliffs or escarpments, where they are fed by watertables from higher terrain under gravitational pressure. Water drains out of the rocks under gravity or through the intersection of the ground surface with a saturated aquifer rather than welling upwards under artesian pressure. After a succession of wet summers, water can seep out from recharge springs for some months but, unlike discharge springs, they may be dry for years. Groundwater residence times vary considerably but are generally relatively short, and some springs can dwindle to seepages or disappear completely in dry times. Some feed quite large waterholes and streams, while others form small shallow pools or soaks. Water is generally slightly acidic and has low conductivity, reflecting its relatively short residence time. The water regimes of outcrop springs also tends to be more dynamic and less unusual as a habitat type, compared to GAB discharge springs (Fensham et al., 2011). Although their overall diversity is greater than rockholes, no endemic species have been recorded at any non-GAB springs in the

Copper GBA region. This type of spring within this landscape class is represented by the 'recharge springs' conceptual model (Fensham et al., 2016) in which the aquifer is confined by impermeable sandstone above and Cretaceous sediments of the Winton formation below. The aquifer is fed by local rainfall through fissures in the impermeable sandstone.

The springs landscape class is represented by the 'recharge springs' conceptual model (Fensham et al., 2016) (Figure 38).

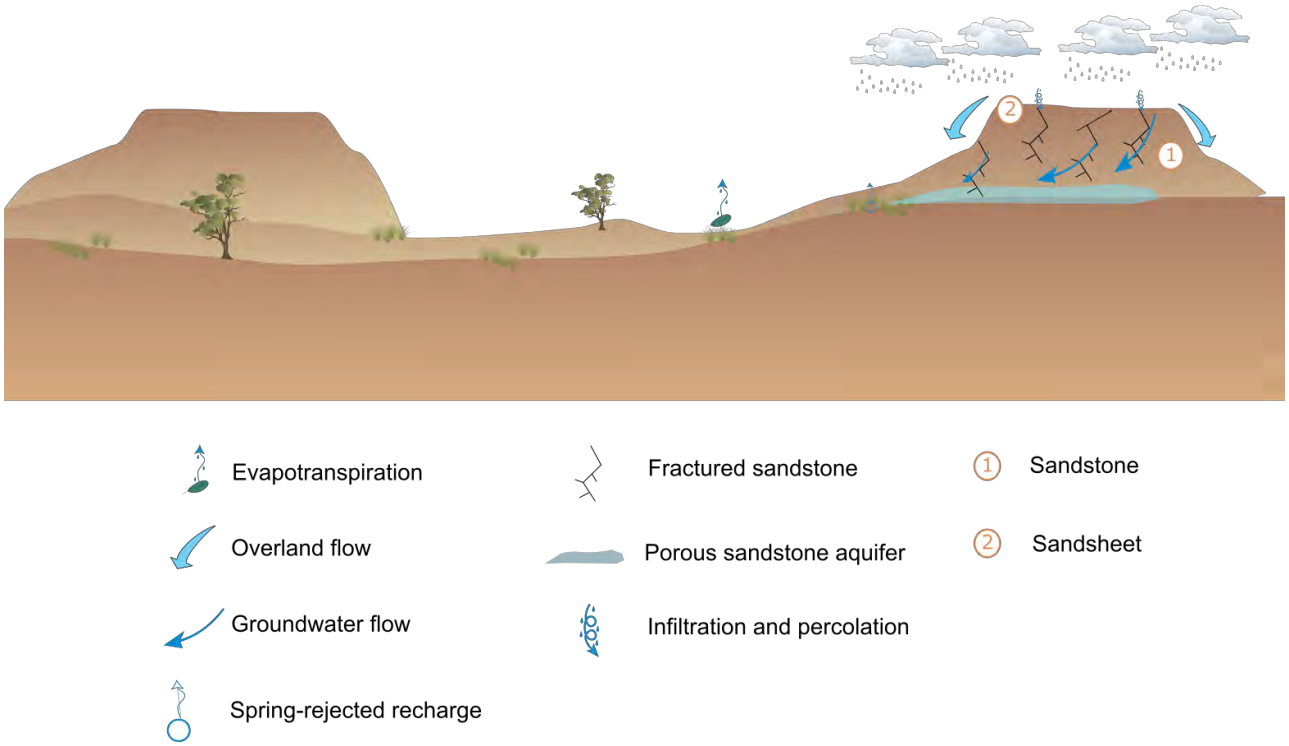

Figure 38 Conceptual diagram of a typical Tertiary sandstone spring at base of escarpment, where a porous sandstone aquifer is exposed by erosion of the plateau. This aquifer is confined by impermeable sandstone above and Cretaceous sediments of the Winton formation below. Unconnected GAB aquifers (not shown) occur at depth below these sediments. The aquifer is fed by local rainfall through fissures in the impermeable sandstone

Source: Redrawn from Fensham et al. (2016)
Element: GBA-COO-2-138

4 Protected matters prioritisation and screening

4.1 Protected matters prioritisation and screening approach

A prioritisation and screening process was adopted to identify individual protected matters that were likely to be impacted by potential shale, tight and deep gas resource development within the Cooper GBA region. The approach reviewed each matter identified in relation to its extent and distribution within the Cooper GBA region. The steps in the prioritisation and screening are outlined below.

4.1.1 Step one - identify matters

The process for identifying protected matters has been outlined in section one and two of this report.

4.1.2 Step two – Categorise matters

To identify individual matters that were likely to be impacted by potential shale, tight and deep coal resource development, we reviewed each matter in relation to its extent and distribution within the Cooper GBA region. Individual protected matters and landscape classes were assigned to one of three categories:

Priority 1-Importance of the region to the matter warrants a detailed level of assessment. Stage 3 assessment of the matter will endeavour to provide:

- Spatial extent and quantification of possible impacts where possible;
- Scale of impact relative to national and State values (e.g. EPBC significant impact guidelines, Table 12);
- Field or remote sensing data validation of occurrence and areas of impact;
- Details of direct and indirect impact causes and effects that may result;
- Evaluation of standard and model conditions to control impacts;
- Recommended specific and standard mitigation measures.

Priority 2- Importance of the region to the matter warrants a high level assessment. Future Assessment will endeavour to:

- Spatial extent of possible impacts where possible;
- Description of possible direct and indirect impact causes and effects;
- Evaluation of standard and model conditions to suitably control impacts.

Priority 3- Importance of the region to the matter does not warrant further assessment

- Impacts to these matters will not be assessed but it is anticipated that general mitigation and avoidance measures will provide some level of protection to biodiversity as a whole.

MNES, MSES and other matters were initially categorised as shown in Table 11.

Table 11 Initial categorisation of protected matters

	Priority
MNES	
World heritage properties	Not present
National heritage places	1
Internationally important (Ramsar) wetlands	1
Nationally listed threatened species	1
Nationally listed threatened ecological communities	Not present
Migratory species protected under international agreements	1
Other matters protected by the EPBC Act	
Listed marine species	1
Whales and other Cetaceans	Not present
Commonwealth lands	Not present
Other Matter not protected by the EPBC Act	
Nationally important wetlands (DIWA)	1
Landscape classes	2
MSES	
High ecological significance wetlands	1
High ecological value waters (wetland and water course)	Not present
Strategic environmental areas	1
Heritage areas	2
Regional ecosystems-Endangered	1
Regional ecosystems-Of concern	2
Regional ecosystems-Other	3
Threatened species-Endangered, Vulnerable (SA, QLD), Rare (SA)	1
Threatened species-Other	3
Other Matters	
Groundwater-dependent ecosystems	1

4.1.3 Step three: preliminary screening

Following initial categorisation, matters categorised as priority 1 or 2 were subject to preliminary screening of potential for impact. Where the protected matter was a *species*, species occurrence records were downloaded from the Atlas of Living Australia. In addition to these records the spatial data associated with the predicted distribution of each species was reviewed (Figures 1-25). The presence of each species was assessed in relation to the percentage of the species occurrence (known records and predicted distributions) within the Cooper GBA region in relation to its national distribution and potential for impact from shale, tight and deep coal gas development. This was assessed using the significant impact guidelines (Table 12), species recovery plans, conservation advises and threat abatement plans.

The spatial data for each species were reviewed in relation to the extent of the protected matter within areas licenced for exploration and within areas deemed to be prospective for shale, tight and deep coal gas development. Where the protected matter was a *place*, e.g. a wetland of national significance, the matter was included if the area;

- partially or wholly intersected with areas licenced for exploration and within areas deemed to be prospective for shale, tight and deep coal gas development
- could be deemed to be hydrologically connected to these areas from a surface water or groundwater perspective
- thought to contain habitat for an identified species protected matter.

If the matter was a landscape class (Figure 31), the landscape class was included using the same criteria as defined for place protected matters.

Protected matters and landscape classes that remained after this screening process were matters that are potentially exposed to impacts associated with development within the region and are to be considered further as part of the impact assessment.

Table 12 Significant impact guidelines for assessing matters of national environmental significance

Class	Status	Criteria
Listed threatened species and ecological communities	Extinct in the wild species	NA
	Critically endangered or endangered species	An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will: • lead to a long-term decrease in the size of a population • reduce the area of occupancy of the species • fragment an existing population into two or more populations • adversely affect habitat critical to the survival of a species • disrupt the breeding cycle of a population • modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline • result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat • introduce disease that may cause the species to decline, or • interfere with the recovery of the species.

Class	Status	Criteria
	Vulnerable species	An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will: • lead to a long-term decrease in the size of an important population of a species • reduce the area of occupancy of an important population • fragment an existing important population into two or more populations • adversely affect habitat critical to the survival of a species • disrupt the breeding cycle of an important population • modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline • result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat • introduce disease that may cause the species to decline, or • interfere substantially with the recovery of the species.
	Critically endangered or endangered communities	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: • reduce the extent of an ecological community • fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission lines • adversely affect habitat critical to the survival of an ecological community • modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns • 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 • cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to: -- assisting invasive species, that are harmful to the listed ecological community, to become established, or -- 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 • interfere with the recovery of an ecological community.

Class	Status	Criteria
Listed migratory species		An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will: • substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species • result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species, or • seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species
Wetlands of international importance		An action is likely to have a significant impact on the ecological character of a declared Ramsar wetland if there is a real chance or possibility that it will result in: • areas of the wetland being destroyed or substantially modified • a substantial and measurable change in the hydrological regime of the wetland, for example, a substantial change to the volume, timing, duration and frequency of ground and surface water flows to and within the wetland • the habitat or lifecycle of native species, including invertebrate fauna and fish species, dependent upon the wetland being seriously affected • a substantial and measurable change in the water quality of the wetland – for example, a substantial change in the level of salinity, pollutants, or nutrients in the wetland, or water temperature which may adversely impact on biodiversity, ecological integrity, social amenity or human health, or • an invasive species that is harmful to the ecological character of the wetland being established (or an existing invasive species being spread) in the wetland.
The commonwealth marine environment		NA
World heritage properties		NA
National heritage places		An action is likely to have a significant impact on the National Heritage values of a National Heritage Place if there is a real chance or possibility that it will cause: • one or more of the National Heritage values to be lost • one or more of the National Heritage values to be degraded or damaged, or • one or more of the National Heritage values to be notably altered, modified, obscured or diminished.

4.2 Screening-Matters of environmental significance

The spatial extent for the area of potential impact arising from the development of shale, tight and deep coal gas resources is defined as the extent of the union between the existing licenced

tenements and the area defined as being prospective for development (Lech et al., 2020). Ten species of national environmental significance were identified as being potentially at risk from the development of shale, tight and deep coal gas resources in the Cooper GBA region (Table 13). These include five species listed as critically endangered or endangered and five species listed as vulnerable. In addition to these, four species listed as matters of state environmental significance in Queensland (all vulnerable) were identified as potentially at risk from shale, tight and deep coal gas resources in the Cooper GBA region; Major Mitchell Cockatoo (*Lophochroa leadbeateri* and three plants species (*Eremophila stenophylla, Indigofera oxyrachis, Nyssanthes impervia*). In the South Australia potion of the Cooper GBA Region, four bird species (*Ardeotis australis, Cladorhynchus leucocephalus, Lophoictinia isura, Stictonetta naevosa*), one mammal (*Notomys cervinus*), one reptile (*Emydura macquarii*) and five plant species (*Bergia occultipetala*, *Cyperus dactylotes*, *Osteocarpum pentapterum*, *Sauropus ramosissimus*, *Stylidium desertorum*) were identified as being potentially at risk from shale, tight and deep coal gas resources in the Cooper GBA region.

The spatial extent for the area of potential impact arising from the development of shale, tight and deep coal gas resources is defined as the maximum extent of the union between the existing licenced tenements and the area defined as being prospective for development (Lech et al., 2020). Based on this, development of shale, tight and deep coal gas resources is likely to impact on all landscape classes within the Cooper GBA region.

Table 13 Matters of national environmental significance with potential to be impacted by shale, tight and deep coal gas resource development in the Cooper GBA region

Status	Species	Tenements (km^2)	Prospective (km^2)	Area in Cooper GBA region (km^2)
Critically endangered/ endangered	*Pedionomus torquatus* (Plains wanderer)	44730.1 (0)	42142.9 (0)	114020.0 (0)
	Amytornis barbatus barbatus (Bullo Grey Grasswren, Grey Grasswren (Bulloo)	13477.0 (17)	17590.6 (8)	35077.3 (30)
	Pezoporus occidentalis (Night Parrot)	39514.2 (2)	31474.9 (0)	96669.2 (2)
	Rostratula australis (Australian Painted Snipe)	50584.0 (0)	45685.4 (1)	130060.3 (1)
	Frankenia plicata	38790.5 (0)	38313.9 (0)	97709.7 (0)
Vulnerable	*Dasyuroides byrnei* (Kowari, brushy-tailed marsupial rat, Byrne's cresttailed marsupial rat)	3358.4 (10)	276.0 (0)	8787.8 (13)
	Notomys fuscus (Dusky Hopping-mouse, Wilkiniti)	16777.9 (35)	15867.8 (197)	36403.4 (245)
	Petrogale xanthopus celeris (Yellow-footed Rock-wallaby (central-western Queensland))	3988.8 (2)	4547.9 (2)	17570.8 (24)
	Sclerolaena walkeri	30730.8 (2)	21230.0 (0)	80150.9 (2)
	Xerothamnella parvifolia	665.3 (0)	483.0 (4)	1352.1 (18)

Note: Numbers within brackets are numbers of relevant observations from the Atlas of Living Australia
Data: Geological and Bioregional Assessment Program (2019b)

All seven of the landscape classes intersect with the area defined as being prospective or likely for the development of shale tight and deep coal gas resources (Table 14) and will be considered further in the assessment of potential impacts.

The area of predicted distribution for each species (MNES only) within each landscape class is shown in Table 15. It should be noted that the predicted distribution is not a surrogate of species habitat, and thus the areas reported in Table 15 give a broad overview of the distribution of the species across the landscape only. More detail assessment of habitat suitability is required to better assess the potential for impact arising from shale, tight and deep coal gas resource development.

Impacts arising from shale, tight and deep coal gas development to all other matters in categories 1 and 2 (Table 11) will be considered as part of stage 3 of the assessment.

Table 14 Area of landscape class within existing exploration tenements and within areas identified as being prospective for develop of shale, tight gas and deep coal resources

Landscape class	Tenements (km^2)	Prospective (km^2)
Floodplain and Alluvium	16626.8	17156.6
Inland dunefields	17210.6	14748.6
Sedimentary hills and ranges	9802.9	8295.2
Tablelands and duricrusts	2749.1	2997.2
Loamy and sandy plains	4193.8	2463.6
Clay plains	0.7	20.2

Data: Geological and Bioregional Assessment Program (2019b)

Table 15 MNES matters and associated landscape classes within the Cooper GBA region

Species	Landscape class	Predicted distribution (km^2)	Number of ALA records
Pedionomus torquatus (Plains wanderer)	Floodplain and Alluvium	38782.8	0
	Inland dunefields	29822.3	0
	Sedimentary hills and ranges	24785.6	0
	Tablelands and duricrusts	9603.8	0
	Loamy and sandy plains	11004.5	0
	Clay plains	20.9	0
Amytornis barbatus barbatus (Bullo Grey Grasswren, Grey Grasswren (Bulloo)	Floodplain and Alluvium	18410.9	22
	Inland dunefields	6478.8	0
	Sedimentary hills and ranges	5812.1	8
	Tablelands and duricrusts	1565.5	0
	Loamy and sandy plains	3439.9	0
	Clay plains	0	0
Pezoporus occidentalis (Night Parrot)	Floodplain and Alluvium	26908.9	0
	Inland dunefields	37422.9	2

Species	Landscape class	Predicted distribution (km²)	Number of ALA records
	Sedimentary hills and ranges	14520.4	0
	Tablelands and duricrusts	9296.5	0
	Loamy and sandy plains	8492.1	0
	Clay plains	20.9	0
Rostratula australis (Australian Painted Snipe)	Floodplain and Alluvium	41655.1	1
	Inland dunefields	39776.3	0
	Sedimentary hills and ranges	26556.7	0
	Tablelands and duricrusts	10853.6	0
	Loamy and sandy plains	11190.4	0
	Clay plains	20.9	0
Frankenia plicata	Floodplain and Alluvium	3243.5	0
	Inland dunefields	35755.1	0
	Sedimentary hills and ranges	21060.1	0
	Tablelands and duricrusts	2492.0	0
	Loamy and sandy plains	5654.9	0
	Clay plains	0	0
Dasyuroides byrnei (Kowari, brushy-tailed marsupial rat, Byrne's crest-tailed marsupial rat)	Floodplain and Alluvium	2776.2	7
	Inland dunefields	2129.1	0
	Sedimentary hills and ranges	3684.5	6
	Tablelands and duricrusts	69.0	0
	Loamy and sandy plains	128.9	0
	Clay plains	0	0
Notomys fuscus (Dusky Hopping-mouse, Wilkiniti)	Floodplain and Alluvium	10255.7	123
	Inland dunefields	20005.5	108
	Sedimentary hills and ranges	5982.9	13
	Tablelands and duricrusts	113.1	1
	Loamy and sandy plains	46.2	0
	Clay plains	0	0
Petrogale xanthopus celeris (Yellow-footed Rock-wallaby (central-western Queensland))	Floodplain and Alluvium	2066.9	1
	Inland dunefields	432.8	0
	Sedimentary hills and ranges	4909.9	7
	Tablelands and duricrusts	7272.1	12
	Loamy and sandy plains	2889.2	4
	Clay plains	0	0
Sclerolaena walkeri	Floodplain and Alluvium	27453.8	2

Species	Landscape class	Predicted distribution (km²)	Number of ALA records
	Inland dunefields	11705.5	0
	Sedimentary hills and ranges	20620.8	0
	Tablelands and duricrusts	10765.1	0
	Loamy and sandy plains	9584.8	0
	Clay plains	20.9	0
Xerothamnella parvifolia	Floodplain and Alluvium	293.8	3
	Inland dunefields	149.7	3
	Sedimentary hills and ranges	354.6	0
	Tablelands and duricrusts	304.1	11
	Loamy and sandy plains	250.0	1
	Clay plains	0	1

Data: Geological and Bioregional Assessment Program (2019b)

5 Knowledge gaps

A range of environmental and cultural assets have been identified within the Cooper GBA region, including matters of national environmental significance and matters of state environmental significance. The level of knowledge for many of these matters varies significantly and this will impact the capacity to assess the potential impacts associated with shale, tight and deep coal gas resource development.

For threatened species, knowledge of their distribution and occurrence within the Cooper GBA region is patchy. For many species, local surveys have been limited, and some MNES species are listed as 'likely to occur' or 'may occur'. Furthermore, it is difficult to assess the validity and accuracy of many of the records in data bases such as the Atlas of Living Australia. A better understanding of species occurrence and habitat in the region would facilitate an assessment of the potential impacts associated with shale, tight and deep coal gas resource development. Detailed ecological knowledge for many threatened species remains sparse, especially in a localised context. Similarly the potential for impacts associated with changes in the quantity and quality of the regions water resources is extremely limited as the water requirements for many species is poorly known.

For many species listed as matters of state environmental significance, the threatening processes associated with their listing is unknown. This information is relevant to understanding the potential impacts of environmental change and the potential for impacts associated with shale, tight and deep coal gas development to act in a cumulative manner with other threats. Similarly the low numbers of species identified in the region suggests that the region is poorly surveyed. It is difficult to make an assessment of the current biodiversity status of the region based on these species lists.

The landscape classification is limited by the quality of available datasets, including surface geology, elevation, vegetation and landform mapping, and extent and quality of ground observations. In particular, the distribution of clay plains is not clearly indicated in geological mapping. Reference to additional land resource data, particularly geomorphology data, together with interpretation of satellite imagery, aerial photographs and soil information is necessary to identify clay plains. Similarly, determining the extent and nature of unconsolidated deposits can be problematic and can only be accurately determined with the aid of soil cores.

The distribution of knowledge associated with the landscape classes is also very patchy. The Cooper Creek system itself has been the focus of a number of detailed studies and assessments, but these have largely been restricted to the riverine channels themselves and very little process based understanding exists for other landscape classes within the Cooper GBA region. This is particularly true for groundwater-dependent ecosystems. The capacity to develop locally relevant conceptual models for the landscape classes will be constrained by locally relevant knowledge of key system processes and how these will be impacted by regionally and locally relevant threatening processes.

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Glossary

The register of terms and definitions used in the Geological and Bioregional Assessment Program is available online at https://w3id.org/gba/glossary (note that terms and definitions are respectively listed under the 'Name' and 'Description' columns in this register). This register is a list of terms, which are the preferred descriptors for concepts. Other properties are included for each term, including licence information, source of definition and date of approval. Semantic relationships (such as hierarchical relationships) are formalised for some terms, as well as linkages to other terms in related vocabularies. Many of the definitions for these terms have been sourced from external glossaries – several from international sources; spelling variations have been retained to maintain authenticity of the source.

activity: for the purposes of Impact Modes and Effects Analysis (IMEA), a planned event associated with unconventional gas resource development. For example, activities during the exploration life-cycle stage include drilling and coring, ground-based geophysics and surface core testing. Activities are grouped into ten major activities, which can occur at different life-cycle stages.

aeolian: relating to or arising from the action of wind

aquifer: rock or sediment in a formation, group of formations, or part of a formation that is saturated and sufficiently permeable to transmit quantities of water to bores and springs

aquitard: a saturated geological unit that is less permeable than an aquifer, and incapable of transmitting useful quantities of water. Aquitards commonly form a confining layer over an artesian aquifer.

asset: an entity that has value to the community and, for the purposes of geological and bioregional assessments, is associated with a GBA region. An asset is a store of value and may be managed and/or used to maintain and/or produce further value. An asset may have many values associated with it that can be measured from a range of perspectives; for example, the values of a wetland can be measured from ecological, sociocultural and economic perspectives.

barrel: a standard unit of measurement for all production and sales of oil. It has a volume of 42 US gallons [0.16 m^3].

basement: the oldest rocks in an area; commonly igneous or metamorphic rocks of Precambrian or Paleozoic age that underlie other sedimentary formations. Basement generally does not contain significant oil or gas, unless it is fractured and in a position to receive these materials from sedimentary strata.

bed: in geosciences, the term 'bed' refers to a layer of sediment or sedimentary rock, or stratum. A bed is the smallest stratigraphic unit, generally a centimetre or more in thickness. To be labeled a bed, the stratum must be distinguishable from adjacent beds.

bore: a narrow, artificially constructed hole or cavity used to intercept, collect or store water from an aquifer, or to passively observe or collect groundwater information. Also known as a borehole or piezometer.

charge: in petroleum geoscience, a 'charge' refers to the volume of expelled petroleum available for entrapment

coal: a rock containing greater than 50 wt.% organic matter

coal seam gas: coal seam gas (CSG) is a form of natural gas (generally 95% to 97% pure methane, CH_4) extracted from coal seams, typically at depths of 300 to 1000 m. Also called coal seam methane (CSM) or coalbed methane (CBM).

conceptual model: an abstraction or simplification of reality that describes the most important components and processes of natural and/or anthropogenic systems, and their response to interactions with extrinsic activities or stressors. They provide a transparent and general representation of how complex systems work, and identify gaps or differences in understanding. They are often used as the basis for further modelling, form an important backdrop for assessment and evaluation, and typically have a key role in communication. Conceptual models may take many forms, including descriptive, influence diagrams and pictorial representations.

confined aquifer: an aquifer saturated with confining layers of low-permeability rock or sediment both above and below it. It is under pressure so that when the aquifer is penetrated by a bore, the water will rise above the top of the aquifer.

consequence: synonym of impact

context: the circumstances that form the setting for an event, statement or idea

Cooper Basin: the Cooper Basin geological province is an Upper Carboniferous – Middle Triassic geological sedimentary basin that is up to 2500 m thick and occurs at depths between 1000 and 4400 m. It is overlain completely by the Eromanga and Lake Eyre basins. Most of the Cooper Basin is in south-west Queensland and north-east SA, and includes a small area of NSW at Cameron Corner. It occupies a total area of approximately 130,000 km2, including 95,740 km^2 in Queensland, 34,310 km^2 in SA and 8 km^2 in NSW.

crust: the outer part of the Earth, from the surface to the Mohorovicic discontinuity (Moho)

dataset: a collection of data in files, in databases or delivered by services that comprise a related set of information. Datasets may be spatial (e.g. a shape file or geodatabase or a Web Feature Service) or aspatial (e.g. an Access database, a list of people or a model configuration file).

deep coal gas: gas in coal beds at depths usually below 2000 m are often described as ‘deep coal gas’. Due to the loss of cleat connectivity and fracture permeability with depth, hydraulic fracturing is used to release the free gas held within the organic porosity and fracture system of the coal seam. As dewatering is not needed, this makes deep coal gas exploration and development similar to shale gas reservoirs.

deposition: sedimentation of any material, as in the mechanical settling of sediment from suspension in water, precipitation of mineral matter by evaporation from solution, and accumulation of organic material

development: a phase in which newly discovered oil or gas fields are put into production by drilling and completing production wells

discovered: the term applied to a petroleum accumulation/reservoir whose existence has been determined by its actual penetration by a well, which has also clearly demonstrated the existence of moveable petroleum by flow to the surface or at least some recovery of a sample of petroleum. Log and/or core data may suffice for proof of existence of moveable petroleum if an analogous reservoir is available for comparison.

dome: a type of anticline where rocks are folded into the shaped of an inverted bowl. Strata in a dome dip outward and downward in all directions from a central area.

ecosystem: a dynamic complex of plant, animal, and micro-organism communities and their non-living environment interacting as a functional unit. Note: ecosystems include those that are human-influenced such as rural and urban ecosystems.

ecosystem asset: an ecosystem that may provide benefits to humanity. It is a spatial area comprising a combination of biotic and abiotic components and other elements which function together.

effect: for the purposes of Impact Modes and Effects Analysis (IMEA), a change to water or the environment, such as changes to the quantity and/or quality of surface water or groundwater, or to the availability of suitable habitat. An effect is a specific type of an impact (any change resulting from prior events).

ephemeral stream: a stream that flows only briefly during and following a period of rainfall, and has no baseflow component

erosion: the wearing away of soil and rock by weathering, mass wasting, and the action of streams, glaciers, waves, wind, and underground water

field: in petroleum geoscience, a 'field' refers to an accumulation, pool, or group of pools of hydrocarbons or other mineral resources in the subsurface. A hydrocarbon field consists of a reservoir with trapped hydrocarbons covered by an impermeable sealing rock, or trapped by hydrostatic pressure.

floodplain: a flat area of unconsolidated sediment near a stream channel that is submerged during or after high flows

fluvial: sediments or other geologic features formed by streams

formation: rock layers that have common physical characteristics (lithology) deposited during a specific period of geological time

fracture: a crack or surface of breakage within rock not related to foliation or cleavage in metamorphic rock along which there has been no movement. A fracture along which there has been displacement is a fault. When walls of a fracture have moved only normal to each other, the fracture is called a joint. Fractures can enhance permeability of rocks greatly by connecting pores together, and for that reason, fractures are induced mechanically in some reservoirs in order to boost hydrocarbon flow. Fractures may also be referred to as natural fractures to distinguish them from fractures induced as part of a reservoir stimulation or drilling operation. In some shale reservoirs, natural fractures improve production by enhancing effective permeability. In other cases, natural fractures can complicate reservoir stimulation.

gilgai: a small ephemeral lake formed from a depression in the soil surface in expanding clay soils

groundwater: water occurring naturally below ground level (whether stored in or flowing through aquifers or within low-permeability aquitards), or water occurring at a place below ground that has been pumped, diverted or released to that place for storage there. This does not include water held in underground tanks, pipes or other works.

groundwater-dependent ecosystem: ecosystems that require access to groundwater on a permanent or intermittent basis to meet all or some of their water requirements

hazard: an event, or chain of events, that might result in an effect (change in the quality and/or quantity of surface water or groundwater)

hydraulic fracturing: also known as 'fracking', 'fraccing' or 'fracture simulation'. This is a process by which geological formations bearing hydrocarbons (oil and gas) are 'stimulated' to increase the flow of hydrocarbons and other fluids towards the well. In most cases, hydraulic fracturing is undertaken where the permeability of the formation is initially insufficient to support sustained flow of gas. The process involves the injection of fluids, proppant and additives under high pressure into a geological formation to create a conductive fracture. The fracture extends from the well into the production interval, creating a pathway through which oil or gas is transported to the well.

hydrogeology: the study of groundwater, including flow in aquifers, groundwater resource evaluation, and the chemistry of interactions between water and rock

impact: the difference between what could happen as a result of activities and processes associated with extractive industries, such as shale, tight and deep coal gas development, and what would happen without them. Impacts may be changes that occur to the natural environment, community or economy. Impacts can be a direct or indirect result of activities, or a cumulative result of multiple activities or processes.

impact cause: an activity (or aspect of an activity) that initiates a hazardous chain of events

impact mode: the manner in which a hazardous chain of events (initiated by an impact cause) could result in an effect (change in the quality and/or quantity of surface water or groundwater). There might be multiple impact modes for each activity or chain of events.

Impact Modes and Effects Analysis: a systematic hazard identification and prioritisation technique based on Failure Modes and Effects Analysis

Lake Eyre Basin: a geologic province containing Cenozoic terrestrial sedimentary rocks within the Lake Eyre surface water catchment. It covers parts of northern and eastern SA, south-eastern NT, western Queensland and north-western NSW. In the Cooper GBA region, the basin sedimentary package is less than 300 m thick.

landscape class: for the purposes of geological and bioregional assessments (GBA), a collection of ecosystems with characteristics that are expected to respond similarly to changes in groundwater and/or surface water due to unconventional gas resource development. Note that there is expected to be less heterogeneity in the response within a landscape class than between landscape classes. They are present on the landscape across the entire GBA region and their spatial coverage is exhaustive and non-overlapping. Conceptually, landscape classes can be considered as types of ecosystem assets.

mantle: the region of the Earth composed mainly of solid silicate rock that extends from the base of the crust (Moho) to the core–mantle boundary at a depth of approximately 2900 km

material: pertinent or relevant

mature: a hydrocarbon source rock that has started generating hydrocarbons

mudstone: a general term for sedimentary rock made up of clay-sized particles, typically massive and not fissile

oil: a mixture of liquid hydrocarbons and other compounds of different molecular weights. Gas is often found in association with oil. Also see petroleum.

outcrop: a body of rock exposed at the surface of the Earth

play: a conceptual model for a style of hydrocarbon accumulation used during exploration to develop prospects in a basin, region or trend and used by development personnel to continue exploiting a given trend. A play (or group of interrelated plays) generally occurs in a single petroleum system.

recharge: see groundwater recharge

reserves: quantities of petroleum anticipated to be commercially recoverable in known accumulations from a given date forward under defined conditions. Reserves must further satisfy four criteria: they must be discovered, recoverable, commercial and remaining (as of the evaluation date) based on the development project(s) applied.

reservoir: a subsurface body of rock having sufficient porosity and permeability to store and transmit fluids and gases. Sedimentary rocks are the most common reservoir rocks because they have more porosity than most igneous and metamorphic rocks and form under temperature conditions at which hydrocarbons can be preserved. A reservoir is a critical component of a complete petroleum system.

ridge: a narrow, linear geological feature that forms a continuous elevated crest for some distance (e.g. a chain of hills or mountains or a watershed)

riparian: within or along the banks of a stream or adjacent to a watercourse or wetland; relating to a riverbank and its environment, particularly to the vegetation

risk: the effect of uncertainty on objectives (ASNZ ISO 3100). This involves assessing the potential consequences and likelihood of impacts to environmental and human values that may stem from an action, under the uncertainty caused by variability and incomplete knowledge of the system of interest.

runoff: rainfall that does not infiltrate the ground or evaporate to the atmosphere. This water flows down a slope and enters surface water systems.

sandstone: a sedimentary rock composed of sand-sized particles (measuring 0.05–2.0 mm in diameter), typically quartz

sediment: various materials deposited by water, wind or glacial ice, or by precipitation from water by chemical or biological action (e.g. clay, sand, carbonate)

sedimentary rock : a rock formed by lithification of sediment transported or precipitated at the Earth's surface and accumulated in layers. These rocks can contain fragments of older rock transported and deposited by water, air or ice, chemical rocks formed by precipitation from solution, and remains of plants and animals.

shale: a fine-grained sedimentary rock formed by lithification of mud that is fissile or fractures easily along bedding planes and is dominated by clay-sized particles

shale gas: generally extracted from a clay-rich sedimentary rock, which has naturally low permeability. The gas it contains is either adsorbed or in a free state in the pores of the rock.

siltstone: a sedimentary rock composed of silt-sized particles (0.004 to 0.063 mm in diameter)

spring: a naturally occurring discharge of groundwater flowing out of the ground, often forming a small stream or pool of water. Typically, it represents the point at which the watertable intersects ground level.

structure: a geological feature produced by deformation of the Earth's crust, such as a fold or a fault; a feature within a rock, such as a fracture or bedding surface; or, more generally, the spatial arrangement of rocks

surface water: water that flows over land and in watercourses or artificial channels and can be captured, stored and supplemented from dams and reservoirs

tenement: an area of land held by an authority holder. May be an authority to prospect, a petroleum lease, a petroleum facilities lease or a petroleum pipeline lease.

terrane: an area of crust with a distinct assemblage of rocks (as opposed to terrain, which implies topography, such as rolling hills or rugged mountains)

tight gas: tight gas is trapped in reservoirs characterised by very low porosity and permeability. The rock pores that contain the gas are minuscule, and the interconnections between them are so limited that the gas can only migrate through it with great difficulty.

trap: a geologic feature that permits an accumulation of liquid or gas (e.g. natural gas, water, oil, injected CO_2) and prevents its escape. Traps may be structural (e.g. domes, anticlines), stratigraphic (pinchouts, permeability changes) or combinations of both.

unconfined aquifer: an aquifer whose upper water surface (watertable) is at atmospheric pressure and does not have a confining layer of low-permeability rock or sediment above it

watertable: the upper surface of a body of groundwater occurring in an unconfined aquifer. At the watertable, pore water pressure equals atmospheric pressure.

weathering: the breakdown of rocks and other materials at the Earth's surface caused by mechanical action and reactions with air, water and organisms. Weathering of seep oils or improperly sealed oil samples by exposure to air results in evaporative loss of light hydrocarbons.

well: typically a narrow diameter hole drilled into the earth for the purposes of exploring, evaluating, injecting or recovering various natural resources, such as hydrocarbons (oil and gas), water or carbon dioxide. Wells are sometimes known as a 'wellbore'.

well integrity: maintaining full control of fluids (or gases) within a well at all times by employing and maintaining one or more well barriers to prevent unintended fluid (gas or liquid) movement between formations with different pressure regimes, or loss of containment to the environment

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