SECOND MURRAY RIVER CROSSING AT ECHUCA - MOAMA

ECOLOGICAL ASSESSMENT REPORT OF ALIGNMENT IN NSW

New South Wales Roads and Maritime Services

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Report 8194 (15.5)

1. EXECUTIVE SUMMARY

The New South Wales Roads and Maritime Services (Roads and Maritime) engaged Brett Lane & Associates Pty. Ltd. (BL&A) to prepare an ecological investigation report relating to the portion of the Second Murray River Crossing at Echuca – Moama Project (the 'Proposal') which falls under NSW legislative jurisdiction. This report was required to form part of a Review of Environmental Factors, as required under Part 5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act), and considers the potential impacts on biodiversity of the Proposal relative to New South Wales legislative requirements.

The alignment in the New South Wales section of the study area would result in the removal of 5.08 hectares of native vegetation, including seven hollow-bearing trees.

A biodiversity offset strategy would need to be developed in consultation with Roads and Maritime to compensate for residual impacts of the proposed action.

No flora species listed under the NSW *Threatened Species Conservation Act 1995* (TSC Act) were recorded and none are considered likely to occur in the study area due to either a lack of suitable habitat or the results of targeted surveys.

A total of 15 fauna species listed under the NSW *Threatened Species Conservation Act 1995* (TSC Act) and *Fisheries Management Act 1994* (FM Act) were recorded or considered likely to occur in the study area due to the availability of suitable habitat. In the addition to these threatened fauna species one EEC — Lower Murray River Aquatic Ecological Community — was also identified as occurring within the study area.

While some threatened fauna species and EEC habitat will be impacted to facilitate the proposed development, impacts are not considered to be significant (i.e. result in the extinction of any local populations or reduce the long-term existence of any of these species). For example, long-term impacts on the local Squirrel Glider population are unlikely to be significant provided mitigation measures outlined in Van Der Ree *et al* (2015 — see Appendix 8) and BL&A (2015d — see Appendix 10) are implemented.

One Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) listed species — Rainbow Bee-eater (migratory) — was recorded in the study area. This summer visitor is not threatened and will not be impacted by the proposal.

Based on the analysis of calls recorded during the bat surveys, it was initially determined that the EPBC Act-listed South-eastern Long-eared Bat was also present within the study area. A subsequent peer review of these findings found that the habitat present was not suitable for this species and that the recorded calls could not be attributed to South-eastern Long-eared Bat — as such, it was determined that this bat was not likely to occur within the study area (Gration 2015 — see Appendix 9).

Based on the initial findings in relation to South-eastern Long-eared Bat, a Referral under the *Environment Protection and Biodiversity Conservation Act 1999* was undertaken in respect of potential impacts upon this bat. Given the information provided, the Project was determined by the Commonwealth Department of Environment to be a 'controlled action' that would require assessment by Preliminary Documentation.

Preliminary Documentation is currently being prepared based on the current understanding that South-eastern Long-eared Bat is not likely to occur within the study area and therefore the project is highly unlikely to have a significant impact on this species.

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3. GLOSSARY OF TERMS

Alignment Options	The geometric form of the centerline (or other reference line) of a carriageway in both the horizontal and vertical directions. For this Project the Alignment Options being assessed include: • *Mid-West option;* • *Mid-West 2A option;* • *Mid-West 2B option; and* • *No Project Option.*
Batter	An artificial uniform slope created on the sides of fills or cuts in road construction. The proposed batters for the Project are 2:1.
Bridge	A bridge is a structure built to cross an obstacle in the road network. The Project comprises bridges across the Campaspe River, the Murray River and some bridging components over the Campaspe/Murray River floodplains.
Construction Environmental Management Plan (CEMP)	A site or project specific plan developed to ensure that appropriate environmental management practices are followed during the construction and/or operation of a Project.
Construction Area	The area defined for the Project that would be directly impacted by construction activities. It typically includes areas where vegetation would be removed and could include site compounds and laydown areas, which are outside the proposed Right-of-Way.
Corridor	A major area of travel between two points. It may include more than one major route and more than one form of transport.
Earthworks	All operations involved in loosening, removing, depositing, shaping and compacting soil or rock.
Environmental Management Framework (EMF)	Outlines the environmental measures recommended to be adopted.
Environment	For the purpose of this report, environment incorporates biological, aspects.
Environment Effects Statement (EES)	A statement prepared at the request of the Victorian Minister for Planning, pursuant to the Victorian *Environmental Effects Act 1978*, on the potential environment impact of a proposed development.
Fill	One or more of the following:

	1. The depth from the subgrade level to the natural surface. 2. That portion of road where the formation is above the natural surface. 3. The material placed in an embankment.
Floodway	An area near a creek or river which takes flood flows.
Freehold land	Privately owned land.
Gradeline	A vertical section, usually with an exaggerated vertical scale, showing the existing surface levels along a road centreline, or other specified line. It commonly also shows the levels to which the road is to be constructed or reconstructed.
Highway	A principal road in a road system with direct property access, such as the Murray Valley Highway.
Initial Alignment	For the purpose of this EES, the initial alignment comprises the construction of a two lane, single carriageway road including a bridge across each waterway.
Intersection	The place at which two or more roads meet or cross.
Land use	The type of development permitted in an area whether it be industrial, commercial, residential, recreational or a combination of some or all of these different uses.
Major Road	A road to which is assigned a permanent priority for traffic movement over that of other roads.
Mid-West Option	The Mid-West option extends from the Murray Valley Highway along Warren Street before diverting to the northwest where it re-joins the Mid-West 2B corridor to the west of Victoria Park Oval. This option then turns north-east to cross the Murray River before extending north to connect with Forbes Street/ Cobb Highway and meets the intersection of Perricoota Road and the Cobb Highway.
Mid-West 2A Option	The Mid-West 2A option extends north/northwest on a new alignment from the intersection of the Murray Valley Highway and Warren Street around the north-west of the Echuca Cemetery before turning northeast towards Reflection Bend on the Murray River. This option then passes immediately south of Reflection Bend and crosses the Murray River to the east/northeast before returning approximately north in alignment with Forbes Street/Cobb Highway and meeting the intersection of Perricoota Road and the Cobb Highway.
Mid-West 2B Option	The Mid-West 2B option extends north/northwest on a new alignment from the intersection of the Murray River Highway

	and Warren Street around the north-west of the Echuca Cemetery before turning north towards the Echuca Sports and Recreation Reserve. This option then turns north/northeast before turning to cross the Murray River in an east/north east direction to immediately north of the Echuca Caravan Park. Finally this option returns approximately north with Forbes Street/Cobb Highway and meets the intersection of Perricoota Road and the Cobb Highway.
Mitigation Measures	Measures which are implemented to reduce an adverse impact caused by road improvement works.
No Project Option	This assumes no additional bridge crossing of the Murray River and assumes existing road conditions and networks remain unchanged.
Project Area	A corridor defined for the Project encompassing the Right-of-Way sufficient for the ultimate duplication and the construction area of each alignment option.
Right-of-Way	The Right-of-Way is a strip of land that is reserved through a planning scheme amendment and encompasses sufficient land to construct the Project. The Right-of-Way comprises the sealed road surfaces (including shoulders / verges) and a 7 metre clear zone either side of the formed road.
Roads and Maritime	Roads and Maritime Services, who are the co-proponent for the Echuca-Moama Bridge EES. Roads and Maritime Services are the NSW state government department responsible for the environmental assessment on the NSW component of the Project.

4. ABREVIATIONS

DEPI - Department of the Environment and Primary Industries (Victoria)

DoE - Department of the Environment (Commonwealth)

EPBC Act - Environment Protection and Biodiversity Conservation Act 1999

EEC - Endangered Ecological Community

EES - Environment Effects Statement

EPA (Vic) - Environment Protection Authority (Victoria)

EPA (NSW) - Environment Protection Authority (New South Wales)

FFG Act - Flora and Fauna Guarantee Act 1988

FM Act - Fisheries Management Act 1994

Roads and Maritime (NSW) - Roads and Maritime Services, New South Wales

SEPP (Vic) - State Environment Protection Policy (Victoria)

SEPP (NSW) - State Environmental Planning Policy (New South Wales)

TSC Act - Threatened Species Conservation Act 1995

5. INTRODUCTION

5.1. Project Background

The existing bridge across the Murray River was built in 1878 and operated as a combined road/rail bridge until 1989. The nearest alternative road crossings are at Barham, 86 km to the west, Barmah 36 km to the east, or Tocumwal 120 km to the east.

The existing road bridge and its approaches have inherent safety and operational limitations including an inability to carry over-width loads and higher mass-limited vehicles used by an increasing proportion of the freight transport industry. Rehabilitation works to upgrade the operational capacity of the bridge would require lengthy road closures and would be further complicated by heritage considerations.

The existing bridge with one lane in each direction also does not provide a suitable level of service for the increased volume of light vehicle traffic experienced during peak summer tourist events. Extensive delays are commonly experienced at these times which are easily exacerbated by any minor traffic incidents. This results in sizeable delays and in particular restricts the movement of emergency services vehicles from one town to the other.

Early investigations to provide for a second Murray River crossing at Echuca-Moama commenced in 1965. Since then, extensive planning investigations have been undertaken. Over the past 15 years, five corridors have been considered for an additional Murray River crossing.

As a result of the investigations completed and stakeholder consultation conducted, significant knowledge has been gained of existing environmental, social and economic conditions and community values in the Echuca-Moama region.

5.2. The Proposal

The Echuca-Moama Bridge Proposal (the 'Proposal') involves the construction and operation of a second road bridge crossing of the Murray and Campaspe Rivers at Echuca-Moama via one of three potential alignment options. The Project options include an elevated roadway and extensive bridging across the Campaspe and Murray River floodplains, as well as changes to existing approach roads.

The Project comprises a Right-of-Way sufficient to build a four lane road and duplicated bridges across both Rivers. Construction of the Project would be staged to meet traffic demands and includes the initial alignment and an ultimate duplication.

The initial alignment comprises the construction of a two lane, single carriageway road including a bridge across each waterway. The ultimate duplication comprises the construction of a duplicated roadway and bridges, which would be constructed when future traffic demand warrants.

5.3. Project Objectives

The Proposal Objectives are to:

- Improve accessibility and connectivity for the community of Echuca-Moama and the wider region;
- Provide security of access between Echuca and Moama;
- To enable cross border access for high productivity vehicles and oversized vehicles;
- Provide road infrastructure that supports:
    - the local and regional economy of Echuca-Moama; and
    - the state and national economies through improved connectivity of goods and services.

5.4. Project Options

This ecological investigation is required to form part of a Review of Environmental Factors as required under Part 5 of the *Environmental Planning and Assessment Act 1979*. This ecological investigation is required to include detailed assessments of the potential effects of the Proposal (and relevant alternatives) on environmental assets and values. The relevant alternatives for the Proposal are three alignment options referred to as:

- Mid-West Option (MW);
- Mid-West 2A Option (MW2A); and
- Mid-West 2B Option (MW2B).

The Proposal comprises three separate alignments within Victoria and one alignment within New South Wales which is common to all options.

The main construction activities associated with the Proposal for all alignment options would comprise:

- Civil and structural works associated with the construction of new elevated roadway and bridges across the Murray and the Campaspe River;
- Construction of earthworks and flood relief structures for the new Link Road across the Murray River and Campaspe River floodplains; and
- Improvements to existing roads and intersections on approaches in Victoria and New South Wales, including the construction of a large diameter roundabout at the Murray Valley Highway / Warren Street intersection and traffic signals with Meninya Street and Perricoota Road in Moama.

5.4.1. Mid-West Option:

The Mid-West option is approximately 4.1 kilometres in length and extends from the Murray Valley Highway along Warren Street before diverting to the northwest where it re-joins the Mid-West 2B corridor to the west of Victoria Park Oval. This option then turns north-east to cross the Murray River before extending north to connect with the Cobb Highway.

5.4.2. Mid-West 2A:

Option 2A is approximately 3.8 kilometres in length and extends north/northwest on a new alignment from the intersection of the Murray Valley Highway and

Warren Street around the north-west of the Echuca Cemetery before turning northeast towards Reflection Bend on the Murray River. This option then passes immediately south of Reflection Bend and crosses the Murray River to the east/northeast before turning north to connect to the Cobb Highway.

5.4.3. Mid-West 2B Option:

Option 2B is approximately 3.8 kilometres in length and extends north/northwest on a new alignment from the intersection of the Murray River Highway and Warren Street around the north-west of the Echuca Cemetery before turning north towards the Echuca Sports and Recreation Reserve. This option then turns north/northeast before turning to cross the Murray River in an east/north east direction to immediately north of the Echuca Caravan Park. Finally this option turns north to connect with the Cobb Highway.

5.5. Proposal Area

The Proposal Area (Figure 1) comprises the proposed Right-of-way for each option. The width of the right-of-way varies due to batters and bridging.

Figure 1: The proposal area

5.6. Study area

The study area for this assessment (Figure 2) encompasses the section of the Mid-West Corridor of the second Murray River Crossing at Echuca-Moama under NSW legislative jurisdiction, which is essentially the proposed construction footprint. The investigation corridor is situated between the Murray River and the Cobb Highway and Perricoota Road intersection in Moama.

Land in the study area is predominantly privately owned and used for passive recreation and falls within the Murray CMA and the Murray Fans CMA sub-region in the Riverina bioregion, and occurs on two Mitchell Landscapes; the Murray Scalded Plains and the Murray Channels and Floodplains. The Local Government Area is the Murray Shire.

The study area was found to be composed of both heavy clay soils and deep fluvial sands on a mostly flat landscape, with the southern half being subject to periodic inundation from the Murray River.

A little over half of the study area supports native vegetation in the form of River Red-gum tall open forest and River Red-gum – Black Box woodland. The balance of the study area includes open roadside areas and private land which, with the exception of 11 scattered indigenous canopy trees, has been cleared of native vegetation.

Metres
0 50 100 200

Legend

Study Area

Figure 2: Study area

Project: Murray River Crossing Echuca

Client: VicRoads

Project No.: 8194	Date: 29/08/2014	Created By: B. MacDonald / M. Ghasemi

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5.7. Legislative context

The primary purpose of this assessment was to identify the potential impacts of the Proposal of ecological values under the following relevant NSW and Commonwealth legislation and policy:

- NSW and Commonwealth legislation:
  - Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act);
  - NSW *Environmental Planning and Assessment Act 1979* (EP&A Act);
  - NSW *Threatened Species Conservation Act 1995* (TSC Act);
  - NSW *Fisheries Management Act* 1994 (FM Act);
  - NSW *Native Vegetation Act 2003* (NV Act);
  - NSW *Noxious Weeds Act 1993* (NW Act); and
  - NSW *National Parks and Wildlife Act 1974* (NP&W Act).
- NSW planning policy:
  - State Environmental Planning Policy (Infrastructure) 2007;
  - State Environmental Planning Policy No. 44 (Koala Habitat);
  - State Environmental Planning Policy No. 14 - Coastal Wetlands; and
  - State Environmental Planning Policy No. 26 - Littoral Rainforests.

These are discussed in the following sections.

5.7.1. Commonwealth Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) protects a number of threatened species and ecological communities that are considered to be matters of national environmental significance. Any significant impacts on these matters require the approval of the Australian Minister for the Environment.

If there is a possibility of a significant impact on matters of national environmental significance, a Referral under the EPBC Act should be considered. The Minister will decide after 20 business days whether the project will be a 'controlled action' under the EPBC Act, in which case it cannot be undertaken without the approval of the Minister. This approval depends on a further assessment and approval process (lasting between three and nine months, depending on the level of assessment).

5.7.2. NSW Environmental Planning and Assessment Act 1979

The Proposal will be assessed under Part 5 of the EP&A Act, which requires an assessment of threatened flora and fauna and their habitats that are likely to occur within the study area, or that may be indirectly affected by the constructional and operational aspects of the Proposal.

The assessment must address whether or not the Proposal is likely to have a significant impact on ecological values which are likely to occur in or adjacent the study area, which informs whether or not an Environmental Impact Statement or Species Impact Statement is required. The relevant regulatory authority would then decide on those requirements based on consideration of the potential effects of activities relating to the Proposal on the following listed values:

- Threatened species, populations and ecological communities listed under the TSC Act and/or FM Act, and whether there is likely to be a significant impact on those values in accordance with Section 5A of the EP&A Act;
- Critical habitats listed under the TSC Act and/or FM Act; and
- Any values listed under the NP&W Act.

5.7.3. NSW Threatened Species Conservation Act 1995

The TSC Act lists threatened species, populations and ecological communities that require a significance assessment under section 5A of the EP&A Act.

Section 5A of the EP&A Act sets out seven criteria (the 'Seven Part Test') that determines whether a Species Impact Statement should be prepared under the TSC Act for a development. The aim of the Seven Part Test is to ascertain whether a proposed project is likely to lead to a significant impact on a threatened species or community that requires more detailed assessment under the TSC Act, in the form of a Species Impact Statement.

5.7.4. NSW Fisheries Management Act 1994

The FM Act lists threatened fish, aquatic invertebrates, marine vegetation and ecological communities and provides policy and guidelines to aid in their conservation and recovery. It also provides policy and guidelines for the identification and management of key threatening processes which affect threatened species.

Any dredging or reclamation works required as part of the Proposal would require the approval of the NSW Minister for Primary Industries.

5.7.5. NSW Native Vegetation Act 2003

Development consent is not required under the NV Act for the Proposal, as it will be assessed under Part 5 of the EP&A Act.

5.7.6. NSW Noxious Weeds Act 1993

Under the NW Act, all listed noxious weeds in the relevant council area must be controlled to the level stated on the NSW Department of Primary Industries (DPI) Noxious Weeds database (Appendix 3).

5.7.7. NSW National Parks and Wildlife Act 1974

The NP&W Act provides policy and guidelines for the care, control and management of all NSW national parks, historic sites, nature reserves, reserves, Aboriginal areas and state game reserves, State conservation areas and the biological, cultural and historical values within those reserves.

5.7.8. State Environmental Planning Policy (Infrastructure) 2007

The New South Wales State Environmental Planning Policy (Infrastructure) 2007 (ISEPP) aims to facilitate effective delivery of infrastructure across the State. Clause 94 of ISEPP permits development on any land for the purpose of a road or road infrastructure facilities to be carried out by or on behalf of a public authority without consent.

As the proposal is for the construction of new road infrastructure and is to be carried out by Roads and Maritime, it is assessed under Part 5 of the EP&A Act and development consent from council is not required.

5.7.9. State Environmental Planning Policy No. 44 (Koala Habitat)

State Environmental Planning Policy No. 44 requires Councils to take into consideration impacts on the Koala before taking a decision about a proposed project. Specifically, it "aims to encourage the proper conservation and management of areas of natural vegetation that provide habitat for koalas to ensure a permanent free-living population over their present range and reverse the current trend of koala population decline".

Murray Shire is listed in Schedule 1 of this SEPP as a shire to which the policy applies.

The policy identifies Koala habitat as either:

- "**Core koala habitat** is an area of land with a resident population of koalas, evidenced by attributes such as breeding females (that is, females with young) and recent sightings of and historical records of a population; or
- **Potential koala habitats** are areas of native vegetation where the trees of the types listed in Schedule 2 constitute at least 15% of the total number of trees in the upper or lower strata of the tree component."

5.7.10. Other State Environmental Planning Policies

The Proposal may also have implications under the following policies and guidelines:

- State Environmental Planning Policy No. 14 - Coastal Wetlands; or
- State Environmental Planning Policy No. 26 - Littoral Rainforests.

5.8. Purpose of this report

Roads and Maritime engaged Brett Lane & Associates Pty. Ltd. (BL&A) to prepare an ecological assessment of the portion of the Second Murray River Crossing at Echuca – Moama Project which falls under NSW legislative jurisdiction. This report was required to form part of a Review of Environmental Factors, as required under Part 5 of the *Environmental Planning and Assessment Act 1979*, and considers the potential impacts of the Proposal relative to Commonwealth and New South Wales legislative requirements.

The ecological investigation was undertaken in accordance with Roads and Maritime Environmental Planning and Assessment Practice Note - Biodiversity assessment (EIA-NO6) (Roads and Maritime Services 2011a), and is based on a review of the following existing reports:

- Echuca Bridge Planning Study - Mid West 2 Option Aquatic Flora and Fauna Assessment, GHD, 2013;
- Mid-West 2 Murray River Crossing at Echuca-Moama Matters of National Environmental Significance, Brett Lane and Associates, 2013; and
- Mid-West 2 Murray River Crossing at Echuca-Moama Detailed Flora, Fauna, Native Vegetation and Net Gain Assessment, Brett Lane and Associates, 2013.

This investigation was undertaken by a team from BL&A, comprising Khalid Al-Dabbagh (Zoologist), Curtis Doughty (Zoologist), Peter Lansley (Senior Ecologist), Brett Macdonald (Senior Ecologist), Bill Wallach (Botanist), Justin Sullivan (Senior Ecologist & Project Manager) Alan Brennan (Senior Ecologist & Project Manager) and Brett Lane (Principal Consultant).

6. METHODOLOGY

6.1. Literature review and database searches

6.1.1. Existing reporting and documentation

The following reports relating to the study area were reviewed; these formed the basis of this assessment:

- Echuca Bridge Planning Study - Mid West 2 Option Aquatic Flora and Fauna Assessment (GHD, 2013);
- Mid-West 2 Murray River Crossing at Echuca-Moama Matters of National Environmental Significance, Brett Lane and Associates (BL&A 2013a); and
- Mid-West 2 Murray River Crossing at Echuca-Moama Detailed Flora, Fauna, Native Vegetation and Net Gain Assessment, Brett Lane and Associates, (BL&A 2013b).
- Brett Lane & Associates (BL&A) 2015d, Second Murray River Crossing, Echuca-Moama: Squirrel Glider Habitat Linkage Strategy, Report No. 8194 (18.1), consultants report prepared for Roads and Maritime Services, Brett Lane and Associates Pty Ltd, East Hawthorn, VIC. (see Appendix 10)

6.1.2. Database searches

Search region

The search region for the following database searches was an area of radius ten kilometres from the approximate centre point of the study area - coordinates: latitude 36˚ 06’ 47” S and longitude 144˚ 44’ 36” E.

Matters of national environmental significance (Commonwealth)

The likelihood of suitable habitat in the study area for nationally threatened ecological communities, flora and fauna species was ascertained on the 12 November 2012 through a search of the online EPBC Act Protected Matters Search Tool (PMST) (DSEWPC 2011) using the search region defined above. A follow up search of the PMST (Department of the Environment 2015) was carried out on the 17th June 2015 to determine the validity of the 2012 search. For the purpose of expediency, the 2012 PMST Report is not included in this assessment, it is provided as Appendix 10 in BL&A 2013b. The 2015 PMST Report is provided in this report as Appendix 1.

Matters of State significance (NSW)

Flora

A list of flora species recorded in the search region was obtained from the Atlas of New South Wales Wildlife (ANSWW) on the 22nd November 2011, a database administered by the Office of Environment and Heritage (OEH) (OEH 2011). This database search listed all plant species, including rare and threatened plants found in the search region (see Appendix 12 in BL&A 2013b). A follow up search of the ANSWW (OEH 2014) was carried out on the 6th August 2014 to determine

the validity of the 2011 search. The results of this search are presented in Appendix 2.

A search of the NSW DPI Noxious Weeds database was also undertaken for this assessment, the results of which are presented in Appendix 3.

Note: a search of the Primary Industries Records viewer was not undertaken for any of the BL&A assessments to date.

Fauna

A list of the fauna species recorded in the search region was obtained from the following sources:

- ANSWW viewed on the 3rd November 2011, administered by the OEH (see Appendix 14 in BL&A 2013b), and then reviewed on the 6th August 2014 (Appendix 4);
- The New Atlas of Australian Birds viewed on the 22nd September 2011, administered by Birds Australia (see Appendix 15 in BL&A 2013b); and
- Threatened and Protected Fish Species Records Viewer (TPFSRV) viewed on the 8th January 2013, a database administered by the NSW Department of Primary Industries (DPI).

Note that a follow up current search of the New Atlas of Australian Birds database was not performed as part of this assessment.

Endangered flora and fauna populations

A search of the ANSWW for endangered flora and fauna populations recorded in the search region was conducted on the 6th August 2014.

Endangered ecological communities

A list of endangered ecological communities recorded in the search region was obtained from the ANSWW on the 6th August 2014. This is provided as Appendix 5

Critical habitats

A search of the Critical Habitat Register (OEH 2013a) for listed critical habitats recorded in the search region was conducted on the 6th August 2014.

6.2. Field survey methodology

6.2.1. Flora

The flora field assessment was undertaken over five days from 26th to 30th September, 2011, concurrently with the site assessment of the Victorian component of the greater study area. The primary aims of the flora assessment was to collate an species inventory to ascertain which threatened species were present in the study area, to inform which vegetation communities were present and what threatened flora species may occur and in which vegetation type.

During this assessment, the entire study area was inspected in detail on foot. Sites in the study area found to support native vegetation and/or habitat for rare or threatened flora were mapped. Mapping was undertaken through a

combination of aerial photograph interpretation and ground-truthing using a hand held GPS (accurate to approximately five metres).

Incidental records of flora species within vegetation types and landforms were made whilst conducting field work. Specimens requiring identification using laboratory techniques were collected by botanists from BL&A.

The methodology employed for the assessment was consistent with the OEH's threatened species field survey methods (OEH 2013b) and the Threatened species survey and assessment guidelines (DECC 2008).

6.2.2. Native vegetation assessment

The native vegetation assessment was undertaken over five days from 26th to 30th September, 2011, concurrently with the site assessment of the Victorian component of the greater study area. The methodology employed for the assessment was consistent with the OEH's threatened species field survey methods (OEH 2013b) and the Threatened species survey and assessment guidelines (DECC 2008).

Stratification

Vegetation community stratification was based on recent aerial photography and ground-thruthing via systematic traverses of the study area on foot. Vegetation in the study area was stratified by OEH Biometric Vegetation type.

Vegetation classification and condition

Existing information regarding native vegetation classification within the Murray Catchment Management Authority (CMA) was sourced from various databases incorporated in BioMetric 2.0, a tool that supports the Biobanking Assessment Methodology (DECC 2008). This tool works alongside separate tools for assessing threatened species, soils, water quality, salinity and invasive native scrub.

Native vegetation in New South Wales is classified using three hierarchical levels:

- Formations – Broad classification of vegetation (e.g. Rainforest, Grassland, Grassy Woodland).
- Classes – Detailed classification of vegetation based on geographical range and indicative species (e.g. Northern Warm Temperate Rainforest, Western Slopes Grassland, New England Grassy Woodlands).
- Types – Further classification of vegetation classes based on the dominant canopy species, characteristic mid- and understorey species and landscape position (e.g. Norton's Box - Red Box - White Box grassy open forest of the southern section of the NSW South Western Slopes Bioregion).

Vegetation formations and classes are outlined in Keith (2006). Information on vegetation types was sourced from the BioMetric Vegetation Type tool.

During the site inspection, existing vegetation was classified to type and mapped (using aerial photograph interpretation and ground-truthing) within the study area as per the criteria outlined in the Biobanking Assessment Methodology (DECC 2008).

Each vegetation type was further stratified by vegetation condition into discreet, relatively homogeneous vegetation units as per the following condition criteria:

- **High**: Native floral species diversity and structural characteristics similar to pre-European equivalent (near benchmark state). Relative to benchmark: native flora diversity is high; native overstorey cover, mid-storey cover and ground cover are relatively intact; hollow-bearing trees and fallen logs are present near benchmark values; weed cover is low.
- **Moderate**: Native floral species diversity and structural characteristics differ from pre-European equivalent (benchmark state) due to disturbance where some components have been degraded or lost. Relative to benchmark: native flora diversity is moderate; native overstorey cover intact, though native mid-storey cover and/or ground cover are degraded (outside benchmark limits) or largely absent; hollow-bearing trees and fallen logs maybe present; weed cover is moderate to high.
- **Low**: Significantly modified vegetation, where most components differ markedly from pre-European equivalent (benchmark state) due to disturbance where most components have been degraded or lost. Relative to benchmark: native flora diversity is low to moderate; native overstorey cover partially intact, and native mid-storey cover and/or ground cover are highly degraded (well outside benchmark limits) or absent; hollow-bearing trees and fallen logs maybe present; weed cover is generally high.

Note: 'Benchmark' refers to vegetation condition benchmarks for individual vegetation types, which are quantitative measures that describe the range of variability in condition in vegetation which is largely unaltered from it assumed pre-European state.

6.2.3. Tree surveying

The locations of all scattered paddock trees in the study area were mapped using a handheld GPS.

A systematic search was conducted on the 17th October 2012 for hollow-bearing trees in the study area, along transects spaced approximately 15 metres apart. All identified hollow-bearing trees were mapped using a hand-held GPS unit (accuracy approximately +/- 5 metres), and the number, nature and size of the hollows was recorded.

6.2.4. Threatened ecological communities

The presence of threatened ecological communities in the study area was assessed against the relevant National and State descriptions and selection criterion, provided by the Federal Department of the Environment (DoE) and the OEH.

6.2.5. Fauna

The following techniques were used to detect fauna species inhabiting the study area.

Direct search and observations during initial assessment

This included traversing the study area during the day searching for and recording fauna species; this effort included the following:

- Bird observation during the day;
- The diurnal bird surveys concentrated on detecting or finding threatened species with emphasis on threatened bird species such as the Brown Treecreeper and the Bush Stone–Curlew;
- Incidental searches for mammal scats, tracks and signs (e.g. diggings, signs of feeding and nests/burrows);
- Turning over logs and other ground debris for reptiles, frogs and mammals;
- General searches for reptiles and frogs; including identification of frog calls in seasonally wet areas;
- General searches for bat habitat including water bodies and potential roosting sites such as dead trees with hollows and underneath bark of trees;
- Inspection of hollows and canopies of River Red-gums using binoculars for signs of active nesting or occupation by arboreal mammals.

Spotlighting during initial assessment

Spotlighting was undertaken on the evening of the 26th and the 27th September 2011 and as follows;

- Within the River Red-gum forest, close to the Murray River, in the study area corridor. A total of four person hours was spent spotlighting;

Spotlighting was mainly targeted at finding nocturnal arboreal mammals likely to be present in the study area with particular emphasis on Squirrel Gliders.

Call playback during initial assessment

Call playback for the Bush Stone–Curlew was undertaken in the same woodland where spotlighting took place (described above). The call of the curlew was played several times, interspersed with listening periods.

Call playback for the Southern Bell Frog was also undertaken at a billabong in River Red-gum woodland in the study area.

Call playback was not undertaken for the threatened owls, as the time of the initial investigation was not appropriate for owls and might cause disruption of their breeding activities. This was delayed until November, after the most sensitive period of the breeding season has passed.

Trapping during initial assessment

Two types of mammal traps were employed from the 26th to 30th September 2011 as part of the initial survey work; Elliot traps and Hair Tube traps. Trapping was carried out as follows:

- A line of ten hair tubes placed at ten metre intervals within the River Red-gum woodland, mostly placed on the main tree trunks.

- A line of ten small Elliot traps placed at ten metre intervals within a small regrowth section of River red-gum close to the above hair tubes site;
- A line of ten large Elliot traps placed at ten metre intervals at another section of the River Red-gum woodland; and
- Another line of five hair tubes placed on tree trunks close to the large Elliot traps.

Habitat assessment

Fauna habitat types were characterised in the study area and are described in Section 7.3.1. The quality of fauna habitat was assessed based on the criteria detailed below. These are based on habitat components which include old-growth trees, fallen timber, leaf litter, surface rocks. Three quality categories were used, as described below:

High: The majority of fauna habitat components are present and habitat linkages to other remnant ecosystems in the landscape are intact.

Moderate: The majority of fauna habitat components are present but habitat linkages to other remnant ecosystems in the landscape are absent; or

The majority of habitat components are absent but habitat linkages to other remnant ecosystems in the landscape are intact.

Low: The majority of fauna habitat components are absent and habitat linkages to other remnant ecosystems in the landscape are absent.

6.2.6. Aquatic habitat assessment

The Roads and Maritime Environmental Assessment Practice Note (2011a) required a detailed description of aquatic habitat in the study area, which documented the following attributes of such habitat:

- Dimensions of waterway;
- Depth of water;
- Flow characteristics of water;
- Bed substrate;
- Habitat features;
- Existing infrastructure and barriers to fish movement;
- Width and species composition of riparian vegetation, with particular attention paid to mangroves; and
- Flora and fauna species present.

The results of this assessment have been provided in Section 7.

In addition to the aquatic habitat assessment a search for Threatened Ecological Communities, related to aquatic fauna communities, listed under the *Fisheries Management Act 1994* (FM Act) was undertaken.

6.2.7. Targeted Flora and Fauna Surveys

Flora survey

Targeted flora surveying was undertaken over three days from 21st to 23rd November 2011. During the targeted flora assessment, areas of suitable habitat identified in the initial survey were walked by two botanists along transects spaced 5 metres apart throughout the entire study area. This was consistent with the survey guidelines prescribed in 'Threatened species survey and assessment guidelines for developments and activities (working draft)' (Department of Environment and Conservation 2004).

Targeted flora species were undertaken on the species that were initially considered likely to occur due to presence of suitable habitat and included the following:

- Slender Darling-pea;
- Small Scurf-pea;
- River Swamp Wallaby-grass; and
- Western Water Starwort.

Fauna surveys

A large amount of additional targeted fauna surveying work was undertaken between 2011 and 2012. Threatened species that could potentially be impacted by the proposed development and that were considered likely to occur due to the presence of suitable habitat were targeted to gain more information on whether they utilise the study area or otherwise.

Details on the methodology employed for each targeted survey are provided below, and locations of the surveys are presented Figure 3.

Targeted fauna surveys comprised:

- Hair tube trapping for Squirrel Glider: 08/11/2011 to 22/11/2011;
- Spotlighting and call playback for Bush Stone-curlew, Squirrel Glider and Barking Owl: 08/11/2011 to 17/11/2011;
- First bat survey: 08/11/2011 to 22/11/2011;
- Second bat survey: 24/02/2012 to 14/03/2012;
- Southern Bell Frog survey: 17/10/2012 to 18/10/2012;
- Arboreal cage trapping for Squirrel Glider: 15/10/2012 to 18/10/2012; and
- Hollow-bearing tree survey, particularly for potential Squirrel Glider habitat: 17/10/2012.

Note that all targeted survey work was undertaken at the appropriate time of year for the relevant species. Surveying was undertaken under the following permit:

- New South Wales National Park and Wildlife Service: National Parks & Wildlife Act 1974, Section 132c – Scientific Licence – Document No. SL100136.

- Additional intensive survey work targeting the Squirrel Glider was carried out by the Australian Research Centre for Urban Ecology (ARCUE), from 16/03/2015 – 27/03/2015 (van der Ree et al. 2015) — see Appendix 8.

Hair tube trapping survey

Hair tube trapping was used to investigate, in more detail than previously used in the initial fauna survey (see above), the presence and use of the study area by Squirrel Glider. Hair tube trapping was carried out in November 2011, at a higher survey effort than employed during the initial field survey. For this purpose, hair tubes were used and set up on trees targeting arboreal mammals.

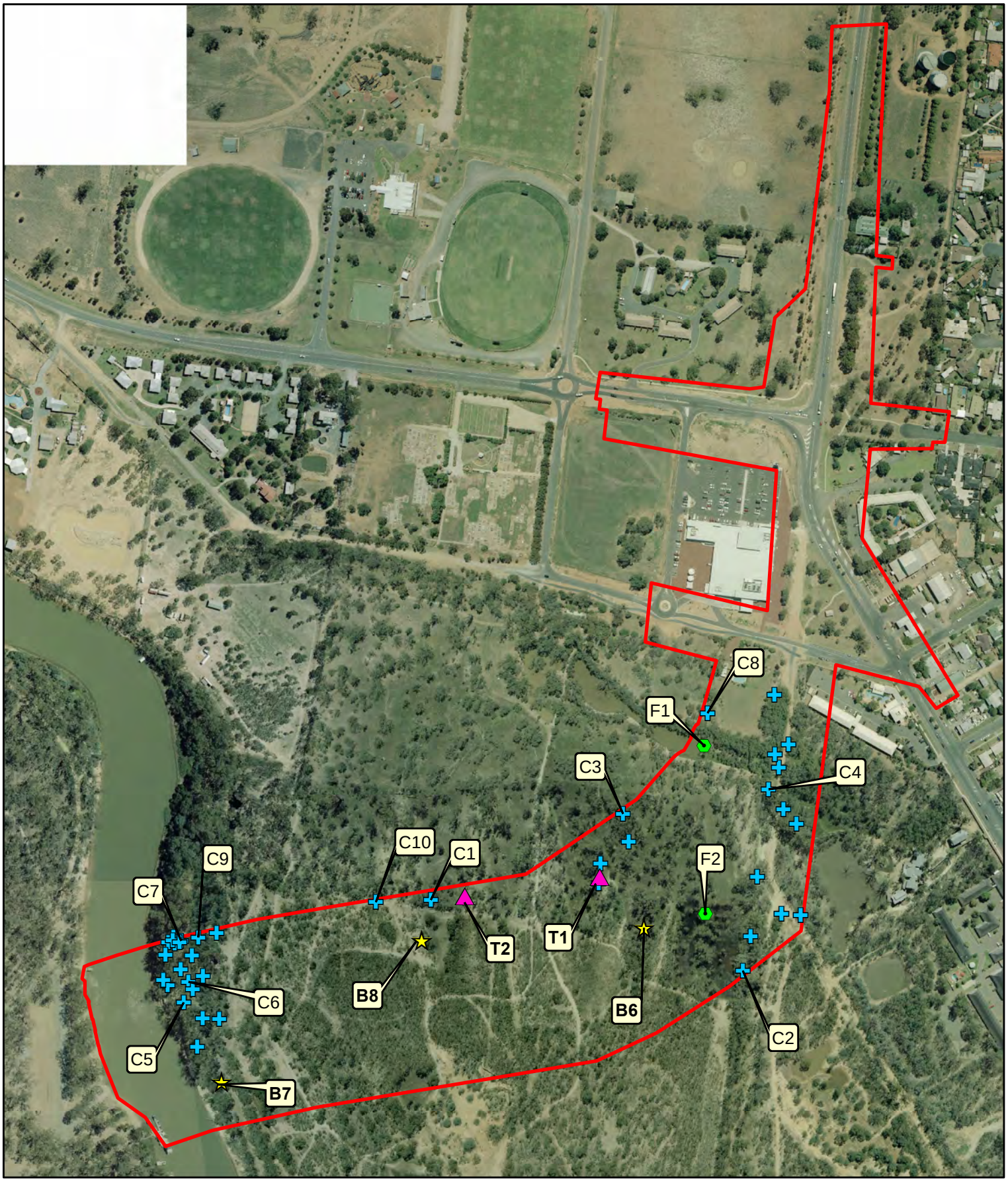
Hair tube traps were set up along two transects as part of the additional targeted surveying. The central point of each of the 50 metre transects is presented Figure 3. The transects comprised two lines of 10 hair tubes each, set up in River red-gum forest; Transect 1 in relatively young forest (see Figure 10 for habitat type), and Transect 2 in more mature forest, with several large old trees.

Hair tube traps were set up on the trunks of trees spaced at five metre intervals and were at least 1.5 metres above ground.

Hair tube traps were collected, and hair harvested during the survey was analysed by Hans Brunner, an internationally recognised expert on mammalian hair analysis.

Call playback and night spotlighting

Detailed targeted surveys of the Bush Stone–Curlew and Barking Owl were undertaken on five different nights at five selected sites within the study area. The surveys were carried out between the 8th and 17th November, 2011. During each of the five survey nights, the threatened species were surveyed consecutively starting with the Bush Stone–Curlew and followed by Barking Owl. Surveys were undertaken following the guidelines in 'Threatened species survey and assessment guidelines for developments and activities (working draft)' (Department of Environment and Conservation 2004), except for the Bush Stone–Curlew for which such guidelines were not available.



Legend

- Study area
- Anabat locations (Bat Survey Sites)
- Mammal trapping locations (Hair Tubes)
- Mammal trapping locations (Aerial Cage Traps)
- Growling Grass Frog Survey Sites

0 75 150 300 Metres

Figure 3: Targeted Fauna Survey Locations

Project: Murray River Crossing Echuca

Client: VicRoads

Project No.: 8194	Date: 29/08/2014	Created By: J. Sullivan / M. Ghasemi

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N

Survey methods used for the Plains Wanderer were adopted for this species. Spotlighting was also undertaken for Squirrel Glider.

Surveys were conducted from dusk to midnight during mild to warm weather conditions. Under these conditions, threatened species were more likely to be active, making detection easier. All animals observed during the survey were identified and recorded. Methods followed in each of the surveys are outlined below.

Bush Stone–Curlew

On first arrival at each site, the call of the Bush Stone–Curlew was played through a megaphone in an effort to elicit the response of this species. Following the ten minute call playback and listening time, each site was systematically searched for the species using transects.

The surveyor walked the length of each transect, situated 40 metres apart with a search area of 10 metres either side of the transect line. Transect length depended on the size of native vegetation patch. Each transect was searched for Bush Stone–Curlew using a hand-held spotlight and binoculars.

Barking Owl

Consistent with 'Threatened species survey and assessment guidelines for developments and activities (working draft)' (Department of Environment and Conservation 2004), the following steps were followed during the Barking Owl surveys:

- 5 minutes initial passive listening,
- 20 seconds call playback,
- 30 seconds silent listening for elicited response,
- 1 minute call-playback in different direction,
- 30 seconds listening for elicited response,
- 1 minute call-playback in different direction,
- 12 minutes silent listening.
- After call playback, a 30-minute spotlighting session was conducted within 200 metres to check trees for any owls while listening for a distant response.
- Spotlighting concentrated on large hollow-bearing trees that may also support tree-dwelling mammals, such as possums and gliders.
- A hand-held spotlight with powerful beam was used.

In addition to above, active diurnal searches were also made to locate evidence of whitewash or regurgitated pellets to determine owl presence in the study area and evaluation of the presence and abundance of suitable hollows that might provide suitable nesting habitat for the owls.

Squirrel Glider

During the 2012 field work, representative transects were searched for Squirrel Glider after dusk using spotlights. Transects were spaced at 50 metres apart through likely habitat, and spotlighting was conducted for 30 minutes at each transect.

Additional targeted surveys were carried out by the Australian Centre for ARCUE in March 2015. These detailed targeted surveys covered nine sites within or near to the mid-west alignment, and six sites of other potential habitat along the Murray River vegetated corridor within 5 km of the alignment, A total of 1068 trap-nights' effort was expended in the search (van der Ree et al. 2015) — see Appendix 8.

Bat surveys

Bats were surveyed using electronic detectors to record the ultrasonic echolocation calls of bats. Detectors offer several major advantages over trapping or other means of detection; they are non-invasive, can add significantly to the number of species detected at a particular site, allow detection of species not readily captured, and in many cases, do not need to be attended constantly. In Australia, the Anabat system (Titley Electronics) is the most widely used system. Anabat detectors are especially well suited for unattended detector surveys, with several options available for storing recorded calls. The survey methodology employed was consistent with the guidelines prescribed in:

- Threatened species survey and assessment guidelines for developments and activities (working draft) (Department of Environment and Conservation 2004); and
- The Federal *'Survey guidelines for Australia's threatened bats'* (DEWHA 2010b).

Automated Anabat Systems

Automated Anabat® (Titley Electronics, Ballina, NSW) bat detectors that record the species-specific echolocation calls of free-flying bats are used at a series of sampling points that are representative of the habitats in the proposed study area. The detectors are programmed to commence operation approximately 30 minutes before dusk, and to cease approximately 30 minutes after dawn.

Calls from the units are downloaded and sent to Dr Greg Richards (Greg Richards and Associates Pty Ltd, Canberra), for identification.

Call identification is based on a key developed by comparing the characteristics of bat search calls within reference calls from known species recorded across NSW. Identification is largely based on changes to frequency patterns over time, especially as the characteristic frequency changes. Only those recordings that contained at least two definite and discrete calls were classified as bat calls. For most species, a call sequence of several seconds in duration is required before identification can be made confidently.

The identification of echolocation calls from microbats in south-eastern Australia is facilitated by the fact that many calls are species-specific. However, not all species can be consistently or reliably identified. There is a large overlap in the call characteristics of some NSW species and many calls are attributable only to species "complexes" and not to single species.

A significant limitation in the use of this technique is that it is not possible to census bats accurately. That is, the Anabat unit may record 10 calls of a particular species but it is not known if this represents 10 individuals or one individual flying past 10 times. Therefore, it is not possible to determine utilisation rates as it is for birds.

Sites and times of recording

Two bat surveys were undertaken within the study area, the first during November 2011 and the second survey across February and March 2012. Three sites were selected for bat recordings and the same sites were used for both surveys. Sites were selected to reflect the various habitats existing in the study area.

First Bat Survey

During the first bat survey, Anabat recording was left for seven nights in the field for each of the sites, between the 15th and the 22nd November, 2011.

The locations of the recording sites are shown in Figure 3. Anabat recorders were located in the following habitats:

- Site 6: Set up among River Red-gum forest.
- Site 7: Set up on the banks of the Murray River among large and tall River Red-gum trees.
- Site 8: Set up among River Red-gum forest.

Second Bat Survey

Following the results of the initial bat survey, it was decided a second bat survey would be undertaken to provide further information of the abundance of particular species. During the second bat survey; the same three sites were used to record bats as were used in the first survey (described above). Recording during the second survey was carried out between 5th and 14th March, 2012. Unlike the first survey, the Anabat recorders were left for ten nights in the field at each of the recording sites.

This extended survey period was recommended by Dr Greg Richards (Greg Richards and Associates Pty Ltd, Canberra) as to provide additional information on the presence and abundance of threatened bat species.

Southern Bell Frog targeted survey

The Southern Bell Frog targeted survey was carried out in accordance with the following published survey guidelines:

- Federal 'Survey guidelines for Australia's threatened frogs' (DEWHA 2010a);
- OEH's 'Threatened species survey and assessment guidelines for developments and activities (working draft)' (Department of Environment and Conservation 2004); and
- OEH's 'Threatened species survey and assessment guidelines: field survey methods for fauna (amphibians)' (DECC 2009).

The survey was undertaken on two consecutive nights: 17th and 18th October 2012. Prior to commencing surveying, wetlands with potential to support Southern Bell Frog were examined to identify suitable survey locations. Two sites were selected based on their likelihood for supporting Southern Bell Frog.

The surveys were conducted at night during warm weather conditions where temperatures were not lower than 14°C with moderate to no wind. Under these conditions, frogs are more likely to be calling and active, making detection easier. For each survey, weather conditions were recorded throughout the survey,

including ambient temperature, wind strength and cloud cover / presence absence of precipitation.

Two survey methods were employed: call playback and active searches.

On first arrival at a site, 15 minutes was spent listening for frog calls and all frog species heard calling were noted. After the first five minutes, the call of the Southern Bell Frog was played through a megaphone in an effort to elicit the response of this species.

Following the 15 minute frog call playback and listening time, each site was systematically searched for frogs with a spotlight for 30 minutes. This involved visual inspection of the water body, call recognition and limited active searching (including turning surface debris). All frog species seen or heard during the search time were recorded.

Additional data was collected when Southern Bell Frog was detected at a survey site. This data included age class and microhabitat.

In addition to Federal guidelines, the OEH guidelines require Southern Bell Frog tadpole surveying be carried out in conjunction with call playback and visual searches.

Tadpole surveying was carried out in suitable aquatic habitat in accordance with OEH's survey and assessment guidelines for threatened amphibians (DECC 2009). The specific method applied was dip-netting adjacent to the vegetated margins of suitable wetlands at various depths in the water column. Dip-netting was carried out both night and day on two consecutive days; the 7th and 8th October 2012.

Arboreal cage trapping for Squirrel Glider

Arboreal cage trapping for Squirrel Glider was recommended by Envirokey (2012) as a more suitable method of trapping the species than the large 'Elliot' traps and hair tube traps previously employed (see above). Arboreal cage trapping was carried out in accordance OEH's 'Threatened species survey and assessment guidelines for developments and activities (working draft)' (Department of Environment and Conservation 2004), which require a minimum survey effort of 24 trap-nights over three to four consecutive nights per 50 hectares of suitable habitat.

Arboreal cage trapping was conducted on four consecutive nights between the 15th and 18th October 2012, using ten standard cage traps. This equated to a survey effort of 40 trap-nights. Each cage trap was affixed to a suitable Squirrel Glider habitat tree at a height of between two to three metres from the ground, with the trap entrances easily accessible from either the tree trunk or a branch.

The suitability of trees chosen for the traps was based on the following criteria:

- Preference for trees with suitable hollows and evidence of sap feeding sites; and
- Preference for habitat supporting *Acacia* species in the understorey.

Additional intensive cage trapping for Squirrel Glider (van der Ree et al. 2015)

Further detailed work was carried out targeting the Squirrel Glider, from 16th to 27th March, 2015).

This survey comprised setting cage traps on trunks of trees at heights of 3-5 metres above ground level. Usually, large or hollow-bearing trees were used as trap sites. Traps were spread in clusters of five to 33 over 15 sites, nine close to or within the mid-west alignment, and six farther away, but still within 5 km of the alignment and within the contiguously-vegetated corridor of the Murray River. Traps were set for seven nights (inner zone near the mid-west alignment) or five nights (outer zone). Trapping was avoided on weekends in areas close to recreational areas with high activity.

A total of 1068 trap-nights survey effort was expended.

Full details of this survey are presented in van der Ree *et al*. (2015).

6.3. Survey effort

Survey effort for each relevant environmental matter covered by this assessment is described above for each survey undertaken. The survey effort for all surveys undertaken was consistent with the guidelines prescribed in;

- Environmental Planning and Assessment Practice Note - Biodiversity assessment (EIA-NO6) (Roads and Maritime Services (Transport Department) 2011a); and
- Threatened species survey and assessment guidelines for developments and activities (working draft) (Department of Environment and Conservation 2004).

It should be noted that much of the survey work carried in 2011 pre-dated the Environmental Planning and Assessment Practice Note - Biodiversity assessment (EIA-NO6).

6.4. Limitations of field assessments

Where feasible, all efforts are made to schedule flora and fauna field surveys in optimal weather conditions and times of year. Nevertheless, field surveys usually fail to record all species present for various reasons, including the seasonal absence of some species and short survey duration. Rare or cryptic species are often missed in short surveys.

Initial flora surveying was carried out in early spring, when many later spring or summer-emergent plant species may have been absent or in the senescent stage of their life-cycle and lacking essential identification characteristics. The timing of the initial survey and condition of vegetation was otherwise considered suitable to ascertain the extent and quality of native vegetation. Targeted flora surveys were then undertaken in late spring within the known flowering time for these species. The timing of the targeted flora survey was therefore considered suitable to ascertain the presence or otherwise of the targeted flora species.

The initial fauna assessment was undertaken during mild to warm weather conditions. These conditions were considered suitable for detecting all groups of fauna likely to occur in the study area; however, many of the fauna species are

highly cryptic and are difficult to detect. Targeted fauna surveying was undertaken in mid-late spring when the targeted species are known to be detectable. The timing and survey effort of the targeted fauna surveys was therefore considered suitable to ascertain the presence or otherwise of the targeted fauna species.

The outer limit of works governed by the detailed design was provided from VicRoads in June 2012. On review of this data, some small areas within the alignments fell just beyond the surveyed corridor. These small areas have since been included in the current assessment based on a combination of additional survey effort in July 2012, earlier field assessments and aerial photo interpretation.

During this assessment, the local and regional significance of listed threatened matters was not comprehensively investigated and may require further work.

As the primary purpose of the investigation was to assess the extent and classification of native vegetation, the extent and quality of fauna habitats in the study area, the presence or likely presence of listed threatened species and/or ecological communities, and any potential impacts on those values, the review of existing information, combined with the field surveys was sufficient to complete this aspect of the assessment.

Wherever appropriate, a precautionary approach has been adopted in the discussion of implications. That is, where insufficient evidence is available on the occurrence or likelihood of occurrence of a species, it is assumed that it could be in an area of suitable habitat. The implications under legislation and policy are considered accordingly.

7. EXISTING ENVIRONMENT

7.1. Study Area

The study area for this investigation (Figure 2) encompasses the section of the Mid-West Corridor of the second Murray River Crossing at Echuca-Moama under NSW legislative jurisdiction. The investigation corridor is situated between the Murray River and the Cobb Highway and Perricoota Road intersection in Moama. A little over half of the study area supports native vegetation in the form of River Red-gum tall open forest and River Red-gum – Black Box woodland. The balance of the study area includes open roadside areas and private land which, with the exception of 11 scattered indigenous canopy trees, has been cleared of native vegetation.

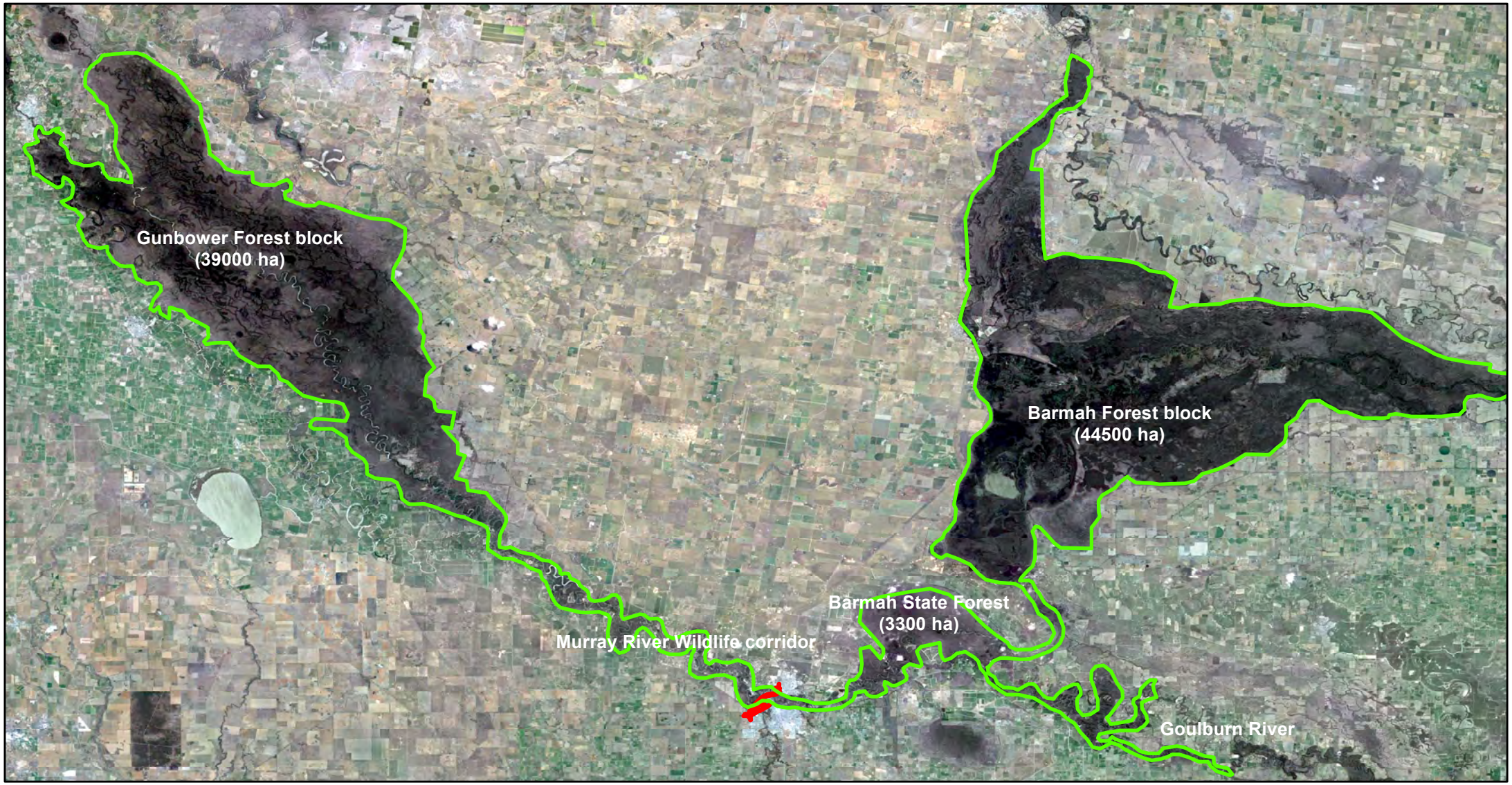
The study area for the investigation comprises both freehold private land, which includes the large area of bushland in the south, and public land.

The study area was found to be composed of both heavy clay soils and deep fluvial sands on a mostly flat landscape, with the southern half being subject to periodic inundation from the Murray River.

The study area falls within the Murray CMA and the Murray Fans CMA sub-region in the Riverina bioregion, and occurs on two Mitchell Landscapes; the Murray Scalded Plains and the Murray Channels and Floodplains. The Local Government Area is the Murray Shire.

7.1.1. Wildlife Connectivity and corridors

Aerial photography reveals that the native vegetation in the study area constitutes part a long and often tenuous wildlife corridor between two very large and important areas of native vegetation: to the north-east, the 'Barmah block' (approximately 44500 hectares), which comprises Barmah National Park (NP), Moira NP, Murray Valley NP, Gulpa Island NP and Tuppel NP; to the north-west, the 'Gunbower block' (approximately 39000 hectares), which comprises Gunbower NP, Perricoota State Forest (SF) and Koondrook SF. An important part of the wildlife corridor between Echuca/Moama and the Barmah block is another large area of native vegetation: the Barmah State Forest (approximately 3300 hectares). There are also several other far smaller reserves scattered along the wildlife corridor. The wildlife corridor is approximately 65 kilometres long and is centred on the Murray River and its tributaries and, excluding the Barmah State Forest, ranges in width from over two kilometres to as little as 150 metres (including the river channel). The confluence of the Murray River and Goulburn River is situated in the Barmah State Forest, and native vegetation along the Goulburn River provides another even longer wildlife corridor (approximately 100 kilometres long) through Shepparton and Murchison to the Rushworth State Forest block, some 65 Kilometres south-east of Echuca/Moama. The spatial distribution of the forest blocks and connecting wildlife corridors are presented in Figure 4, and Figure 5 presents a view of the wildlife corridor at the local scale, in the vicinity of the study area. The forest blocks and wildlife corridor in the greater region are situated within a matrix of predominantly cleared agricultural land, which is hostile to all but hardy generalist species, such as common farmland birds.



Legend

- Study area
- Habitat connectivity

Kilometers
0 5 10 20

Figure 4: Regional scale habitat connectivity

Project: Murray River Crossing Echuca

Client: VicRoads

Project No.: 8194	Date: 6/11/2014	Created By: M. Ghasemi / B. MacDonald

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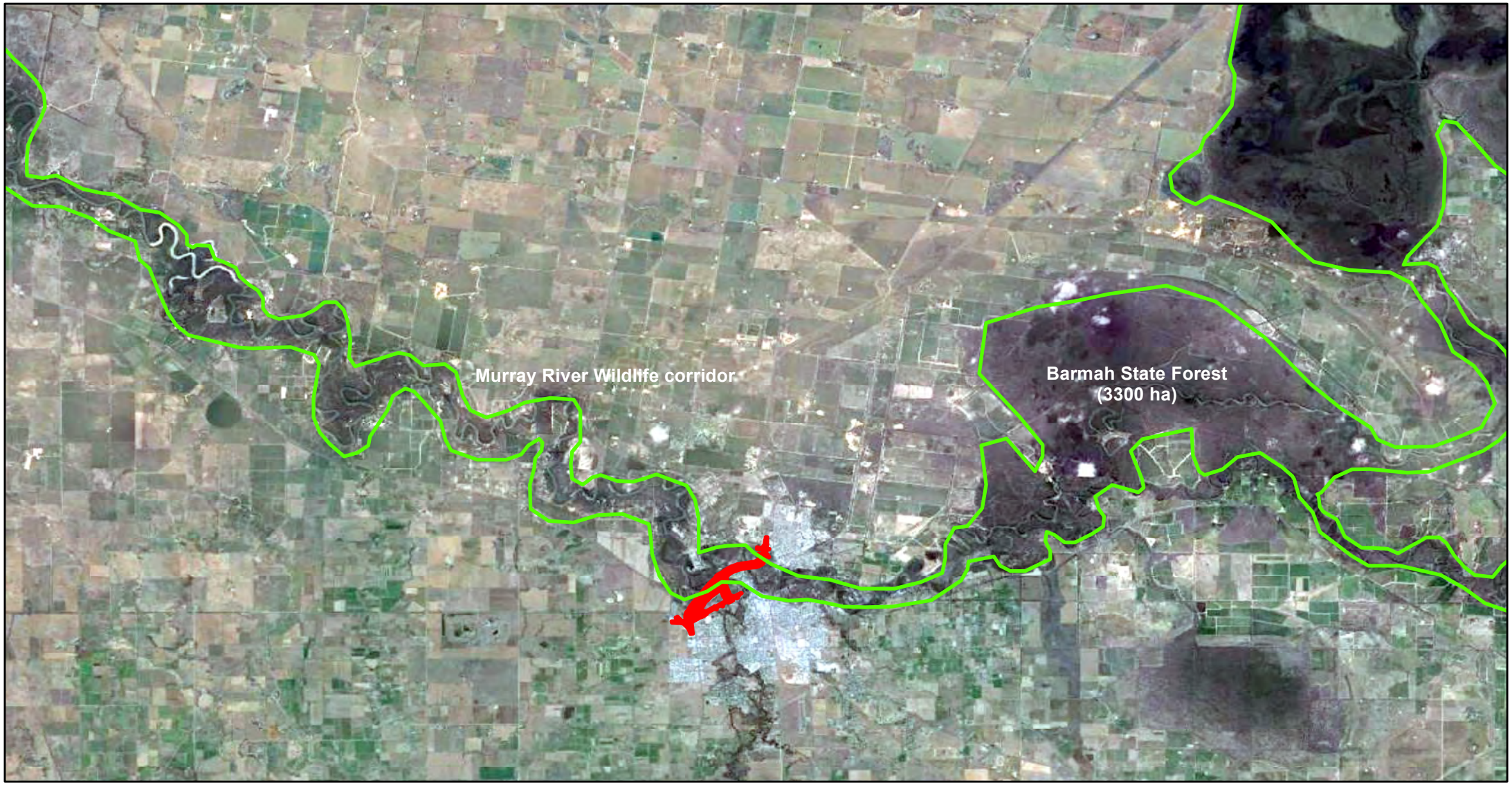

Legend

- Study area
- Habitat connectivity

Kilometers

0 2 4 8

Figure 5: Local scale habitat connectivity

Project: Murray River Crossing Echuca

Client: VicRoads

Project No.: 8194	Date: 13/11/2014	Created By: M. Ghasemi / B. MacDonald

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The proposed road carriageway would dissect an approximately 2.25 kilometre wide section of the wildlife corridor (NSW and Victoria).

As such, the wildlife corridor constitutes a very important means of organism gene dispersal between the two large forest blocks and beyond, particularly for more mobile species.

7.1.2. Land use

Study area

Land use in the forested southern half of the study area appears to be largely passive at present, although past disturbance, some severe, was evident, particularly near the Murray River, where vegetation had been cleared sometime in the past. Sand mining has also occurred in the fluvial sand bed are, rendering that it largely devoid of vegetative cover.

In the northern half of the study area, land use is predominately residential and commercial, where the vast majority of native vegetation has been previously cleared.

Local region

The greater township of Echuca/Moama has grown considerably in recent times, particularly Echuca, which has resulted in the removal or modification of a considerable amount of native vegetation. By Victorian standards, the area of native vegetation that remains in the township environs is impressive, especially for a town that size. Although much of that native vegetation is protected as park or reserve, a considerable amount is in private ownership, where it is likely to become increasingly degraded.

Native vegetation within the township environs has obviously had a long history of disturbance, as evidenced by its current condition. Given the increasing popularity of Echuca/Moama as a tourist destination, it is envisaged that the condition of native vegetation in the township environs will steadily decline due to increasing public utilisation for recreation activities.

In the greater region, land use is largely agricultural, and mostly intensive.

7.1.3. Description of vegetation in the study area

Observed vegetation consisted of several various age cohorts of River Red-gums (Figure 6) with the oldest occurring adjacent to the Murray River. Distinct patches of River Red-gum regrowth occurred within this area and are likely to be due to previous disturbance events.

A large area of forested wetland occurred within the north eastern section of the corridor (Figure 7). This area supported a sparse canopy of large River Red-gums with an understorey component dominated by indigenous wetland species including Common Spike-sedge, Poong'ort and various rushes, grasses and herbs. Small billabongs existed within River Red-gum vegetation in the north-eastern part of the study area.

A total of eleven indigenous scattered trees were recorded along roadsides either side of the Cobb Highway and Perricoota Road intersection.

Figure 6: Recruiting River Red-gum dominated vegetation

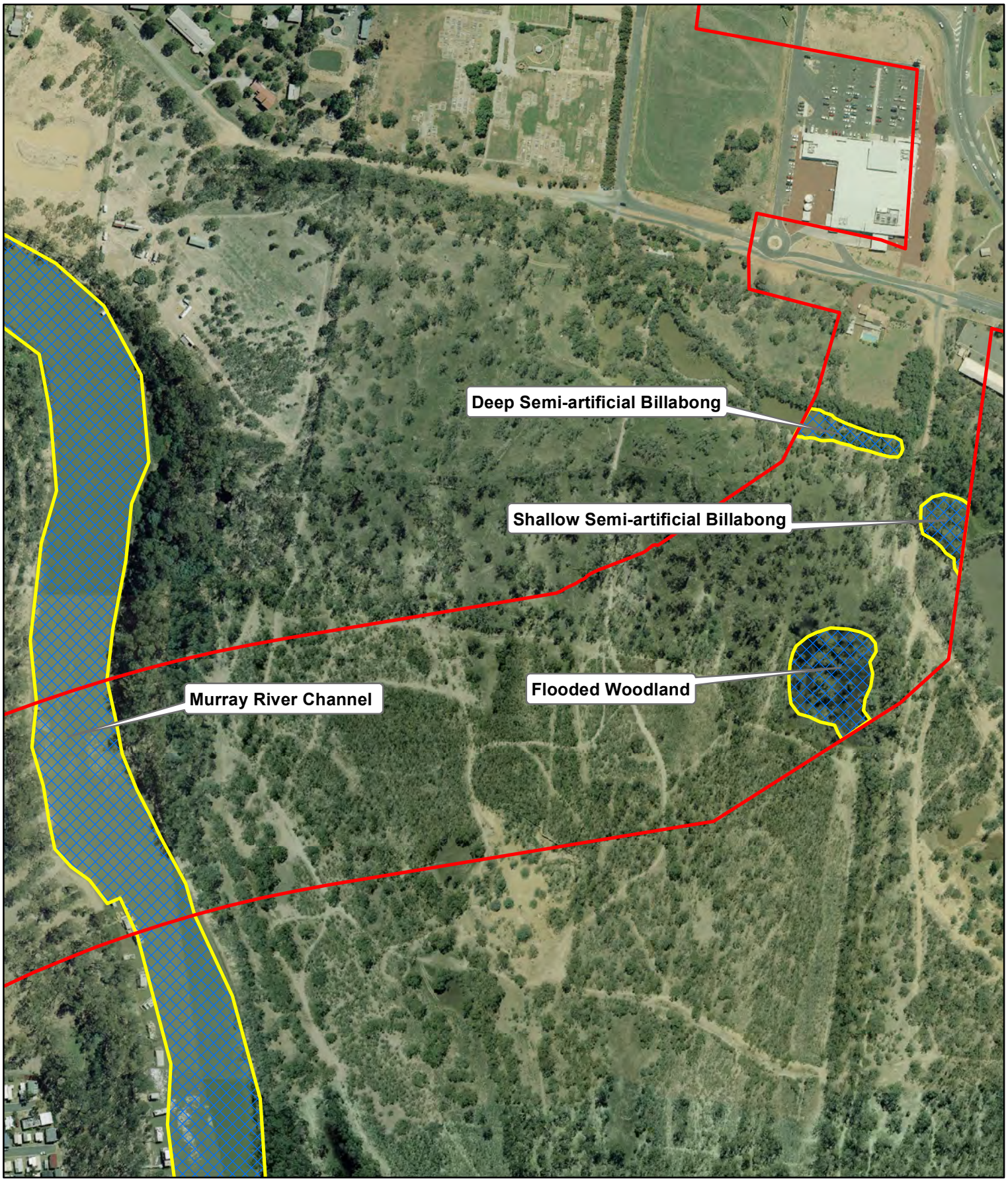
Figure 7: River Red-gum Forested Wetland

7.1.4. Description of aquatic habitat

This section provides a detailed description of the aquatic habitat present within the study area. Further details including the results of a water quality assessment and fish survey for the study area are provided in a separate report prepared by GHD (2012).

The Roads and Maritime 'Environmental Planning and Assessment Practice Note - Biodiversity assessment (EIA-N06)' (Roads and Maritime Services (Transport Department) 2011a)' requires a detailed description of aquatic habitat in the study area. The NSW Department of Primary Industries (Fisheries) has recently published updated policy and guidelines for fish habitat conservation and management (NSW Department of Primary Industries 2013). This document describes and classifies waterways in NSW and provides guidelines to manage these aquatic habitats.

Aquatic habitat in the study area comprised a section of the Murray River channel, deep and shallow semi-artificial billabongs and flooded red gum woodland. All of the aquatic habitats in the study area are considered to include the threatened ecological community - *Lower Murray River* aquatic ecology community which is listed as endangered under the FM Act. Detailed descriptions of these habitats, in accordance with RMS guidelines and NSW Department of Primary Industries policy and guidelines, are provided below. The locations of these habitats are presented below in Figure 8.



Legend

- Study area
- Aquatic Habitat
- Aquatic Ecological Community in the Natural Drainage System of the Lower Murray River Catchment

0 50 100 200 Metres

Figure 8: Aquatic Habitat in the study area

Project: Murray River Crossing Echuca

Client: VicRoads

Project No.: 8194	Date: 16/07/2015	Created By: K. Al-Dabbagh / M. Ghasemi

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Murray River channel

According to the aquatic habitat descriptions, fish habitat sensitivity and waterway classification criteria prescribed in the policy and guidelines for fish habitat conservation and management (NSW Department of Primary Industries 2013), the reach of the Murray River pertinent to this assessment is classified as a major river and Type 1, highly sensitive key fish habitat, and a Class 1, major key fish habitat. This aquatic habitat is also part of the EEC - Lower Murray River Aquatic Ecological Community (DPI 2007).

It is widely acknowledged that the flow characteristics, and subsequent channel structure, of the Murray River have been greatly modified since European settlement. Alienation of much of the river's floodplain and the construction of large on-stream storages and numerous flow regulators along the river has greatly altered its flow regime. In general, flows are weaker, channel sedimentation is higher and flooding is less frequent and of a lower magnitude than would have been in the past.

Within the study area, the Murray River was characterised by an excessively turbid water column, high sedimentation, a conspicuous lack of aquatic and semi-aquatic flora cover and in-stream snags (fallen timber). The river channel has undergone extensive bank erosion on the NSW bank due to watercraft wave action, rendering much of the bank near-vertical and leading to the premature loss of many large River Red-gum trees through bank collapse (Figure 9). As such, the banks were virtually devoid of stabilising vegetation. The bank on the Victorian side of the river has also undergone extensive erosion, although this has been ameliorated so some extent through the installation of a series of 'training' fences. The section of the Murray River within the study area is approximately 80 metres wide and the water column approximately three to five metres deep.

Further details on the aquatic habitat within the Murray River are provided in a separate investigation undertaken by GHD (2012).

Figure 9: Typical bank erosion along the Murray River channel

Deep semi-artificial billabong aquatic habitat

According to the aquatic habitat descriptions, fish habitat sensitivity and waterway classification criteria prescribed in the policy and guidelines for fish habitat conservation and management (NSW Department of Primary Industries 2013), this aquatic habitat is classified as a permanent wetland and Type 2, moderately sensitive key fish habitat. This aquatic habitat is also part of the EEC - Lower Murray River Aquatic Ecological Community (DPI 2007).

This water body (Figure 10) was presumably one of a chain of a shallow billabongs, situated some 600 metres north-east of the Murray River channel. However, there was ample evidence that it had been dammed and excavated, thereby increasing its size and depth. The billabong was approximately 300 metres long, 20 metres wide and 1.5 metres deep, however the majority lay outside the study area.

Prior to its modification, the billabong would have been periodically inundated by flooding of the Murray River, However, storm water drainage from the adjacent commercial precinct and hotel complex appear to be its current main source of inundation. The bed was composed of dispersive clay substrate and several large snags were observed in the water column.

The banks were steep and moderately vegetated with young indigenous River Red-gum and Black Box trees, indigenous shrubs; bottlebrush and Pale-fruit Ballart and planted willows (introduced). The ground layer was very sparse, comprising introduced grass and forb species. Aquatic and semi-aquatic flora was sparse, comprising a range of indigenous flora including Slender Knot-weed, Cumbungi, Slender Dock and Swamp Wallaby-grass. Introduced Water Couch and Water Buttons were also recorded here.

The water column was observed to be highly turbid and near-eutrophic in this habitat due to high nutrient inputs.

Figure 10: Deep semi-artificial billabong aquatic habitat

In-stream fauna was only partially assessed, incidentally, and during tadpole sample netting. Species recorded were the native Nankeen Night Heron, White-

faced Heron, Australian Wood Duck, Pacific Black Duck, Great Cormorant, Australasian Smelt, Eastern Snake-neck Turtle, several frog species (see results of Southern Bell Frog survey), atylid shrimp and various other macro-invertebrates. The introduced Eurasian Carp and Eastern Gambusia were also recorded.

Shallow semi-artificial billabong aquatic habitat

According to the aquatic habitat descriptions, fish habitat sensitivity and waterway classification criteria prescribed in the policy and guidelines for fish habitat conservation and management (NSW Department of Primary Industries 2013), this aquatic habitat is classified as a temporary wetland and Type 2, moderately sensitive key fish habitat. This aquatic habitat is also part of the EEC - Lower Murray River Aquatic Ecological Community (DPI 2007).

This aquatic habitat (Figure 11) was also part of the chain billabongs situated some 600 metres north-east of the Murray River channel. However, it was presumably more representative of the original state of the billabong chain. There was no evidence of any damming or excavation, the billabong being shallow and well vegetated. It was round in shape, approximately 40 metres wide and up to 20 centimetres deep.

Prior to its modification, the billabong would have been periodically inundated by flooding of the Murray River, However, storm water drainage from the adjacent commercial precinct and hotel complex appear to be its current main source of inundation. The bed was composed of dispersive clay substrate and several large snags were observed in the water column.

The entire water column was well vegetated with indigenous flora including Common Spike-sedge, Poong-ort, Cumbungi, Water Plantains, Slender Dock, Common Blown-grass, willow herb and rushes. Introduced Water Couch and Kikuyu were also present. Young indigenous River Red-gum and Black Box trees were scattered throughout.

Figure 11: Shallow semi-artificial billabong aquatic habitat

Native fauna species recorded incidentally were Plains Froglet, Eastern Banjo Frog, Spotted Marsh Frog, Common Froglet, Peron's Tree Frog, Nankeen Night Heron, White-faced Heron, and various terrestrial invertebrates.

Flooded red gum woodland aquatic habitat

According to the aquatic habitat descriptions, fish habitat sensitivity and waterway classification criteria prescribed in the policy and guidelines for fish habitat conservation and management (NSW Department of Primary Industries 2013), this aquatic habitat is classified as a temporary wetland and Type 2, moderately sensitive key fish habitat. This aquatic habitat is also part of the EEC - Lower Murray River Aquatic Ecological Community (DPI 2007).

This aquatic habitat (Figure 12) occurred on ephemeral flooded red gum woodland, some 500 metres east of the Murray River channel. It was round in shape, some 50 metres by 60 metres, and up to 15 centimetres deep. The substrate was dispersive clay.

It is presumed that periodic inundation would be effected by both flooding of the Murray River and heavy rainfall.

The entire wetland was well vegetated with a sparse canopy of large and sapling River Red-gums, virtually no shrub stratum and a ground stratum dominated by indigenous wetland species such as Common Spike-sedge, Poong'ort, various rushes, Swamp Wallaby-grass, Austral Sweet-grass, Common Blown-grass, willow herb, Water Milfoil, Ferny Small-flower Buttercup, Common Sneezeweed and Slender Dock.

Water quality and aquatic fauna were not assessed as part of this investigation. Native fauna species recorded incidentally, and during the frog survey, were Plains Froglet, Eastern Banjo Frog, Spotted Marsh Frog, Common Froglet, Peron's Tree Frog, White-faced Heron, Pacific Black Duck and various terrestrial invertebrates.

Figure 12: Flooded red gum woodland aquatic habitat

7.2. Flora and Vegetation assessment

7.2.1. Native Vegetation

Current native vegetation mapping, as indicated in Keith (2006), suggested the following vegetation formations may occur within the study area:

- Grassy Woodlands;
- Semi-arid Woodlands; and
- Forested Wetlands.

Information provided from the BioMetric database of vegetation types in the Murray CMA, combined with evidence on site, including structure, floristic composition and soil characteristics, suggested that all native vegetation in the study area was of the Forested Wetlands formation, and furthermore classified as Inland Riverine Forest. Two different vegetation types were recorded within the Inland Riverine Forest class:

- River Red Gum - Black Box woodland of the semi-arid (warm) climatic zone (45% cleared in Murray CMA); and
- River Red Gum - herbaceous tall open forest of the Riverina and Murray Darling Depression Bioregions (10% cleared in the Murray CMA)

Seven patches (referred to herein as Habitat Zones 24 to 31) of remnant native vegetation comprising the abovementioned vegetation types were identified in the study area, the combined extent of which was 14.47 hectares. A description of Habitat Zones 24 to 31 is provided below in Table 1. Locations of Habitat Zones in the study area are presented in Figure 13.

All remnant patches of native vegetation in the study area occur within the Murray Channels and Floodplains Mitchell Landscape, which is 56% cleared.

In addition to the remnant native vegetation recorded in the study area, 11 scattered trees occurring outside areas mapped as patches of native vegetation were recorded around the intersection of the Cobb Highway and Perricoota Road (See Figure 13). These scattered trees would have once comprised the canopy component of 'River Red Gum - Black Box woodland of the semi-arid (warm) climatic zone', and also occur across two Mitchell Landscapes; the Murray Channels and Floodplains (56% cleared) and the Murray Scalded Plains (92% cleared).

Table 1: Description of Habitat Zones in the study area

Habitat Zone	Vegetation Type	^Vegetation condition	% cleared in Murray CMA	EEC (Y/N)	Area (ha)	Description
24	River Red Gum - Black Box woodland of the semi-arid (warm) climatic zone	Moderate	45%	*Yes	1.16	River Red-gum dominated patch of woodland abutting the Murray River, with some Black Box in the canopy. Indigenous shrubs including Pale-fruit Ballart, Silver Wattle and Tangled Lignum present. Ground layer supports a high cover of introduced grasses, namely Annual Veldt-grass. Banks of the Murray River highly impacted by erosion.
25	River Red Gum - Black Box woodland of the semi-arid (warm) climatic zone	Low	45%	No	2.21	Sparse River Red-gum dominated patch of woodland with some Black Box present. Canopy sparse with moderate cover of eucalypt regrowth. Understorey disturbed to form series of tracks. Ground layer very sparse, mostly bare ground.
26	River Red Gum - Black Box woodland of the semi-arid (warm) climatic zone	Low	45%	No	3.77	River Red-gum dominated patch of woodland with some Black Box present. Canopy mostly absent, rather patch distinguished by high cover of regrowth of various age cohorts. Indigenous shrubs including Pale-fruit Ballart and Silver Wattle present. Ground layer very sparse, supporting mostly leaf litter and bare ground.
27	River Red Gum - herbaceous tall open forest of the Riverina and Murray Darling Depression Bioregions	Moderate	10%	No	0.16	River Red-gum dominated shallow forested wetland. Old growth River Red-gums scattered throughout. Predominately indigenous understorey dominated by Common Spike-sedge with scattered rushes.

Habitat Zone	Vegetation Type	^Vegetation condition	% cleared in Murray CMA	EEC (Y/N)	Area (ha)	Description
29	River Red Gum - Black Box woodland of the semi-arid (warm) climatic zone	Low	45%	No	1.02	Patch of River Red-gum woodland consisting entirely of young dense regrowth. Canopy absent due to previous disturbance. Ground layer very sparse, supporting mostly leaf litter and bare ground.
30	River Red Gum - herbaceous tall open forest of the Riverina and Murray Darling Depression Bioregions	High	10%	*Yes	4.21	River Red-gum dominated shallow forested wetland. Old growth River Red-gums scattered throughout. Indigenous understorey dominated by Common Spike-sedge and rushes, with various indigenous wetland species present including Nardoo, Water Ribbons, Water Milfoil and Common Swamp Wallaby-grass. Low weed cover and moderate eucalypt recruitment.
31	River Red Gum - herbaceous tall open forest of the Riverina and Murray Darling Depression Bioregions	Moderate	10%	*Yes	1.94	Disturbed River Red-gum dominated woodland occurring adjacent to existing billabong. Vegetation occurs either side of an existing bush track and has therefore been susceptible to weed invasion by species such as Desert Ash and Patterson's Curse. Billabong full of sitting water at time of survey.
Total area (ha)					14.47	

EEC = Endangered ecological community; ^ = As per criteria in Section 6.2.2; * = At least part of the zone comprises aquatic habitat consistent with the EEC: *Aquatic Ecological Community in the Natural Drainage System of the Lower Murray River Catchment* (listed as endangered under the FM Act).

Legend

Study area

Native vegetation

RIver Red Gum - herbaceous tall open forest

River Red Gum - Black Box woodland

Scattered trees

Metres

0 50 100 200

Figure 13: Study area and native vegetation

Project: Murray River Crossing Echuca

Client: VicRoads

Project No.: 8194	Date: 29/08/2014	Created By: B. MacDonald / M. Ghasemi

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7.2.2. Flora

During the field assessment of both the NSW and Victorian sides of the alignment (the greater assessment), 113 plant species were recorded. Of these, 66 (58%) were indigenous and 47 (42%) were introduced or non-indigenous native in origin. It was not possible in all instances to distinguish which species were recorded in which jurisdiction. This does not include listed threatened species, of which all locations were recorded. For a list of all flora species recorded during the greater field assessment, see Appendix 1 in BL&A 21013b.

Threatened flora species

Database searches from the Wildlife Atlas of New South Wales (OEH 2011; 2014) and the EPBC Protected Matters Search Tool (DSEWPC 2011; Department of the Environment 2014) indicate that within the search region there are records of, or there occurs potential suitable habitat for, 12 rare or threatened flora species. Of these, nine species were listed under the federal EPBC Act and nine under the *Threatened Species Conservation Act 1995* (TSC Act). These species are listed in Appendix 1 and Appendix 2.

The likelihood of occurrence in the study area of threatened species listed under the EPBC Act and TSC Act is addressed in Table 2. Suitable habitat is considered to exist for four species of threatened flora within forested wetland based on this assessment:

- Slender Darling-pea (EPBC Act and TSC Act);
- Small Scurf-pea (TSC Act);
- River Swamp Wallaby-grass (EPBC Act and TSC Act); and
- Western Water Starwort (EPBC Act and TSC Act).

Threatened Flora targeted survey

Targeted flora surveying was undertaken in areas of suitable habitat in November 2011 during the peak flowering times for these above listed species. None of the above listed threatened flora species were recorded during this survey and therefore are now considered unlikely to occur. The results of the targeted flora survey are reflected in Table 2.

Table 2: EPBC Act and TSC Act listed flora species and likelihood of occurrence

Common Name	Scientific Name	Conservation Status		Habitat	Likelihood of occurrence in study area
		EPBC	TSC		
^Prasophyllum sp. Moama (an orchid)	*^Prasophyllum sp. Moama*		C	This species is known in NSW from only one locality, discovered in 2005, in a travelling stock route near Moama. Here it occurs in "forb-rich grassland on flat alluvial plains ...The grassland appears to be natural and not derived from *Acacia pendula* woodland". The only tree species recorded as present nearby is *Allocasuarina luehmannii* (Buloke, Bulloak). The soil is a reddish, probably calcareous clay-loam (K. McDougall and N. Walsh, pers. comms. May 2007).	No grassland habitat recorded within the study area – **unlikely to occur.**
Pterostylis despectans (an orchid)	*Pterostylis despectans*	E	C	The New South Wales population occurs in natural forb-rich grassland on flat alluvial plains and not derived from Acacia pendula woodland. The only tree species recorded as present at the site is Allocasuarina luehmannii. The soil is a reddish, probably calcareous, clay loam (OEH 2014a)	No grassland habitat recorded within the study area – **unlikely to occur**
Ridged Spider-orchid (Greencomb Spider-orchid)	*Caladenia tensa*	E		Eucalyptus and Callitris woodland in well drained sandy loams. Grows among shrubs (Jones 2006).	No suitable habitat in study area – **Unlikely to occur.**
Red Swainson-pea	*Swainsona plagiotropis*	V	V	Grows on flat grassland and in heavy red soil. Occurs in the upper Murray River valley in the south-western plains of NSW and into Victoria (DEC 2005).	No grassland habitat recorded within the study area – **unlikely to occur.**
Ridged Water-milfoil	*Myriophyllum porcatum*	V		An aquatic species that occurs in shallow, ephemeral wetlands including lakes, swamps, rock pools in granite outcrops, waterholes in claypans, and highly modified habitats including farm dams and drainage lines on private land. Some wetlands, such as Lake Lascelles, are dry for extended periods and only fill intermittently (Murphy 2006)	Endemic to Victoria. Has not been recorded in NSW - **Unlikely to occur.**
River Swamp Wallaby-grass	*Amphibromus fluitans*	V	V	*Amphibromus fluitans* grows mostly in permanent swamps. The species needs wetlands which are at least moderately fertile and which have some bare ground, conditions which are produced by seasonally-fluctuating water levels. Habitats in south-western NSW include swamp margins in mud, dam and tank beds in hard clay and in semi-dry mud of lagoons with *Potamogeton* and *Chamaeraphis* species (OEH 2014b).	Suitable habitat in Forested Wetland habitat. Not recorded during targeted survey. (Common Swamp Wallaby-grass, *Amphibromus nervosus* recorded) – **unlikely to occur.**
Silky Swainson-pea	*Swainsona sericea*		V	This species has been recorded from the Northern Tablelands to the Southern Tablelands and further inland on the slopes and plains. In the Murray CMA, it is known to occur in Riverine Chenopod Shrublands and Riverine Plain Grasslands (OEH 2013).	No suitable habitat in study area – **Unlikely to occur**
Slender Darling-pea	*Swainsona murrayana*	V	V	Grows in a variety of vegetation types including bladder saltbush, black box and grassland communities on level plains, floodplains and depressions and is often found with Maireana species. Plants have been found in remnant native grasslands or grassy woodlands that have been intermittently grazed or cultivated. The species has been collected from clay-based soils, ranging from grey, red and brown cracking clays to red-brown earths and loams (OEH 2014c).	Suitable habitat in study area. Not recorded during targeted survey in known flowering period – **unlikely to occur.**
Small Scurf-pea	*Cullen parvum*		E	In known populations in Victoria and NSW, plants are found in grassland, River Red Gum (Eucalyptus camaldulensis) Woodland or Box-Gum Woodland, sometimes on grazed land and usually on table drains or adjacent to drainage lines or watercourses, in areas with rainfall of between 450 and 700 mm (OEH 2014d).	Suitable habitat in study area. Not recorded during targeted survey in known flowering period – **unlikely to occur.**

Common Name	Scientific Name	Conservation Status		Habitat	Likelihood of occurrence in study area
		EPBC	TSC		
Spiny Rice-flower	*Pimelea spinescens subsp. spinescens*	C		Endemic to Victoria, where it occurs in grassland or open shrubland on basalt-derived soils, usually comprising black or grey clays (Walsh & Entwisle 1996). Plants from more northerly populations occur on red clay complexes, while plants from southern populations occur on heavy grey-black clay loams. (Carter & Walsh 2006).	Endemic to Victoria. Has not been recorded in NSW - **Unlikely to occur.**
Turnip Copperburr	*Sclerolaena napiformis*	E	E	Grasslands on clay-loam soils (DEC 2005).	No suitable grassland habitat recorded within study area – **unlikely to occur.**
Western Water-starwort	*Callitriche cyclocarpa*	V	V	NSW and Victoria in thick patches in floodwaters (DEC 2005).	Suitable habitat in Forested Wetland habitat in New South Wales. Not recorded during targeted survey in known flowering period – **unlikely to occur.**

^ = This species is potentially not distinct from *Prasophyllum occidentale*. Genetic analysis is required to resolve the taxonomy; **C** = Critically Endangered; **E** = Endangered; **V** = Vulnerable.

7.3. Fauna assessment

7.3.1. Habitat assessment

A little over half of the study area supports native vegetation in the form of River Red-gum tall open forest and River Red-gum – Black Box woodland. The balance of the study area includes open roadside areas and private land which, with the exception of 11 scattered indigenous canopy trees, has been cleared of native vegetation. This entire forested and woodland area was considered **high** quality habitat for fauna. Wetland habitat recorded in the study area was considered as **moderate** quality for fauna. See Section 6.2.5 for habitat assessment criteria.

All fauna habitats recorded in the study area are described below and shown in Figure 14.

River Red-gum Forests: Consisted of several age cohorts of River Red-gum's with the oldest occurring adjacent to the Murray River. This habitat consisted of distinct patches of regrowth, likely due to previous disturbance events. A large area of forested wetland occurs within the north of the study area. This area supports a sparse canopy of large River Red-gums with an indigenous understorey component dominated by wetland species including Common Spike-sedge, Poong'ort and various rushes, grasses and herbs.

River Red-gum - Black Box Woodlands: Comprised a large area of regrowth River Red-gum and Black Box, interspersed with a thin scattering of large old River Red-gum trees. While sparse and degraded, the understorey comprised a scattering of indigenous shrubs, including Pale-fruit Ballart and Silver Wattle. The ground layer was very sparse, supporting mostly leaf litter and bare ground.

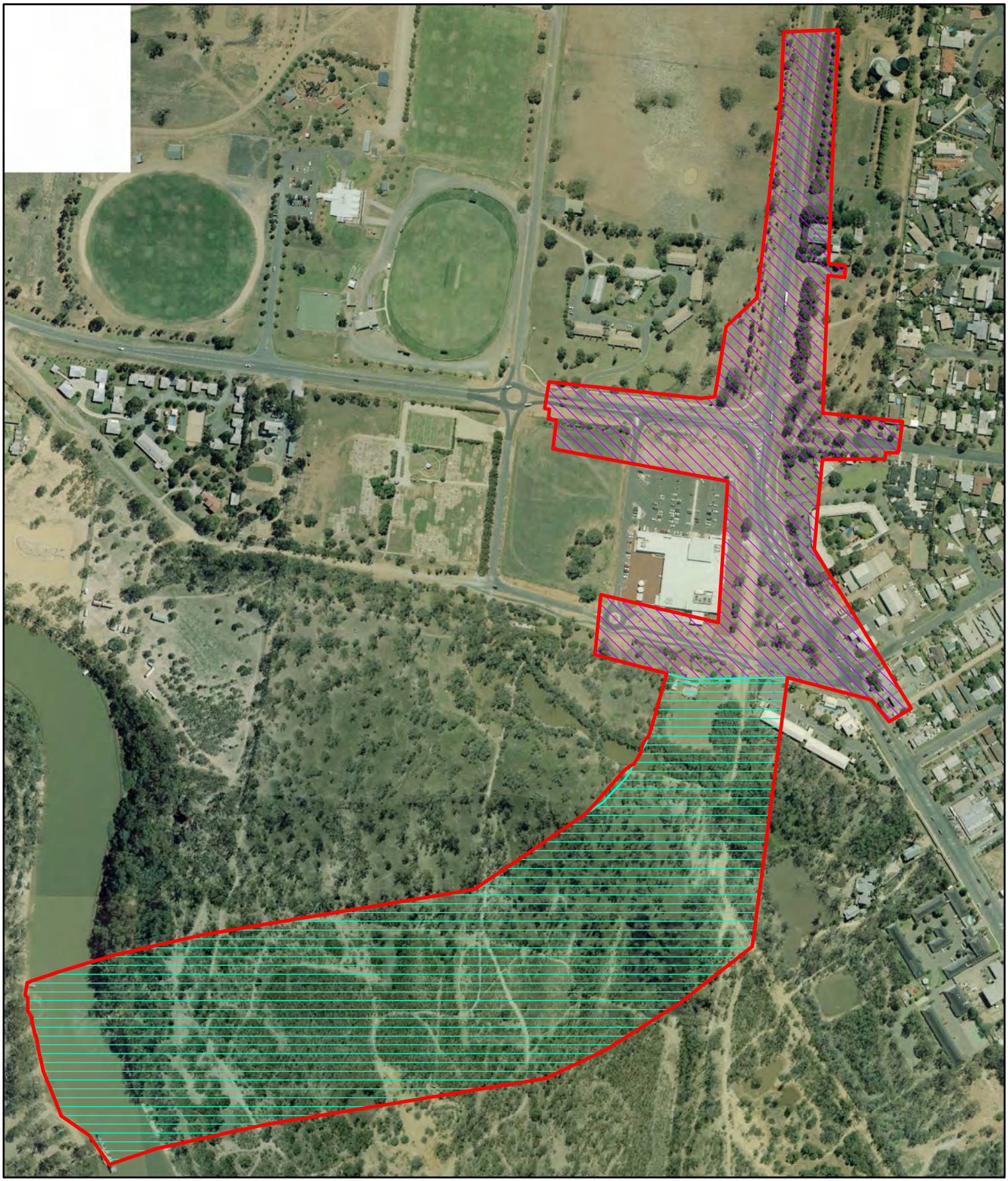
Wetlands: Aquatic habitat in the study area consisted of the Murray River channel and associated billabongs. The river channel had suffered severe bank erosion over time, and was almost devoid of stabilising vegetation, with exception of a few areas supporting sedges and Common Reed. The river provides continuity in habitat, and is therefore a high value habitat corridor, mostly for fish and other aquatic fauna. Common species of frogs may also utilise the river for movement, in particular during the non-breeding season.

Several billabongs were located within the River Red-gum woodland in the study area, which supported a moderate to dense cover of fringing vegetation, which is likely to provide cover and breeding habitat for a number of common native frog species. The water quality was found to be poor and carp were present in at least one of the billabongs. The habitat quality of the billabongs for fauna is considered as moderate.

Disturbed roadside vegetation: This habitat consists of modified and highly disturbed areas. These areas are unlikely to support threatened species, although scattered trees will provide some habitat for locally common native fauna species.

Habitat suitability for Koala: River Red Gum (*E. camaldulensis*) is identified in Schedule 2 of SEPP No. 44 as a Koala feed tree species. As more than 15% of the trees in the affected area belong to this species, the habitat is 'potential koala habitat'. However, considering that no Koalas have been detected in the Echuca region in any of the extensive flora and fauna field investigations for this project since 2008 and the review of existing information for this species in the search

region indicates that the nearest records of the Koala to the study area are from a site approximately 10 kilometers to the west along the Murray River (one record), and the Barmah Forest, approximately 20 kilometers to the east, the habitat in the study area and surrounds is not 'core koala habitat', as defined in the SEPP, and would not be important for the conservation of the species.



Legend

Study Area

Fauna habitat

Disturbed roadside habitat

River Red-gum habitat

0 75 150 300 Metres

Figure 14: Fauna habitats of the study area

Project: Murray River Crossing Echuca

Client: VicRoads

Project No.: 8194	Date: 29/08/2014	Created By: B. MacDonald / M. Ghasemi

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7.3.2. Fauna species

During the field assessment of both the NSW and Victorian sides of the alignment (the greater assessment), 138 fauna species were recorded. This included 105 bird (seven introduced), 22 mammal (four introduced), four reptile, six frog and two fish species. With many exceptions, it was not possible to distinguish which species were recorded in which jurisdiction. This does not include listed threatened species, of which all locations were recorded. For a list of all fauna species recorded during the greater field assessment, see Appendix 2 in BL&A 21013b.

The study area was found to be rich in fauna as it consisted of quality forest and woodlands, and moderate quality wetlands. These habitats attracted a large and diverse fauna. Fauna species, particularly birds, were not usually restricted to certain habitats; they were almost equally distributed among the various habitat types, with the exception of the waterbirds, which were generally confined to the river banks and other wetlands. Records for fauna, as stated above, originated from existing databases and those recorded during the field inspection days.

7.3.3. Listed threatened fauna species

The review of existing information and current field survey indicate that within the search region 40 species (26 birds, seven mammals, one reptile, one frog, four fish and one invertebrate) listed on the EPBC Act, TSC Act and FM Act may occur within the study area. Their likelihood of occurrence within the study area is assessed and presented in Table 3. Species that are likely to occur are highlighted. Table 3 indicates all threatened species and also species listed as migratory species under the EPBC Act.

Of the listed fauna species predicted to occur in the study area, five threatened fauna species and one migratory species were recorded. These were:

- Threatened species:
  - Brown Treecreeper;
  - Masked Owl;
  - Squirrel Glider;
  - Varied Sittella; and
  - Yellow-bellied Sheathtail Bat.
- Migratory species:
  - Rainbow Bee-eater.

The location of threatened fauna species recorded during the investigation is presented in Figure 15. Threatened fauna recorded in the study area are discussed in the following sections.

Based on the likelihood of occurrence assessment for threatened fauna, suitable habitat was deemed to occur in the study area for 22 listed fauna species, including the six listed species recorded. These 22 species, including those recorded in the study area are shaded in Table 3 and are discussed in more detail below. Species considered unlikely to occur based on lack of suitable habitat or

lack of recent and regular records from the search region are not highlighted and not discussed further.

Legend

Study Area

Threatened Fauna

- Masked Owl
- Nankeen Night Heron
- Rainbow Bee-eater
- Squirrel Glider
- Varied Sittella
- Yellow-bellied Sheattail Bat

0 75 150 300 Metres

Figure 15: Threatened fauna species recorded

Project: Murray River Crossing Echuca

Client: VicRoads

Project No.: 8194	Date: 21/07/2015	Created By: B. MacDonald / M. Ghasemi

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Table 3: Listed fauna identified as occurring or potentially occurring in the study area

Common Name	Scientific Name	Conservation Status			Habitat	Number of Records from NSW databases	Likelihood of Occurrence
		EPBC	TSC	FM			
Birds							
Australasian Bittern	*Botaurus poiciloptilus*	EN	VU		Usually inhabits permanent freshwater wetlands with tall dense vegetation, particularly those dominated by sedges, rush, reeds or cutting grass (Marchant and Higgins 1990).	0	No suitable habitat and lack of recent and regular records, **unlikely to occur**
Australian Painted Snipe	*Rostratula australis*	VU, M (CAMBA)	EN		Shallow freshwater or brackish swamps, usually inland and often ephemeral, with emergent vegetation such as River Red Gum and Lignum and muddy margins. Uncommon summer visitors to Victoria (Marchant and Higgins 1993; Garnett and Crowley 2000).	0	No suitable habitat and lack of recent and regular records, **unlikely to occur**
Barking Owl	*Ninox connivens connivens*		VU		Eucalyptus dominated forests and woodlands, commonly near water-bodies, such as streams and rivers, and requires hollow trees for nesting and trees with dense foliage for roosting. Prefers edge habitats to the interior of forests, with riparian vegetation through farmland supporting the species most regularly. It prefers sites with higher proportion of large trees greater than 60 centimeters in diameter at breast height and containing hollows (Higgins and Davies 1996; Taylor *et al*. 2002).	1	Suitable habitat present and targeted survey was undertaken. The Barking Owl was not recorded during targeted survey, therefore **unlikely to occur**
Black Falcon	*Falco subniger*		VU		Inhabits woodlands, open country and terrestrial wetlands in arid and semi-arid zones. Mainly occurs over open plains and undulating land with large tracts of low vegetation. It is more commonly found in north western Victoria and is only occasionally found in southern Victoria. It is a highly mobile species, moving in response to food availability and seasonal conditions (Marchant and Higgins 1993).	0	No suitable habitat and lack of recent and regular records, **unlikely to occur**
Black-chinned Honeyeater	*Melithreptus gularis gularis*		VU		Open box-ironbark forests and woodlands. Usually found in Red or Mugga Ironbarks, Grey Box, Yellow Gum and Yellow Box. Especially mature tall trees along gullies, low-lying flats and lower slopes. Characteristic box-ironbark species, widespread but moderately common. The species is gregarious, usually seen in groups of 3–10 birds (Higgins *et al.* 2001; Tzaros 2005).	1	Not recorded in the study area, although was recorded within the Black Box woodland on the Victorian side of the alignment. **Likely to occur**
Blue-billed Duck	*Oxyura australis*		VU		Terrestrial freshwater and brackish wetlands, preferring deep permanent, well vegetated water bodies. Secretive birds, usually feeding in open water or beside tall dense vegetation (Marchant and Higgins 1990).	0	No suitable habitat and lack of recent and regular records, **unlikely to occur**
Brown Treecreeper	*Climacteris picumnus victoriae*		VU		Woodlands dominated by eucalyptus, especially Stringybarks or other rough-barked eucalypts usually with open grassy understorey, some dead trees and fallen timber (Higgins *et al.* 2001).	6	A thriving population occurred on both sides of Murray River. **Recorded within the study area**
Bush Stone-curlew	*Burhinus grallarius*		EN		Plains and riverine grassy woodlands, box-ironbark forests often with dead leaves and fallen dead timber. The species is mainly found in north and west Victoria. This species has declined since European settlement, especially in the south of the state (Marchant and Higgins 1993; Robinson and Johnson 1997; Olsen et al. 2005).	1	Suitable habitat present and targeted survey was undertaken. The Bush Stone-curlew was not recorded during targeted survey, therefore is considered **unlikely to occur**
Cattle Egret	*Ardea ibis*	M (JAMBA, CAMBA)			Terrestrial freshwater wetlands and pasture, in association with cattle (Marchant and Higgins 1990).	0	No suitable habitat and lack of recent and regular records, **unlikely to occur**
Diamond Firetail	*Stagonopleura guttata*		VU		Commonly found in open forests and woodlands often with sparse grassy understorey also occur along watercourses and in farmland areas. Widespread but scattered. Populations have declined in Victoria since the 1950's (Higgins *et al.* 2006).	1	Suitable habitat present, **likely to occur**
Eastern Great Egret	*Ardea modesta*	M (JAMBA, CAMBA)			Variety of wetlands including estuaries and intertidal mudflats; various permanent and ephemeral freshwater, brackish and saline wetlands; shallows of deep permanent lakes (Marchant and Higgins 1990).	0	Suitable habitat present in wetland habitats along the Murray River and billabongs, **likely to occur**
Fork-tailed Swift	*Apus pacificus*	M (JAMBA, CAMBA, ROKAMBA)			Aerial, over inland plains, sometimes above foothills or in coastal areas, over cliffs and urban areas (Higgins 1999).	0	May occasionally fly over the study area, **potential to occur**

Common Name	Scientific Name	Conservation Status			Habitat	Number of Records from NSW databases	Likelihood of Occurrence
		EPBC	TSC	FM			
Grey-crowned Babbler	*Pomatostomus temporalis temporalis*		VU		Inhabits dry woodlands and forests with a shrub layer and a groundcover of leaf litter and fallen timber. In Victoria it is found in woodlands and forests with box-ironbark eucalypt associations and River Red Gums, including narrow remnants along roadsides and streams. Formerly widespread over much of Victoria, but populations has declined and range has contracted markedly, mostly from the south and west since the 1970's (Higgins and Peter 2002; Tzaros 2005).	4	Suitable habitat present and local residents have reported sightings. **Likely to occur**
Hooded Robin	*Melanodryas cucullata cucullata*		VU		Mostly in lightly timbered woodlands dominated by acacias or eucalypts, often with pockets of saplings or taller shrubs, an open shrubby understorey, sparse grasses and patches of bare ground and leaf-litter with scattered fallen timber. This species typically occurs north of the great divide in shrubland or woodland dominated by acacias (Higgins and Peter 2002; Tzaros 2005).	1	Suitable habitat present, **likely to occur**
Latham's Snipe	*Gallinago hardwickii*	M (JAMBA, CAMBA, ROKAMBA, Bonn Convention (A2H))			Occurs in wide variety of permanent and ephemeral wetlands; it prefers open freshwater wetlands with dense cover nearby, such as the edges of rivers and creeks, bogs, swamps, waterholes (Naarding 1983; Higgins and Davies 1996).	0	Suitable habitat present in wetlands, however due to lack of any records it is considered **unlikely to occur**
Malleefowl	*Leipoa ocellata*	M, VU			Mainly in semi-arid zones in heath and mallee-heath, rarely arid zones. Associated with mallee, particularly floristically rich tall dense mallee of higher rainfall areas (Marchant and Higgins 1993).	0	No suitable habitat, **unlikely to occur**
Masked Owl	*Tyto novaehollandiae* race *novaehollandiae*		VU		Mostly occurs in open woodlands and forests that provide dense and tall tree cover, and adjoining open habitats such as cleared farmlands (Higgins 1999).	0	Suitable habitat at the study area and was recorded there. **Recorded in the study area**
Plains Wanderer	*Pedionomus torquatus*	VU			This species inhabits native grasslands with sparse cover, preferring grasslands that include Wallaby Grass and Stipa species. In Victoria no recent records in south east, sporadic reports from Keilor–Werribee Plains. Widespread in small areas in the mallee, most common in northern Victoria between Bendigo and Swan Hill (Marchant and Higgins 1993).	0	No suitable habitat, **unlikely to occur**
Rainbow Bee-eater	*Merops ornatus*	M (JAMBA)			Usually in open or lightly timbered areas, often near water. Occur in partly cleared land such as farmland and in sand-dunes, both coastal and inland (Higgins 1999).	1	Birds observed flying over the study area in woodland habitats, **Recorded in the study area**
Regent Honeyeater	*Anthochaera phrygia*	EN, M (JAMBA)	VU		Mainly occurs in dry scrleophyll forests and box-ironbark woodlands with copious flowering eucalypts and/or mistletoes, usually near rivers and creeks on inland slopes of the Great Dividing Range. It can also occur in small remnant patches or isolated clumps of mature flowering trees in farmland, coastal or urban areas. Occur in northern and central Victorian box-ironbark forests. It is now considered extinct in western Victoria (Higgins *et al*. 2001).	0	No suitable habitat and lack of recent and regular records, **unlikely to occur**
Rufous Fantail	*Rhipidura rufifrons*	M (Bonn Convention (A2H))			Primarily found in dense, moist habitats. Less often present in dry sclerophyll forests and woodlands (Higgins *et al. 2006)*.	0	No suitable habitat and lack of recent and regular records, **unlikely to occur**
Satin Flycatcher	*Myiagra cyanoleuca*	M (Bonn Convention (A2H))			Tall forests and woodlands in wetter habitats but not in rainforest (Higgins *et al.* 2006).	0	No suitable habitat and lack of recent and regular records, **unlikely to occur**
Speckled Warbler	*Chthonicola sagittata*		VU		Inhabits dry eucalypt forests and woodlands, especially those with box-ironbark eucalypt associations. It is also found in River Red Gum woodlands. The species is uncommon, populations have declined since the 1980s (Higgins and Peter 2002; Tzaros 2005).	1	Suitable habitat present, **likely to occur**

Common Name	Scientific Name	Conservation Status			Habitat	Number of Records from NSW databases	Likelihood of Occurrence
		EPBC	TSC	FM			
Superb Parrot	*Polytelis swainsonii*	VU	VU		It occurs in riparian River Red Gum forests and adjacent areas of box eucalypt vegetation from the Murrumbidgee and Murray Rivers northwards to the Namoi Valley (Higgins 1999).	2	Suitable habitat present, but lack of recent and regular records, **potential to occur**
Swift Parrot	*Lathamus discolor*	EN	EN		This species prefers a narrow range of eucalypts in Victoria, including White Box, Red Ironbark and Yellow Gum as well as River Red Gum when this species supports abundant 'lerp'. It breeds in Tasmania and migrates to the mainland of Australia for the autumn, winter and early spring months (Higgins 1999; Kennedy and Tzaros 2005).	1	Suitable foraging habitat present when River Red-gum is flowering, but lack of recent and regular records, **potential to occur**
Turquoise Parrot	*Neophema pulchella*		VU		Occur in eucalypt woodlands and open forests, with ground cover of grasses and sometimes low understorey of shrubs. It usually occurs in native grassy forests and woodlands composed of mixed assemblages of native pine and variety of eucalypts. It can also occur in savannah woodlands and riparian woodlands. In Victoria is has been recorded in East Gippsland, the north and north east districts (Higgins 1999).	0	Suitable habitat present, **likely to occur**
Varied Sittella	*Daphoenositta chrysoptera*		VU		Inhabits eucalypt open woodlands and forests (Higgins and Peter 2002)	0	Birds observed in the woodland habitat, **Recorded in the study area**
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	M (CAMBA)			Occurs in maritime habitats, terrestrial large wetlands and coastal lands of tropical and temperate Australia and offshore islands. Its range extends far inland only over large rivers and wetlands (Marchant and Higgins 1993).	0	Suitable habitat present along Murray River, may occasionally fly over, but lack of recent and regular records, **potential to occur**
White-throated Needletail	*Hirundapus caudacutus*	M (JAMBA, CAMBA, ROKAMBA)			Aerial, over all habitats, but probably more over wooded areas, including open forest and rainforest. Often over heathland and less often above treeless areas such as grassland and swamps or farmland (Higgins 1999).	0	May fly over the study area during summer months, **potential to occur**
Mammals							
Brush-tailed Phascogale	*Phascogale tapoatafa tapoatafa*		VU		Dry forest and woodland in association with box, ironbark and Stringybark eucalypts (Menkhorst 1995).	0	No suitable habitat and lack of recent and regular records, **unlikely to occur**
Brush-tailed Rock Wallaby	*Petrogale penicillata*	VU			Rock faces with large tumbled boulders, ledges and caves (Menkhorst 1995).	0	No suitable habitat and lack of recent and regular records, **unlikely to occur**
South-eastern Long-eared Bat	*Nyctophilus Corbeni*	VU	VU		Occurs in a range of inland woodland and shrubland communities including box, ironbark and cypress pine woodlands (Menkhorst 1995, DSEWPC 2013).	0	Habitat initially deemed suitable. Targeted surveying undertaken. Initial analysis of recorded calls indicated species was present. A Peer Review (Gration 2015 — see Appendix 9) found species was not recorded, nearest reliable record is 50 km distant and habitat is not suitable. Species **unlikely to occur.**
Koala	*Phascolarctos cinereus*	VU	VU		Inhabits sclerophyll forests and woodlands on both sides of the GDR. Arboreal, agile climbers and mostly solitary (Menkhorst 1995).	1	Suitable habitat present, but lack of recent and regular records, **potential to occur**
Large-footed Myotis	*Myotis macropus*		VU		They inhabit vegetated areas in association with streams and permanent waterways (Churchill 2008).	0	Suitable habitat was not recorded during bat surveys, species not recorded during targeted surveys, **unlikely to occur**
Spot-tailed Quoll	*Dasyurus maculatus maculatus*	EN	VU		Rainforest, wet and dry forest, coastal heath and scrub and River Red-gum woodlands along inland rivers (Menkhorst 1995).	0	No suitable habitat and lack of recent and regular records, **unlikely to occur**
Squirrel Glider	*Petaurus norfolcensis*		VU		Dry forest and woodland and nearby riverine corridors (Menkhorst 1995).	1	Suitable habitat present. **Recorded in the study area**

Common Name	Scientific Name	Conservation Status			Habitat	Number of Records from NSW databases	Likelihood of Occurrence
		EPBC	TSC	FM			
Yellow-bellied Sheathtail Bat	*Saccolaimus flaviventris*		VU		Wide range of habitats, from wet and dry sclerophyll forests to open woodlands, acacia shrubland and mallee. Migratory species found only between January and April (Churchill 2008).	1	Suitable habitat present. **Recorded in the study area**
Reptiles							
Striped Legless Lizard	*Delma impar*	VU	VU		Tussock grasslands on the volcanic plains often associated with scattered rocks and cracked soils (Cogger 2000).	0	No suitable habitat and lack of recent and regular records, **unlikely to occur**
Frogs							
Growling Grass-frog/Southern Bell Frog	*Litoria raniformis*	VU	EN		Permanent, still or slow flowing water with fringing and emergent vegetation in streams, swamps, lagoons and artificial wetlands such as farm dams and abandoned quarries (Clemann and Gillespie 2004).	0	Suitable habitat in wetlands in the study area, however was not recorded during three targeted surveys, now considered **unlikely to occur**
Fish							
Macquarie Perch	*Macquaria australasica*	EN		EN	Cool, clear water of rivers and lakes. Favours slower moving water (Allen et al. 2002).	0	No suitable habitat in the study area, **unlikely to occur**
Murray Cod	*Maccullochella peelii*	VU			Slow flowing turbid water of rivers and streams of low elevation; also fast flowing clear upland streams (Allen *et al.* 2002).	1	Suitable habitat along the Murray River, **likely to occur**
Murray Hardyhead	*Craterocephalus fluviatilis*	EN		CE	Lakes and billabongs, mostly around dense vegetation (Allen *et al*. 2002).	0	Marginal habitat in wetlands along the Murray River, lack of recent and regular records and not detected in aquatic survey, **unlikely to occur**
Silver Perch	*Bidyanus bidyanus*	CE			Rivers, lakes and reservoirs, preferring area of rapid flow. Originally in most of the Murray river, but currently numbers have declined (Allen et al. 2002).	0	Suitable habitat along the Murray River, **likely to occur**
Trout Cod	*Maccullochella macquariensis*	EN		EN	Rapidly flowing streams, around the cover of logs and debris, over rocky or gravel bottoms.	1	Marginal suitable habitat along the Murray River, **potential to occur**
Insects							
Golden Sun Moth	*Synemon plana*	CE			Areas that are, or have been native grasslands or grassy woodlands. It is known to inhabit degraded grasslands with introduced grasses being dominant, with a preference for the native wallaby grass being present (DEWHA 2009).	0	No suitable habitat and lack of recent and regular records, **unlikely to occur**

EPBC – Status under EPBC Act; **TSC** – Status from Threatened Species Conservation Act; **FM** – Status under Fisheries Management Act; **NSW databases** – Atlas of NSW wildlife and Threatened and Protected Fish Species Records Viewer; **CE** – Critic ally endangered; **EN** – Endangered; **VU**– Vulnerable; **M** = Listed migratory species; **(JAMBA)** = Japan-Australia Migratory Bird Agreement; **(CAMBA)** = China-Australia Migratory Bird Agreement; **(ROKAMBA)** = Republic of Korea- Australia Migratory Bird Agreement; **(Bonn Convention (A2H))** = listed under Section of Bonn Convention.

Birds

Based on the assessment in Table 3, 16 listed threatened bird species were considered likely to occur in the study area. The vulnerability of these species to potential impacts from the proposed development is discussed below.

Threatened species recorded within the study area

Seven species of threatened birds were recorded during the field inspection days within the study area. These are shown in Figure 15 and discussed below.

- **Brown Treecreeper (TSC - vulnerable)**: This species (*Climacteris picumnus victoriae*) is listed as vulnerable in NSW under the TSC Act. It occurs mostly in eucalypt dominated woodlands, especially with rough–barked eucalypts and often with open grassy understorey. It has been recorded in River Red-gum and Black Box woodlands and requires hollows for breeding (Higgins *et al*. 2001).

  Brown Treecreeper was recorded in the study area, although it did demonstrate a preference for Black Box dominated woodland in the Victorian side of the alignment, where it was far more abundant. The species was also found to breed in suitable hollows within the study area. The removal of native vegetation within the study area is likely to have a negative impact on this species, namely through the reduction of suitable breeding habitat.

  The taxonomic status of the population at Echuca/Moama was questioned as part of a peer review by Envirokey (2012), as Echuca lies in a distributional transition zone between the threatened *victoriae* sub-species and the non-threatened *picumnus* sub-species, according to Schodde and Mason (1999). As such, in the absence of detailed taxonomic studies of the population, and under the precautionary principle, the Echuca/Moama population must be considered as the threatened *victoriae* sub-species. Further analysis could be undertaken (and consultation with the Office of Environment and Heritage (OEH)) to provide more confidence in whether the Brown Treecreeper recorded at the study area is the threatened sub-species.

- **Masked Owl (TSC - vulnerable):** This species (*Tyto novaehollandiae* race *novaehollandiae*) is listed as vulnerable in NSW under the TSC Act. It mostly occurs in open woodlands and forests that provide dense and tall tree cover, and adjoining open habitats such as cleared farmlands (Higgins 1999). According to the NSW recovery plan for the Masked Owl (DEC 2006), records of the species are very scarce in the Echuca/Moama region. Similarly, there are very few records in the Victorian AVW for the region. Therefore it is likely to occur in low numbers in the region. One individual was recorded in the study area (Figure 15).

  The removal of native vegetation within the study area is likely to have a negative impact on this species, namely through the reduction of suitable habitat.

- **Varied Sittella (TSC – vulnerable)**: This species is listed as vulnerable under the NSW TSC Act. It inhabits eucalypt open woodlands and forests (Higgins and Peter 2002). One individual was recorded in the study area, therefore, it is likely occur in low numbers in the study area. (Figure 15).

The removal of native vegetation within the study area is likely to have an impact on this species, namely through the reduction of suitable habitat.

Species with suitable habitat that were not recorded within the study area

Apart from the species recorded in the study area, 13 additional threatened bird species are considered likely to occur within the study area, mostly due to the presence of suitable habitats; these include:

Woodland birds: Eight species of woodland birds were considered likely to occur in the study area. These included three parrots and five additional bush birds. The likelihood of the presence of these species in the study area is as follows:

- **Black-chinned Honeyeater (TSC – vulnerable)**: This species is listed as vulnerable in New South Wales under the TSC Act. This honeyeater inhabits open box-ironbark forests and woodlands. Usually found in Red or Mugga Ironbarks, Grey Box, Yellow Gum and Yellow Box. Especially mature tall trees along gullies, low-lying flats and lower slopes. The species is gregarious, usually seen in groups of 3–10 birds (Higgins *et al.* 2001). Black-chinned Honeyeater was not recorded in the study area, although it was recorded in the Victorian side of the alignment. Therefore Black-chinned Honeyeater is likely to occur and make some use of the habitat in the study area.

  The removal of native vegetation within the study area is likely to have an impact on this species, namely through the reduction of suitable habitat.

- **Swift Parrot (EPBC – endangered, TSC – vulnerable)**: The Swift Parrot migrates to Victoria from Tasmania in winter to feed on the flowering eucalypts of the inland slopes of the Great Divide. The species is considered as nomadic in Victoria and NSW, with movements being determined by flowering eucalypts (Emison *et al.* 1987; Higgins *et al.* 2001). Although the Swift Parrot may occasionally pass through the study area, it is highly unlikely it would occur regularly or in significant numbers — it is regarded as having the potential to occur. For this reason this species is unlikely to be significantly impacted by the project. There are no records of the species in AVW but one record in the ANSWW, and although the study area contains potential foraging habitat, the preferred food trees of the species in this region, such as Red Ironbark, Grey Box, Yellow Gum and White Box, are absent.

- **Superb Parrots (EPBC – vulnerable, TSC – vulnerable)**: This species occurs mainly in mature healthy River Red-gums in forest growing on river flats along with Yellow Box, Black Box and Cypress Pine (Higgins 1999). Forest and woodlands often contain an open mid-storey of wattles and ballart. It nests in the hollows of large trees (dead or alive), mainly in tall, riparian River Red-gum forest or woodland. This species' range includes Barmah-Millewa Forest, within approximately 20km of the study area. It is possible this species may occasionally occur in the study area due to the presence of suitable foraging habitat; however numbers are unlikely to be significant, especially as no records within the search region were found. The centre of the population occurs in habitats further east along the Murray River, associated with the Barmah – Millewa forests. This species has the potential to occur in the study area but is unlikely to be significantly impacted by the project.

- **Turquoise Parrot (TSC – vulnerable):** This species occurs in eucalypt forests and woodlands with grassy ground cover and sometimes with a shrubby understorey. The species has been recorded mostly from box/ironbark eucalypt associations although it may also occur in riparian woodlands dominated by River Red-gum (Higgins 1999). It feeds on seeds of grasses and shrubs. There are no records of this species in search region in the ANSWW, although there are three old records of this species in the Atlas of Victorian Wildlife (AVW) (Viridans Biological Databases 2011), between 1984 and 86. Although this species may occur in the study area as suitable habitat is present, it is unlikely to occur there regularly, as evidenced by the lack of recent atlas records, despite records being submitted regularly to most of these databases. This species is unlikely to be significantly impacted by the project.
- **Grey-crowned Babbler (TSC vulnerable):** This species occurs in woodlands of Black Box, Grey Box, Yellow Box and Cypress-pine, and in open forest dominated by River Red-gum, sometimes with a mid-storey of Black Wattle and groundcover with abundant leaf litter and sparse cover of grasses. The Grey-crowned Babbler is a territorial, co-operative breeding species. The species roosts communally at night in nests known as dormitory nests, comprising sticks externally in a domed form and lined with softer materials such as grass, feathers or wool. Dormitory nests usually number several (usually a minimum of four) in a small area and if used, house up to 14 birds. The babbler is an active, gregarious species and members of a group often draw attention to themselves by their noisy chattering calls and other group behaviors such as chasing and mobbing (Higgins and Peter 2002).

  There were four records of the Grey-crowned Babbler in the search region, from 2004 and 2005, according to the ANSWW.

  All woodland and forest habitat in the study area was considered to be potential habitat for this species. Given that potential habitat exists, this species was considered to have potential to occur in woodland habitat within the study area. During the field survey, as was the case during the 2009 surveys (BL&A 2011), no evidence was found for the occurrence of this species. No nests were located and no birds were found. Information obtained from the Murray Shire indicated that this species is occasionally observed along the proposed alignment on the New South Wales side of the Murray River (BL&A 2011). Such occurrences appear to be dispersing individuals, in the absence of nests that would suggest a permanent presence in the study area. It is therefore unlikely that a breeding population of Grey-crowned Babblers occurs in the vicinity of the proposed alignment, although they may occur elsewhere along the Murray River nearby. This species is unlikely to be significantly impacted by the project.
- Potentially suitable habitat also occurs for several other woodland species, such as the **Diamond Firetail**, **Speckled Warbler (TSC - vulnerable)** and **Hooded Robin (TSC - vulnerable).** The ANSWW contains one record for each of these within the search region. Therefore, although these species may occasionally utilise the habitats in the study area, they are unlikely to occur regularly or in significant numbers. These species are unlikely to be significantly impacted by the project.

Migratory Birds

The EPBC Act Protected Matters Search results also identified suitable habitat in the search region for listed migratory bird species protected under this Act.

Most of the migratory species have not been recorded in the search region and habitat for them (wetter forests and gullies) is absent (see Table 3). Therefore it is expected they would not occur regularly in the study area and are unlikely to be significantly impacted by the proposed development.

- **Rainbow Bee-eater (EPBC – migratory)**: A summer visitor to the region, was recorded within the study area. The bee-eater was not recorded during the initial 2011 survey, probably as it had not yet arrived in the area, but was later recorded during the November 2011 and October 2012 surveys. The Rainbow Bee-eater is widespread in Australia and while listed under the EPBC Act as a migratory species, it is not threatened under state or Federal legislation.
- **White-bellied Sea-eagle (EPBC – migratory)**: The eagle may occur in and forage along the Murray River. One record of this species occurs in the search region from 1999. It is mostly a coastal species, but is also known to occur along the Murray River (Emison *et al.* 1987). The species is known to build its nests in River Red-gum trees, and as suitable habitat is present, it has the potential to occur in the study area. No nests of this species were found during the assessment and it is unlikely to be a resident in the area on regular basis. This species is unlikely to be significantly impacted by the project.
- **Eastern Great Egret (EPBC – migratory):** There is limited habitat for this species along the Murray River, namely the billabongs, and such habitat would be temporally used for foraging but unlikely to support breeding. This species is unlikely to be significantly impacted by the project.
- **Fork-tailed Swift and White-throated Needletail (migratory):** These two bird species are highly nomadic when in Australia and move in flocks ahead of weather fronts, often over heavily forested areas. These species have the potential to occur in the study area occasionally due to the presence of suitable habitat.

Mammals

Based on the assessment in Table 3, three listed mammal species were considered likely to occur in the study area, including two arboreal mammals and one microbat. The potential impacts on these species as a result of the proposed development are discussed below.

- **Squirrel Glider (TSC – vulnerable):** This species occurs in dry forests and woodland and utilises habitats with mature and mixed-age trees, including those dominated by River Red-gum and with Silver Wattle and Black Wattle in the understorey. The species requires hollows for building dens and a range of hollow types can be utilised (Menkhorst 1995). Squirrel Gliders are known to utilise linear road reserves with suitable habitat and in many rural areas of Victoria depend on such habitat, particularly the large trees (van der Ree 2002, van der Ree and Bennett 2003). There was one record of this species in the search region in the ANSWW, and 28 records in the Victorian AVW ranging from 1980 to 2000; three of these locations are close to the study area (within one kilometre). While not detected during either of the initial or

targeted hair tube trapping surveys undertaken in the study area, one Squirrel Glider was detected incidentally during spotlighting surveys in November 2012. This Squirrel Glider was recorded adjacent to aerial cage trap no. 8 (see Section 7.3.4 below).

- A further seven Squirrel Gliders were captured in and near the study area during an intensive targeted survey of 1068 trap-nights, carried out between 16th and 27th March 2015 (van der Ree *et al*. 2015).

  Results of the status of this species in the study area are described in Section 7.3.4, Mitigation measures for Squirrel Glider have been included in Section 9 and discussed in van der Ree et al. (2015) and BL&A (2015d).

- **Koala (EPBC – vulnerable, TSC – vulnerable):** Inhabits sclerophyll forest and woodlands on both sides of the Great Divide (Menkhorst 1995).

- Inhabits sclerophyll forest and woodlands on both sides of the Great Divide (Menkhorst 1995). The ANSWW contained one record from the search region. It is likely that the species may inhabit the study area, but such presence would be rare since habitats in the study area lack the preferred eucalypt food for the Koala. While this species has the potential to occur in the study area, it is unlikely to be significantly impacted by the project.

- **Yellow-bellied Sheathtail Bat (TSC – vulnerable).**

  The presence of Yellow-bellied Sheathtail Bat was confirmed in the study area during the bat surveys and is discussed further below in Section 7.3.4.

Reptiles

Based on the assessment in Table 3, no listed reptiles were considered likely to occur in the study area.

Frogs

Based on the assessment in Table 3, no listed frog species were considered to potentially occur in the study area.

Fish

Based on the assessment in Table 3, three listed fish species were considered likely to occur in the study area. These include:

- Silver Perch (EPBC – Critically endangered);
- Murray Cod (EPBC – Vulnerable, FM – Endangered); and
- Trout Cod (FM Endangered).

The TPFSRV contained records for two of these species: the Murray Cod and Trout Cod. While not recorded in the aquatic survey undertaken in the study area (GHD 2015), all the above fish species are considered likely to occur in the study area. Impacts to fish species should be mitigated by ensuring erosion controls and other mitigation measures are put in place during construction (Section 9.2.5).

7.3.4. Threatened Species Targeted Surveys

Results of the hair tube trapping

An extensive trapping regime was set up during November 2011 (8–22/11/2011) to investigate possible presence of the threatened Squirrel Glider within the study area. Hair tube traps were used and set up along two transects (Figure 3) representing the woodland and forest habitats within the study area (for details of methods; see section 6.2.7).

The analysis of hair trapped by the hair tubes did not reveal the presence of Squirrel Glider in the study area. However, the hair tubes recorded the presence of the Common Brushtail Possum and Sugar Glider; both common arboreal mammals in NSW.

Results of the arboreal cage trapping for Squirrel Glider

Arboreal cage trapping was conducted within suitable habitat in the study area during October 2012 (16-19/10/2012) to determine the status of the threatened Squirrel Glider.

The results were negative for Squirrel Glider; the only species trapped was the Common Brushtail Possum. For detailed trapping results, including weather conditions, see Section 6.2.5 in BL&A 2013b. Trap locations are presented in Figure 3.

However, during incidental spotlighting during the 2012 Southern Bell Frog targeted survey, a Squirrel Glider was detected adjacent to aerial cage trap no. 8 (see next section).

Results of the arboreal cage trapping for Squirrel Glider - 2015 intensive survey

An intensive survey of Squirrel Glider was carried out using cage traps from 16th to 27th March 2015 to elucidate the local distribution and key habitat requirements of the Squirrel Glider in the study area.

The intensive survey captured a total of seven Squirrel Gliders in the survey period.

Six of the Squirrel Gliders were captured close to the mid-west alignment – four in New South Wales and two in Victoria – and the remaining Glider was captured at Sutton Street (Banyle Park State Forest). The Gliders were all captured in *Eucalyptus* woodland, and although most were outside the actual alignment, they were considered likely to use the alignment as part of their normal home ranges and/or dispersal.

The Squirrel Glider population of the local areas was considered to be low, but resident and functioning as well as could be expected given that some habitat elements showed evidence of degradation, e.g. less than optimum density of large, old, hollow-bearing trees, lack of *Acacia* understorey; reduced coarse woody debris due to firewood collection; and patchy weed cover (van der Ree et al. 2015).

Full details including sites where the Squirrel Gliders were found are presented in van der Ree *et al.* (2015) a copy of which is attached as Appendix 8 of this report.

Results of call playback and spotlighting

2011 surveys

Detailed targeted surveys were undertaken at the study area during November 2011. These were designed to complement earlier surveys carried out during the initial surveys of September 2011. The methods and timing for these surveys are described above in the methods section (section 6.2.7).

Surveys were aimed at determining the status of the Bush Stone–Curlew and Barking Owl.

Despite extensive survey effort, none of the two threatened fauna species were detected although suitable habitat is present. Due to this it has been concluded that the Bush Stone-curlew and Barking Owl are not permanent residents in the study area.

For detailed results of these surveys, see Table 8 in BL&A 2013b.

2012 survey

Incidental arboreal spotlight surveying was carried out on the evenings of October 17th and 18th 2012 in the study area, concurrently with the Southern Bell Frog survey (see below).

On the 17th October 2012 an unidentified glider (*Petaurus* spp.) was observed in a tree adjacent cage trap no. 8 (see Figure 15). Numerous photographs were taken of the specimen to aid in identification. Expert advice on the identification of the glider was provided by Rodney van der Ree, based on the photographs. His conclusion was that the specimen was 'almost certainly a Squirrel Glider' (Rodney van der Ree, pers. comm.). As such, the Squirrel Glider is considered resident in the study area.

On the 18th October 2012, a Masked Owl was identified near cage trap no. 2 (see Figure 15). See Section 7.3.3 above for species details.

Results of the Southern Bell Frog survey

Suitable habitat for the Southern Bell Frog was identified in the study area. Two survey sites were selected, and are described as follows:

Site 1: Deep semi-artificial billabong aquatic habitat

This water body was presumably one of a chain of a shallow billabongs, situated some 600 metres north-east of the Murray River channel. However, there was ample evidence that it had been dammed and excavated, thereby increasing its size and depth.

The banks were steep and moderately vegetated with young River Red-gum and Black Box trees, planted willows and bottlebrush and Pale-fruit Ballart shrubs. The ground layer was very sparse, comprising introduced grass and forb species. Aquatic and semi-aquatic flora was sparse, comprising sedges and rushes, Slender Knot-weed, Cumbungi, Water Couch, Water Buttons, Slender Dock and Swamp Wallaby-grass.

A more detailed description of this wetland is provided above in Section 7.1.4.

Site 2: Flooded red gum woodland aquatic habitat

This aquatic habitat occurred on ephemeral flooded red gum woodland, some 500 metres east of the Murray River channel. It is presumed that periodic inundation would be effected by both flooding of the Murray River and heavy rainfall.

The entire water column was well vegetated with a sparse canopy of large and sapling River Red-gums, virtually no shrub stratum and a ground stratum dominated by indigenous wetland species such as Common Spike-sedge, Poong'ort and various rushes, Swamp Wallaby-grass, Austral Sweet-grass, Common Blown-grass, willow herb, Water Milfoil, Ferny Small-flower Buttercup, Common Sneezeweed and Slender Dock.

A more detailed description of this wetland is provided above in Section 7.1.4.

The location of the above survey sites are presented in Figure 3.

Six frog species were aurally detected during the survey, and none were detected visually. These were all common frogs none of which were threatened species. No Southern Bell Frogs were heard or observed during the current targeted survey, nor were any Southern Bell Frog tadpoles captured during dip-netting.

For detailed results of the Southern Bell Frog surveys, including weather conditions, see Tables 9 and 10 in BL&A 2013b.

Results of the hollow-bearing tree survey

Thirty-five (35) hollow-bearing trees were recorded in the NSW component of the study area, the majority of which were associated with the riparian zone of the Murray River and the gazetted road reserve (Forbes Street) in the north-east of the study area. The number, nature of and approximate size of the hollows is presented in Table 4, and their locations are presented in Figure 16.

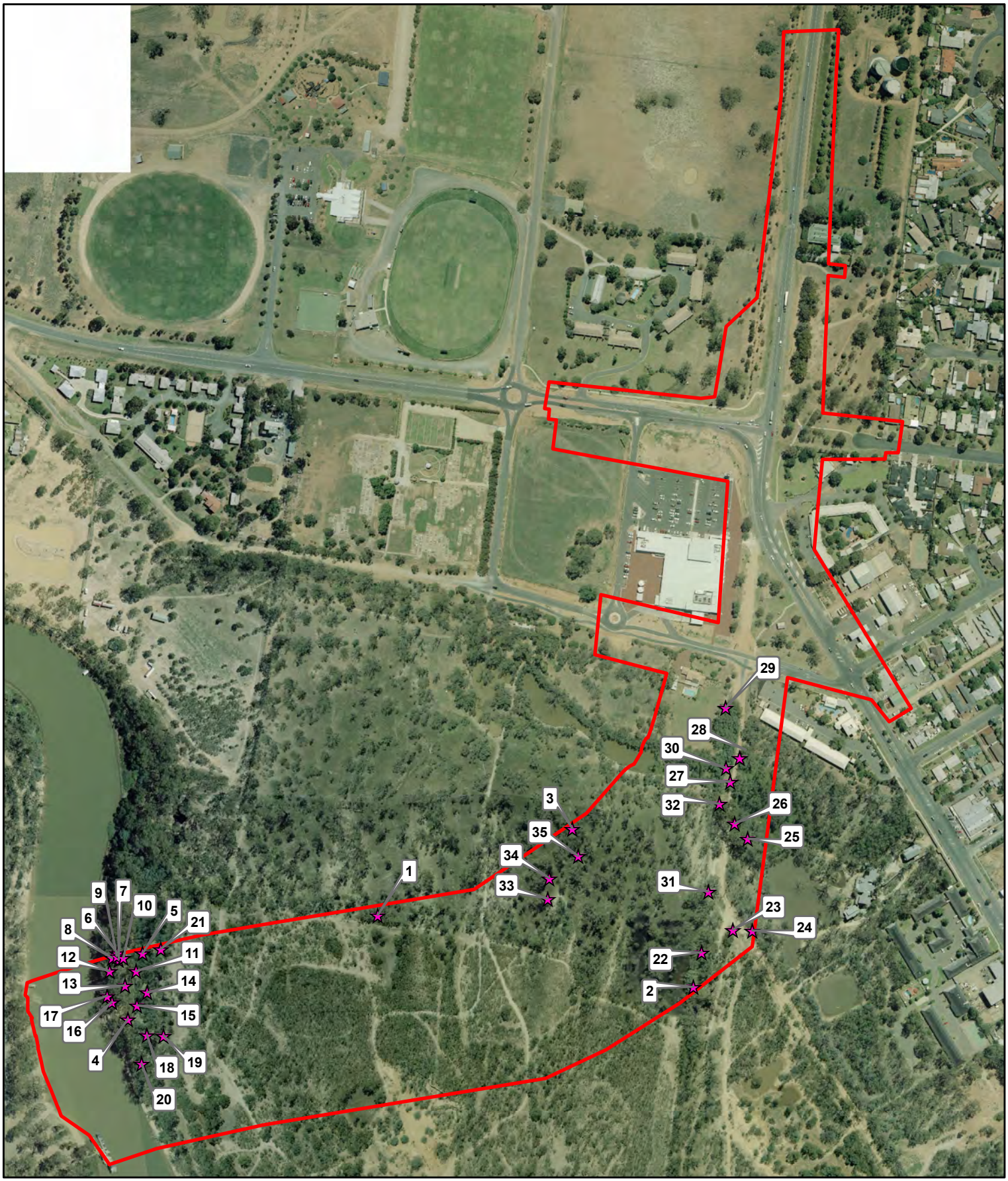
Hollow dependant threatened species include:

- Barking Owl;
- Brown Treecreeper;
- Masked Owl;
- Superb Parrot;
- Turquoise Parrot;
- Brush-tailed Phascogale;
- Squirrel Glider; and
- Yellow-bellied Sheathtail Bat.

Table 4: Hollow bearing trees in the study area

Tree no.	Tree species	Tree hollow details
1	River Red-gum	5 Potential small spouts
2	River Red-gum	4 Trunk hollows (20-50 cm diam'), 8 spouts (10-25 cm diam')
3	River Red-gum	2 Trunk hollows (20 cm diam'), one spout (15 cm diam')
4	River Red-gum	One spout (15 cm diam')
5	River Red-gum	3 Spouts (10-25 cm diam')
6	Dead stag	One trunk hollow (20 cm diam')
7	Dead stag	One trunk hollow (25 cm diam')
8	River Red-gum	Numerous potential trunk fissures
9	River Red-gum	One spout (10 cm diam')
10	River Red-gum	One potential 10 cm diam' spout
11	River Red-gum	Numerous potential spouts
12	River Red-gum	One spout (15 cm diam')
13	River Red-gum	2 Spouts (10 cm diam')
14	River Red-gum	2 Spouts (10 cm diam')
15	River Red-gum	Large trunk basal hollow
16	Dead stag	One trunk hollow (30 cm diam'), 3 spouts (15 cm diam')
17	River Red-gum	One trunk hollow (30 cm diam'), 5 spouts (10 cm diam')
18	River Red-gum	One trunk hollow (20 cm diam')
19	River Red-gum	One trunk hollow (15 cm diam')
20	River Red-gum	One trunk hollow (20 cm diam')
21	River Red-gum	One trunk fissure (10 cm diam')
22	River Red-gum	2 Potential spouts
23	River Red-gum	2 Spouts (10-15 cm diam')
24	River Red-gum	3 Potential spouts (10 cm diam')
25	Dead stag	One trunk fissure (10 cm diam')
26	River Red-gum (near dead)	One large trunk hollow (30 cm diam')
27	River Red-gum	One spout (20 cm diam')
28	River Red-gum	3 Potential spouts (10 cm diam')
29	River Red-gum	2 Spouts (15 cm diam')
30	Dead stag	Potential small spouts
31	River Red-gum	2 Potential spouts (10 cm diam')
32	River Red-gum	One trunk hollow (15 cm diam'), 2 spouts (10 cm diam')
33	River Red-gum	4 Spouts (10 cm diam')
34	River Red-gum	2 Potential spouts (10 cm diam')
35	Dead stag	One trunk hollow (30 cm diam'), one spout (15 cm diam)

Note: diam' = diameter



Legend

Study Area

Hollow-bearing trees

0 75 150 300 Metres

Figure 16: Location of hollow-bearing trees

Project: Murray River Crossing Echuca

Client: VicRoads

Project No.: 8194	Date: 29/08/2014	Created By: B. MacDonald / M. Ghasemi

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Results of the Bat Surveys

Bats were recorded across two separate survey periods, the first during November 2011 and second during February and March 2012. During these surveys, bats were recorded at three sites representing the various habitats in the study area. The location of the bat survey sites is presented in Figure 3. The timing and location of the survey sites are described above in the methods section (section 6.2.7).

The high number of bat calls recorded during both surveys suggests the study area is an important area for bats in general. This is not surprising since the woodland and forest within which recording was carried out, combined with the presence of the Murray River and associated wetlands, provided high quality habitats both for roosting and foraging.

Results of the First Bat Survey

Across the three survey sites, many thousands of bat calls were recorded, with an average of 1,500 calls per site over the seven recording nights.

No attempt was made to separate the number of calls for each species of the common bats as such a process is time and effort consuming and would add little knowledge to the abundance of species. Calls of threatened species were identified and the number of calls recorded counted. Given that the number of bat calls recorded on an Anabat system is not a measure of abundance, the higher the amount of bat calls from one point may reflect a relative measure of the importance of that area to bats at any given point. For example if an Anabat system had a high number of bat calls from any given location, that area is likely to be highly utilised by bats and is therefore an important area for bats in general.

During the first survey, 11 species of bats were recorded from the three sites. The list included ten common and secured bat species and one threatened form.

Table 5 presents the bat species recorded in the study area during the first survey and the number of nights in which species were recorded. The table shows that common species were recorded almost at every night of recording and in all the sites of study. Long-eared bats (*Nyctophilus*) were not possible to identify to species level. All species in this group have therefore been lumped together for the purpose of this assessment.

For detailed results of the first bat survey, see Appendix 8 in BL&A 2013b.

<u>Threatened bats</u>

Of the 11 species of bats recorded for the study area during the first survey, one species was listed as threatened. This was the **Yellow-bellied Sheathtail Bat,** listed as vulnerable under the TSC Act. The number of bat calls recorded for this species during the first survey is presented in Table 6.

Table 5: Bat species, status and number of nights recorded during the first bat survey within the study area

Common names	*Scientific name*	No. nights Recorded at sites			Conservation status	
		6	7	8	EPBC Act	TSC Act
Gould's Wattle Bird	*Chalinolobus gouldii*	7	7	7		
Chocolate Wattle Bat	*Chalinolobus morio*	7	7	6		
Southern Freetail bat (spp. 2)	*Mormopterus spp. 2*	6	7	7		
Southern Freetail bat (spp. 4)	*Mormopterus spp. 4*	7	7	2		
Long-eared Bat	*Nyctophilus spp.*	7	7	7		
Inland Broad-nosed Bat	*Scotorepens balstoni*	5	7	6		
Yellow-bellied Sheathtail Bat	*Saccolaimus flaviventris*	1	7	3		Vulnerable
White-striped Freetail Bat	*Tadarida australis*	7	7	7		
Large Forest Bat	*Vespadelus darlingtoni*	7	7	7		
Southern Forest Bat	*Vespadelus regulus*	0	7	0		
Little Forest Bat	*Vespadelus vulturnus*	7	7	7		

Table 6: Threatened bat species and the number of calls recorded within the study area during the first survey

Threatened Bat Species	Total number of calls for the seven nights of recording at each site						Overall total
	6		7		8		
Yellow-bellied Sheathtail Bat	2	0-2	32	3-8	3	0-1	48

Results of the Second Bat Survey

During the second survey, one of the recording sites (sites 7) failed to record due to unusual heavy rains and partial flooding in the area. For the remaining two sites (Sites 6 and 8), recording was carried out over 10 consecutive nights.

No attempt was made to separate the number of calls for each species of the common bats as such a process is time and effort consuming and would add little knowledge to the abundant species. Calls of threatened species were identified and the amounts were counted. Although bat calls are not a measure of abundance, they may reflect a relative measure of the importance of bats in a given area.

During the second survey, 11 species of bats were recorded from the two sites. The list included ten common and secured bat species and one threatened form.

Table 7 below presents the bat species recorded in the study area during the second survey and the number of nights in which species were recorded. The table shows that common species were recorded during most nights of recording in both survey sites.

The species recorded within the study area in the second survey were similar to those recorded in the first survey. However, call analysis undertaken by Greg Richards indicated that Yellow-bellied Sheathtail Bat was not recorded in the second survey (but was recorded during the first survey).

Despite the reduction of recording sites in the second survey, the findings were similar to the first bat survey, with the majority of bat call files being that of the common species.

For detailed results of the second bat survey, see Appendix 9 in BL&A 2013b.

<u>Threatened bats</u>

One threatened bat species (TSC Act — vulnerable) was recorded during the first survey — Yellow-bellied Sheathtail Bat — but was not recorded during the second survey (see Table7, Table 8 and Table 9).

Table 7: Bat species, status and number of nights recorded during the second bat survey within the study area

Common name	Scientific name	Recording sites		Conservation status	
		6	8	EPBC Act	TSC Act
Gould's Wattle Bird	*Chalinolobus gouldii*	1	2		
Chocolate Wattle Bat	*Chalinolobus morio*	5	4		
Southern Freetail bat (spp. 2)	*Mormopterus ridei*	1	1		
Southern Freetail bat (spp. 4)	*Mormopterus spp. 4*	3	0		
Long-eared Bat	*Nyctophilus spp.*	3	3		
Inland Broad-nosed Bat	*Scotorepens balstoni*	2	1		
White-striped Freetail Bat	*Tadarida australis*	3	0		
Large Forest Bat	*Vespadelus darligtoni*	5	10		
Southern Forest Bat	*Vespadelus rugulus*	1	5		
Little Forest Bat	*Vespadelus vulturnus*	1	9		

Table 8: Comparison of threatened bat species number of calls recorded between first and second bat survey

Site	Yellow-bellied Sheathtail Bat	
	First survey	Second survey
	No. of calls	No. of calls
6	2	0
7	32	*
8	3	0
Totals	**37**	**0**

* = failure of recording at the site.

Note: Call analysis undertaken by Greg Richards

Discussion of threatened bats recorded within the study area

This section discusses the habitats, results of surveying and potential impacts for the one threatened bat species recorded within the study area during the bat surveys.

Yellow-bellied Sheathtail Bat

The Yellow-bellied Sheathtail Bat is listed as vulnerable under the NSW TSC Act. It is a wide-ranging species found across northern and eastern Australia. In the most southerly part of its range, it is a rare visitor in summer and autumn. They

roost singularly or in groups of up to six, in tree hollows and buildings; in treeless areas they are known to utilise mammal burrows. Seasonal movements are unknown; there is speculation about a migration to southern Australia in late summer and autumn.

First survey results

During the first survey, 37 Yellow-bellied Sheathtail Bat calls were recorded in the study area over seven recording nights. And according to BL&A 2013b, nearby, in the Victorian section of the proposed alignment, 92 calls were recorded from all four of the recording sites there. The total calls of this bat constitute only 0.63% of the total calls of bats recorded, indicating low activity compared to the other common bats found in the study area.

Second survey results

During the second survey, no Yellow-bellied Sheathtail Bat calls were recorded in the study area over 10 recording nights. And according to BL&A 2013b, nearby, in the Victorian section of the alignment, 17 calls were recorded from all three of the recording sites there.

The numbers of calls recorded indicate low activity of this species at this time of year (February to March 2012) compared to the number of calls recorded during the first survey undertaken in November 2011. This is likely to be due to the seasonal movements of the species, which is known to be a rare visitor in the southern part of its range during summer and autumn (Churchill 2008).

Conclusion

The review of existing information and results of the surveys suggest that while the Yellow-bellied Sheathtail Bat may infrequently occur in the region, it is unlikely to be a permanent resident there, considering the dispersive characteristics of the species. It is also unlikely that the species breeds in the region either, as very few captured specimens in southern Australia have been in breeding condition.

7.4. Endangered Ecological Communities

The review of existing information revealed that the following endangered ecological communities (EEC's) were either known to exist in the search region or modelling predicted their occurrence there:

- EPBC Act:
  - Buloke Woodlands of the Riverina and Murray-Darling Depression Bioregions (endangered);
  - Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and Derived Native Grasslands of South-eastern Australia (endangered);
  - Natural Grasslands of the Murray Valley Plains (critically endangered);
  - Weeping Myall Woodlands (endangered); and
  - White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland (critically endangered).
- TSC Act:

  - *Acacia melvillei* Shrubland in the Riverina and Murray-Darling Depression bioregions (endangered);
  - *Allocasuarina luehmannii* Woodland in the Riverina and Murray-Darling Depression Bioregions (endangered);
  - Inland Grey Box Woodland in the Riverina, NSW South Western Slopes, Cobar Peneplain, Nandewar and Brigalow Belt South Bioregions (endangered);
  - Myall Woodland in the Darling Riverine Plains, Brigalow Belt South, Cobar Peneplain, Murray-Darling Depression, Riverina and NSW South Western Slopes bioregions (endangered); and
  - Sandhill Pine Woodland in the Riverina, Murray-Darling Depression and NSW South Western Slopes bioregions (endangered).
- FM Act:
  - Aquatic Ecological Community in the Natural Drainage System of the Lower Murray River Catchment (endangered).

When compared against the community descriptions and qualifying criteria for the above listed EEC's, one type of habitat in the study area qualified as an EEC. That was the aquatic habitat, which qualified as *Aquatic Ecological Community in the Natural Drainage System of the Lower Murray River Catchment.*

The area that this EEC encompasses includes all natural creeks, rivers and associated lagoons, billabongs and lakes of the regulated portions of the Murray River downstream of the Hume Weir. This area includes the Murray River and all natural billabongs and wetlands in the study area (Figure 8).

The Murray River EEC is characterised by a list of assemblages of native fauna species including crustaceans, fish, insects, molluscs and sponges. The community includes 23 native fish species and over 400 recorded native invertebrate species. This list is presented in Appendix 16 of BL&A 2013b. All indigenous aquatic biota within the bounds of this EEC has legal protection under the NSW FM Act.

7.5. Critical habitats

No critical habitats were listed as occurring in the search region.

7.6. Endangered flora and fauna populations

No endangered flora and fauna populations were listed as occurring in the search region.

8. POTENTIAL IMPACTS OF THE PROPOSAL

8.1. Loss of vegetation and habitat

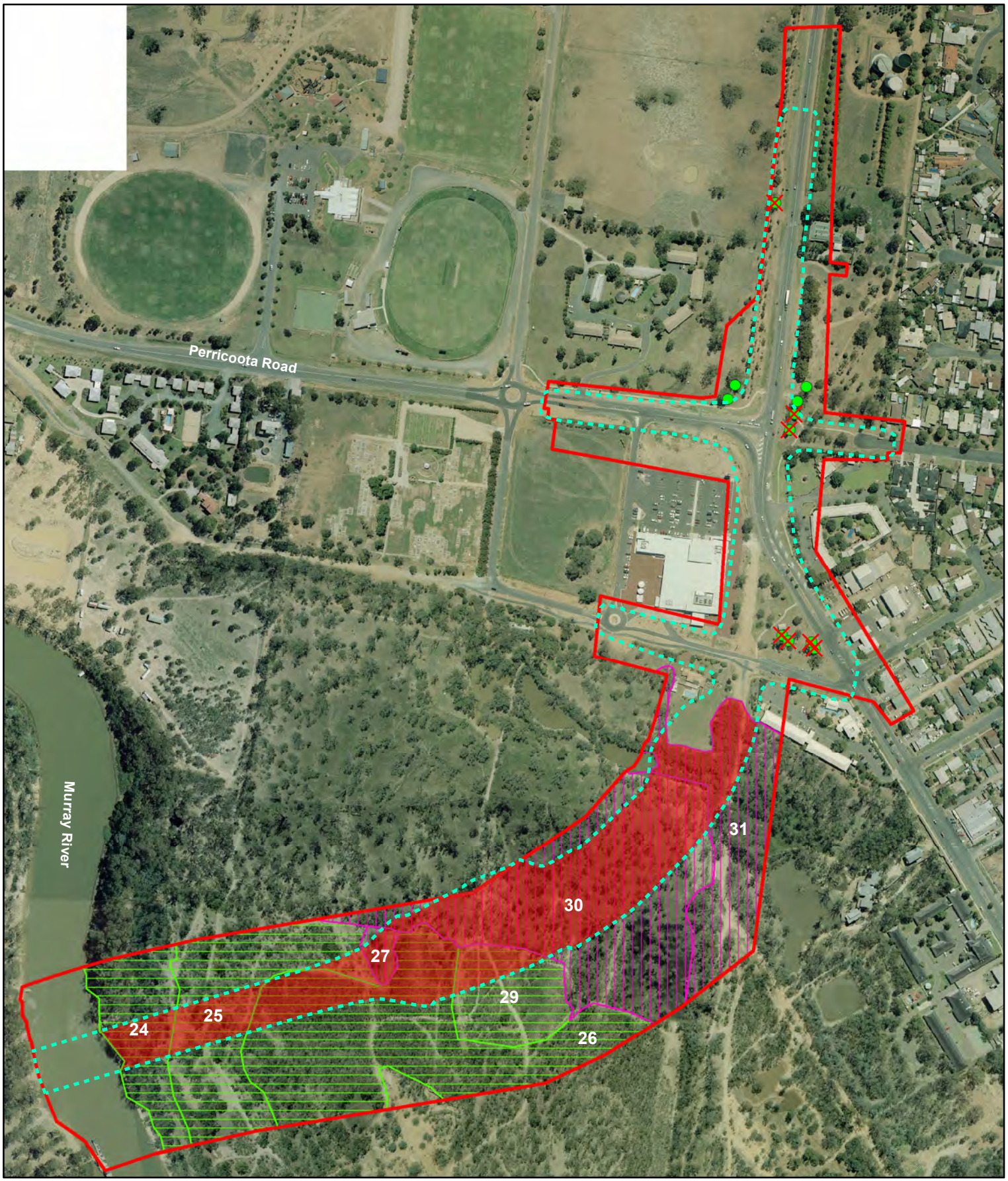
8.1.1. Impacts on native vegetation

The area of remnant native vegetation that would be impacted under the Proposal totals 5.08 hectares (Table 9). A total of seven scattered trees (outside of patches) would also be impacted under the Proposal. Impacts on native vegetation are presented in Figure 17.

River Red Gum - Black Box woodland of the semi-arid (warm) climatic zone is estimated to be 45% cleared in the Murray Catchment, and River Red Gum - herbaceous tall open forest of the Riverina and Murray Darling Depression Bioregions is estimated to be 10% cleared in this catchment. Both these vegetation types fall below the 70% threshold for an 'overcleared vegetation type' according to the supporting databases of the Biobanking Assessment Methodology (DECC 2008).

Table 9: Proposed native vegetation losses

Site ID	Vegetation Type	Area of native vegetation removed (ha)
24	River Red Gum - Black Box woodland	0.27
25	River Red Gum - Black Box woodland	0.49
26	River Red Gum - Black Box woodland	0.92
27	River Red Gum - herbaceous tall open forest	0.13
29	River Red Gum - Black Box woodland	0.27
30	River Red Gum - herbaceous tall open forest	2.43
31	River Red Gum - herbaceous tall open forest	0.57
Totals		5.08



Legend

- Study area
- Alignment
- Native vegetation to be removed
- Scattered trees to be removed

Native vegetation

- River Red Gum - herbaceous tall open forest
- River Red Gum - Black Box woodland
- Scattered trees

Metres
0 50 100 200

Figure 17: Native vegetation to be removed

Project: Murray River Crossing Echuca

Client: VicRoads

Project No.: 8194	Date: 20/07/2015	Created By: B. MacDonald / M. Ghasemi

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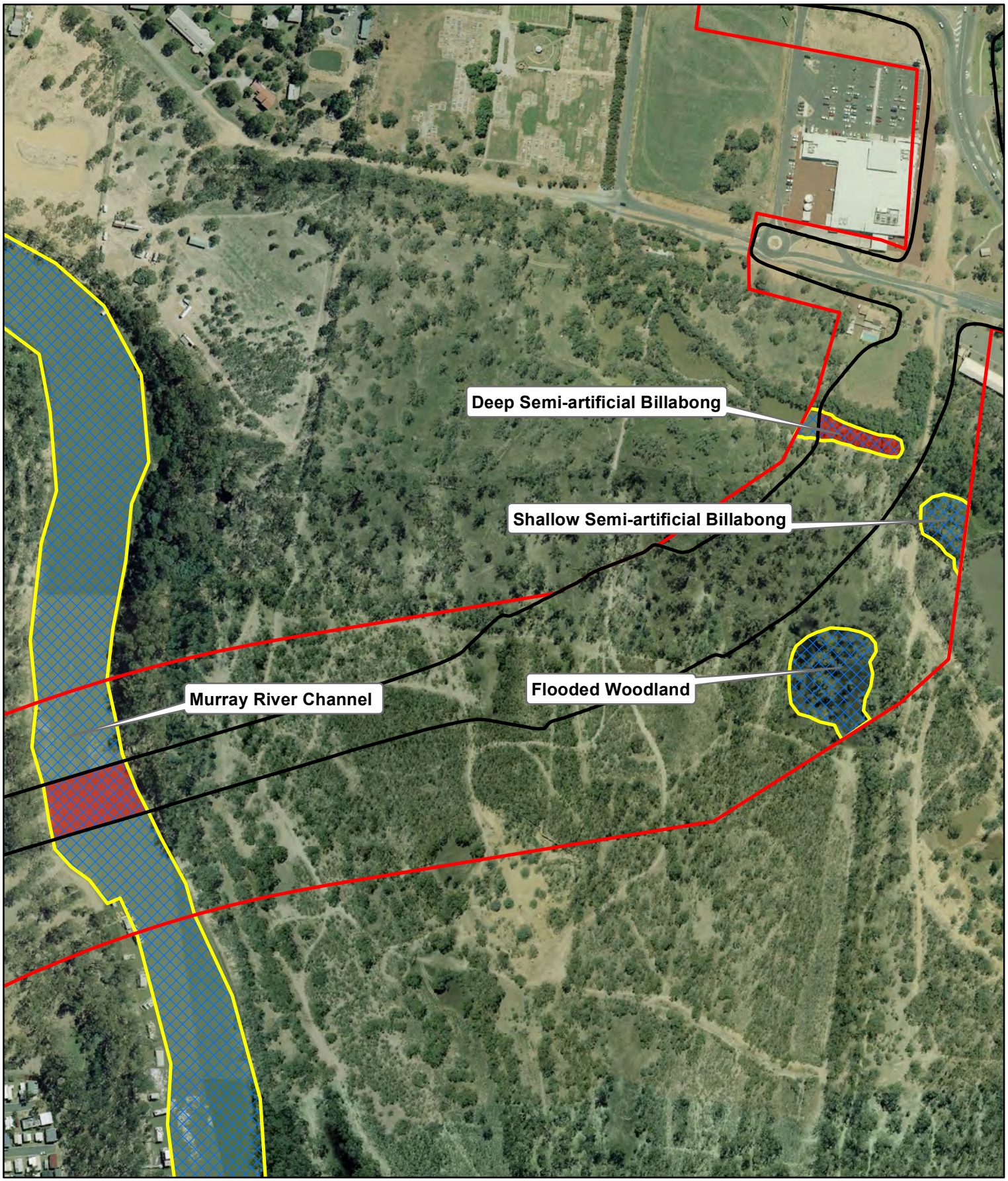
8.1.2. Impacts on endangered ecological communities

The Proposal would impact on approximately 0.5 hectares of the *Aquatic Ecological Community in the Natural Drainage System of the Lower Murray River Catchment* (Murray River EEC), including the Murray River and all associated wetlands in the study area and the EEC's indigenous aquatic biota. These impacts are presented in Figure 18.

8.1.3. Impacts on fauna habitat

The Proposal would impact on 5.08 hectares of fauna habitat in the form of River Red-gum Herbaceous Tall Open Forest and River Red-gum – Black Box Woodland.

The loss of this habitat would impact on numerous fauna species, potentially including 22 listed threatened or migratory fauna species. Table 10 provides a summary of potential impacts on these species



Legend

- Study area
- Midwest 1 Alignment
- Aquatic Habitat
- Aquatic Ecological Community in the Natural Drainage System of the Lower Murray River Catchment
- Impacts on Murray River EEC

0 50 100 200 Metres

Figure 18: Impacts on Murray River EEC

Project: Murray River Crossing Echuca

Client: VicRoads

Project No.: 8194	Date: 16/07/2015	Created By: K. Al-Dabbagh / M. Ghasemi

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Table 10: Potential impacts on threatened or migratory fauna and ecological communities

Species	Breeding habitat loss	Foraging habitat loss	Increased road mortality	Sedimentation and erosion	Shading
Black-chinned Honeyeater	X	X	X		
Brown Treecreeper	X	X	X		
Diamond Firetail	X	X	X		
Grey-crowned Babbler	X	X	X		
Eastern Great Egret		X	X	X	
Hooded Robin	X	X	X		
Masked Owl	X	X	X		
Rainbow Bee-eater		X	X		
Specked Warbler	X	X	X		
Superb Parrot	X	X	X		
Swift Parrot		X	X		
Turquoise Parrot		X	X		
Varied Sittella	X	X	X		
White-bellied Sea-Eagle				X	X
Fork-tailed Swift		X			
White-throated Needletail		X			
Koala	X	X	X		
Squirrel Glider	X	X	X		
Yellow-bellied Sheathtail Bat	X	X	X		
Murray Cod	X	X		X	X
Silver Perch	X	X		X	X
Trout Cod	X	X		X	X
Murray River EEC	X	X		X	X

8.1.4. Impacts on hollow-bearing trees

The Proposal would result in the removal of 11 hollow-bearing trees from the study area (trees 4, 18, 19, 27 to 30 and 32 to 35 (Figure 19). The size and type of those hollows is detailed in Table 4 above.

The density, or availability, of hollow-bearing trees in the surrounding landscape was not assessed; although it is likely to be similar to that in the study area (i.e.

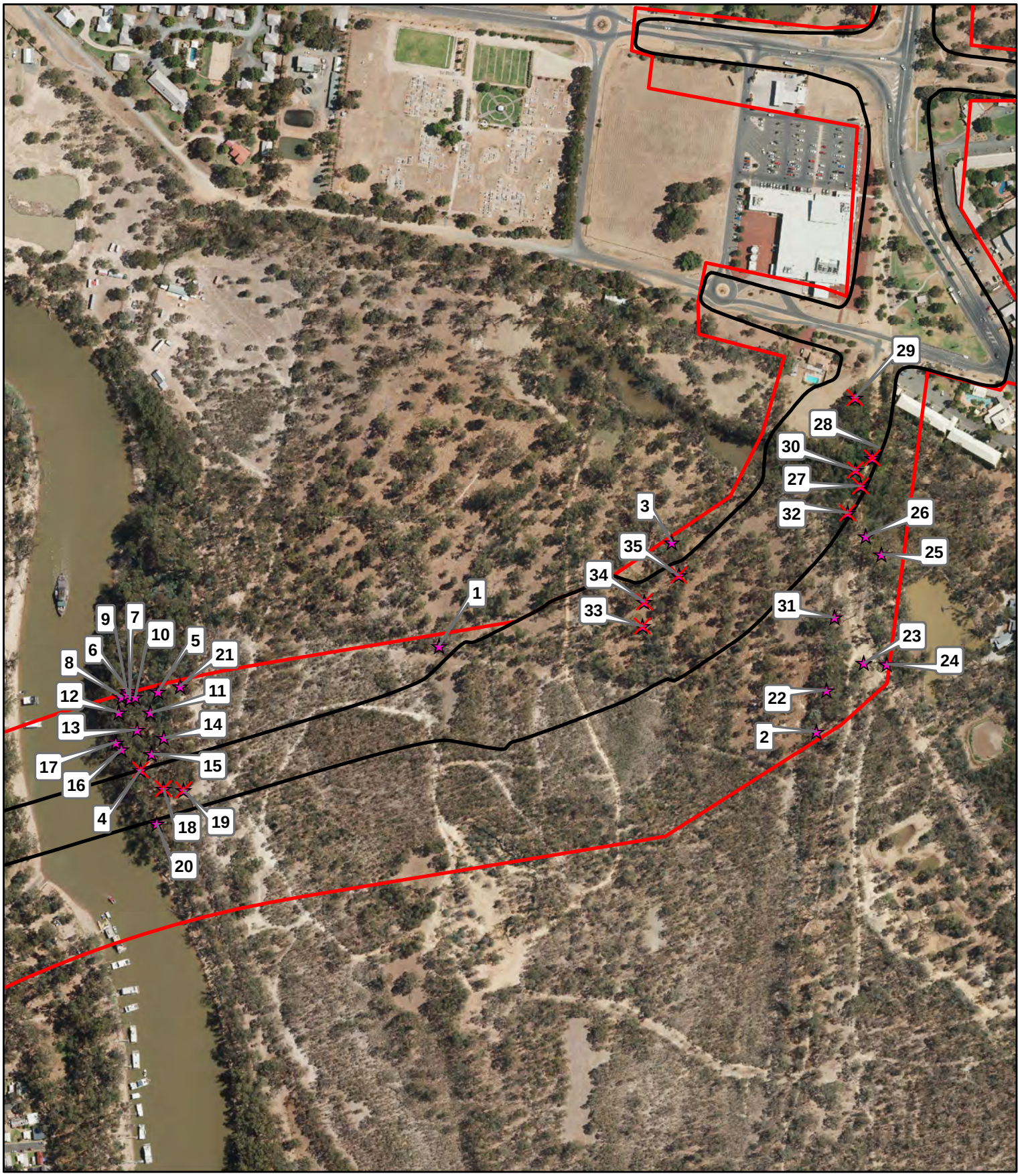
the density was far higher in the habitat subject to the Victorian component of the Proposal).

The loss of hollow-bearing trees from the study area would potentially impact on numerous listed threatened or migratory fauna species either known to occur in the search region, or potentially occur there. These are listed in Table 11.

Table 11: Listed threatened or migratory fauna species potentially impacted by hollow-bearing tree loss

Species	Conservation status	
	EPBC Act	TSC Act
Brown Treecreeper		VU
Masked Owl		VU
Superb Parrot	VU	VU
Swift Parrot	EN	EN
Turquoise Parrot		VU
Squirrel Glider		VU
Yellow-bellied Sheathtail Bat		VU

VU = Vulnerable; EN = Endangered



Metres

0 75 150 300

Legend

- Study Area
- Midwest 1 alignment
- Hollow-bearing trees
- Hollow-bearing trees to be removed

Figure 19: Hollow-bearing trees to be removed

Project: Murray River Crossing Echuca

Client: VicRoads

Project No.: 8194	Date: 13/11/2014	Created By: B. MacDonald / M. Ghasemi

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8.2. Wildlife connectivity and habitat fragmentation

8.2.1. Habitat fragmentation and loss of connectivity

The proposed road carriageway would dissect an approximately 2.25 kilometre wide section of native vegetation (NSW and Victoria), which constitutes part of an important wildlife corridor between the large Barmah and Gunbower forest blocks (Section 7.1.1), thereby increasing fragmentation of habitat in the region – a key threatening process recognised at all regulatory levels. Within the NSW portion of the proposed carriageway, it would also largely isolate an area of native vegetation north of the proposed carriageway, resulting in increased edge effect and subsequent degradation.

The proposal would involve the construction of a raised carriage way across the Murray River floodplain, which would mitigate the effects of habitat fragmentation to some degree, particularly for more mobile terrestrial species, but may remain an effective barrier to more sedentary, less dispersive species.

Mitigation measures have been proposed which would ameliorate some of the potential impacts of habitat fragmentation. These are discussed in sections 9.2.8, 9.2.10 and 9.2.11.

8.2.2. Barrier effects

The barrier effect of roads acts differentially on different faunal groups and species. For some species, the width of habitat clearing itself acts as a deterrent to crossing, for others, the deterrent is the alien nature of the road surface, or traffic noise, or combinations of the above. Studies in Europe, America and Australia have suggested that road width and traffic intensity are the factors that most influence the severity of barrier effects; large multi-lane carriageways which carry heavy traffic loads present the most severe wildlife barriers, while un-sealed roads through national parks present the least. Small terrestrial species with reduced mobility are affected to a greater degree than larger, more mobile species. The movement of birds and bats is less restricted by roads due to their mobility (Donaldson & Bennett 2004).

The most concerning implications of barrier effects on wildlife is fragmentation and isolation of species populations due to movement inhibition, with consequent impacts on the genetic structure and composition of populations. Reduced gene flow between populations increases the risk of extinction, just as habitat fragmentation is widely acknowledged as a primary cause of faunal extinction globally (Donaldson & Bennett 2004).

The scale of the proposed carriageway and predicted high traffic levels could well be expected to constitute a substantial barrier to dispersal for some species. Although, as with habitat fragmentation and loss of connectivity (above), the construction of a raised carriage way across the Murray River floodplain, would mitigate the severity of barrier effects to some degree, particularly for more mobile terrestrial species, but for sedentary and shy and cryptic species, the proposed carriageway may act to isolate populations and may contribute to local faunal extinctions in the long term.

Mitigation measures have been proposed which would ameliorate some of the potential impacts of barrier effects. These are discussed in Section 9.2.11.

8.2.3. Edge effects

Among other disturbance activities, major road carriageway construction through tracts of intact native vegetation tends to create edge effects which penetrate into native vegetation to varying distances from the road. Edge effect zones are characterised by altered vegetation structure and floristics (plant species composition) resulting from changes in local environmental conditions due largely to increased exposure and altered run-off characteristics. Such changes are usually negative; invasive introduced plant species often originate from road sides and penetrate into edge effect zones. Problematic edge specialist fauna, such as the Noisy Miner, also become established in edge effect zones, where they disrupt other fauna.

Edge effect zones would develop north and south of the proposed road carriageway, and impact on the adjacent native vegetation communities and fauna habitat, potentially to a distance of 50 metres or more from the carriageway.

Mitigation measures have been proposed which would ameliorate some of the potential impacts of edge effects. These are discussed in sections 9.2.6 and 9.2.11.

8.3. Impacts on aquatic habitat

8.3.1. Murray River

Potential impacts on the Murray River would include loss or disturbance to riparian vegetation, increased sedimentation and bank erosion, increased rate of water runoff from the road, increased nutrient inputs from road water runoff and shading of the water column and riparian vegetation from the bridge. Natural river flow alteration and obstruction to fish passage would be minimal, as the bridge piers will be constructed either side of the river, such that no permanent bridge infrastructure will be located within the river channel. Refer to GHD's aquatic flora and fauna assessment (GHD 2012) for further detail on potential impacts on aquatic habitat of the Murray.

Mitigation measures have been proposed which would ameliorate some of the potential impacts on the Murray River. These are discussed in Section 9.2.5.

8.3.2. Wetlands

Potential impacts on the three wetlands in the study area (Section 7.1.4) would include loss or severe disturbance to the wetlands, displacement and mortality of aquatic and riparian biota, loss or disturbance to riparian vegetation, increased sedimentation, increased rate of water runoff from the road, increased nutrient inputs from road water runoff and severe shading of the wetlands from the [raised] road carriageway. The Proposal would also likely impact on other wetlands adjacent the study area.

Mitigation measures have been proposed which would ameliorate some of the potential impacts on the wetlands in the study area. These are discussed in Section 9.2.5.

8.4. Injury and mortality

Fauna injury or mortality may occur during the construction phase of the Proposal through the removal of fauna habitat (primarily native vegetation). Injury or mortality are also likely to occur during the operational life of the proposed carriageway, through collision with vehicles. There is also potential for increased fauna injury and mortality as a result of increased habitat fragmentation and modification.

8.4.1. Construction phase

There is potential for fauna injury and mortality during vegetation clearance. Those at greatest risk are species with low mobility, nocturnal species or species with small home ranges. Such species are least inclined, or unable to disperse rapidly away from the disturbance. These include certain ground-dwelling mammals, microbats, possums and gliders, reptiles, juvenile birds in nests and frogs.

Roads and Maritime has developed best practice procedures to minimise impacts on biodiversity during construction activities. These are discussed in sections 9.2.1 through 9.2.4 and 9.2.11.

8.4.2. Operational phase

As the majority of carriageway which dissects native vegetation and fauna habitat will be raised on pylons, terrestrial fauna collisions with vehicles would be far lower than if the carriageway were constructed on earthen road formation, as most terrestrial fauna species would be expected to pass under the carriageway. Arboreal mammals (Koala, possums and gliders), birds and bats would be more vulnerable to collision with vehicles.

Within the scope of this assessment, it was difficult to predict the nature and magnitude of increased fauna injury and mortality resulting from vehicle collision. However, considering that the proposed carriageway would constitute an additional and much larger dissection of the tenuous 'wildlife corridor' between the Gunbower and Barmah forest blocks (Section 7.1.1), fauna injury and mortality rates, compounded by barrier effects (Section 8.2.2), may be significant for some species which are reliant on dispersal between the forest blocks, particularly shy and cryptic species.

It is recommended that further research be conducted to better assess the nature and potential magnitude of this type of impact.

8.5. Weed invasion impacts

The spread and establishment of invasive weeds, in particular noxious species, as listed under the *Noxious Weeds Act 1993*, may occur in the study area during the construction and operation phases of the Proposal. Paterson's Curse was the only weed species listed under the Noxious Weeds Act 1993 which was recorded in the study area. This species is common on roadsides and in disturbed areas. During construction there is potential to disperse Paterson's Curse and other invasive weed seeds and plant material into adjoining areas of remnant vegetation where such weed species do not currently occur. The most likely causes of weed dispersal are associated with clearing of vegetation, stockpile of

contaminated soils and transport of weed propagules via construction vehicles and machinery.

Mitigation measures have been proposed which would ameliorate the spread of invasive weeds in the study area. These are discussed in sections 9.2.6 and 9.2.8.

8.6. Pest and pathogen impacts

8.6.1. Pests

The Proposal has the potential to exacerbate existing impacts on native vegetation and fauna by pest animal species, such as predation by feral cats and the Red Fox and competition for resources by the feral European Rabbit.

The Proposal may contribute to increased levels of predation on native fauna from foxes and cats through the creation of disturbed habitat edges, which facilitate predator movement and predation success rate. Habitat removal will also displace fauna species, rendering them more susceptible to predation.

Habitat modification due to direct clearance and edge effects may favour use of habitat adjacent the proposed carriageway by feral rabbits, which tend to prefer disturbed areas. This may lead to increased competition for food resources between native fauna and rabbits as well as vegetation damage by rabbits.

8.6.2. Pathogens

The Proposal has the potential to facilitate the establishment of deleterious pathogens in the study area. Of particular concern is infection of native plant species by Cinnamon Fungus (*Phytophthora cinnamomi*), which causes root-rot disease and subsequent vegetation dieback. Cinnamon Fungus is spread into new areas by contaminated soil on construction machinery, vehicles and even footwear. There is a risk that Cinnamon Fungus may be introduced into native vegetation in and adjacent the study area during the construction and operational phases of the Proposal.

Chytrid fungus (*Batrachocytrium dendrobatidis*) is a water-borne fungus which causes the disease chytridiomycosis in frogs, and is lethal to a wide variety of Australian frogs. It is spread through cross contamination of water bodies by vehicles and personnel. There is a risk that Chytrid fungus may be introduced into wetlands in and adjacent the study area during the construction phase of the Proposal.

Mitigation measures have been proposed which would ameliorate the impacts of pest animals and pathogens in the study area. These are discussed in Section 9.2.7.

8.7. Hydrological changes

With regard to the hydrology of the Murray River, particularly flow and flooding characteristics, GHD (2012) conclude that, provided that the proposed Murray River Bridge is designed in a manner that does not restrict or impede natural river flows above that currently restricted by the existing bridge upstream, then there

will minimal impact on aquatic habitat due to hydrological changes. Refer to GHD's aquatic flora and fauna assessment (GHD 2012) for further details.

Mitigation measures have been proposed which would ameliorate the impacts of hydrological changes to the Murray River. These are discussed in Section 9.2.5.

8.8. Groundwater dependent ecosystems

River Red Gums along river banks and on floodplains of large rivers in the Murray-Darling Basin are listed as groundwater dependent ecosystems (DPI 2015). This would indicate that proposal will impact on a groundwater dependent ecosystems through removal of vegetation, however, this impact is unlikely to be significant. The proposal is unlikely to alter any groundwater systems.

8.9. Noise, vibration and light

The proposed carriageway would dissect a large tract of fauna habitat which is currently subject to only low levels of artificial light, vibration and noise from adjacent urbanised areas. This would substantially increase during the construction and operational phases of the proposal, and may have an influence on the behaviour of some fauna species in the way that they utilise their environment. For example, some species may not tolerate close proximity to noisy and loud roadways, which may reduce their usable area of habitat.

There is potential for impacts to local fauna from noise and vibration during construction, which may compel some species to temporarily avoid habitats adjacent to the proposed works.

The proposed bridge would also result in shading of the Murray River water Column and riparian vegetation, which would likely modify that vegetation to some extent, and may limit the success of landscaping activities under or near the bridge.

Mitigation measures have been proposed which would ameliorate the impacts of artificial light, vibration and noise associated with the proposal. These are discussed in Section 9.2.11.

8.10. Impact on key threatening processes

Key Threatening Processes (KTP's) listed under the EPBC Act and TSC Act which are relevant to the Proposal are listed in Table 12. The likelihood of the Proposal contributing to these KTP's and proposed measures to mitigate any such contribution is addressed in Table 13.

Key threatening processes identified as being exacerbated by the Proposal were those associated with habitat removal and degradation. Mitigation measures would be implemented to minimise the extent of vegetation removal and habitat degradation (see Section 9.2).

Table 12: Contribution of the Proposal to relevant Key Threatening Processes

KTP	Relevant legislation	Contribute to KTP's?	Proposed mitigation measures
Clearing of native vegetation	EPBC Act TSC Act	Yes	Section 9.2
The degradation of native riparian vegetation along New South Wales water courses	FM Act	Yes	Section 9.2.5
Removal of dead wood and dead trees	TSC Act	Yes	Section 9.2
The removal of large woody debris from NSW rivers and streams	FM Act	Unlikely	Section 9.2.5
Loss of Hollow-bearing Trees	TSC Act	Yes	Section 9.2.9
Invasion of native plant communities by exotic perennial grasses	TSC Act	Potential	Section 9.2.6
Invasion and establishment of exotic vines and scramblers	TSC Act	Potential	Section 9.2.6
Invasion and establishment of Scotch broom (*Cytisus scoparius*)	TSC Act	Potential	Section 9.2.6
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	EPBC Act TSC Act	Potential	Section 9.2.6
Infection of amphibians with Chytrid fungus resulting in chytridiomycosis	EPBC Act TSC Act	Potential	Section 9.2.7
Infection of native plants by *Phytophthora cinnamomi*	EPBC Act TSC Act	Potential	Section 9.2.7
Introduction and Establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae	TSC Act	Potential	Section 9.2.7
Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands	TSC Act FM Act	Unlikely	Section 9.2.5
Loss of terrestrial climatic habitat caused by anthropogenic emissions of greenhouse gases	EPBC Act	Potential	Beyond the scope of this assessment
Human-caused climate change	FM Act	Potential	

8.11. Cumulative impacts

Vegetation communities and fauna habitat in and adjacent the study area have been subject to a long history of disturbance following European settlement of the region. Continuing human population growth and subsequent expansion and intensification of land use in and around the Echuca/Moama township have been placing steadily increasing, and often interacting, pressures on vegetation communities and fauna habitat. The construction of the proposed carriageway (ultimate size – two bridges) would further exacerbate those pre-existing pressures. Given recent population growth estimates for south-east Australia, it would be reasonable to assume that pressures on vegetation communities and fauna habitat in the Echuca/Moama township environs are going to continue to increase.

Of most concern will be the continuing reduction in width and integrity of the wildlife corridor between the Gunbower and Barmah forest blocks. The Proposal would impact this corridor – mostly through native vegetation removal. Future growth of the township would likely further restrict the effectiveness of this very important corridor.

8.12. Potential impacts on Koala habitat

State Environmental Planning Policy No. 44 (Koala Habitat).

River Red Gum (*E. camaldulensis*) is identified in Schedule 2 of SEPP No. 44 as a Koala feed tree species. As more than 15% of the trees in the affected area belong to this species, the habitat is 'potential koala habitat'. Given this, the SEPP calls for a determination to be made on whether the habitat is core koala habitat. This is discussed below.

No Koalas have been detected in the Echuca region in any of the extensive flora and fauna field investigations for this project since 2008. Review of the occurrence of this species in the search region (within 10 kilometers of the proposed development site) in the Atlas of NSW Wildlife indicates that there are no historical records of the species. The nearest records of the Koala to the study area are from a site approximately 10 kilometers to the west along the Murray River (one record) and the Barmah Forest, approximately 20 kilometers to the east.

This indicates that, there is no evidence of either a current or historical population of the Koala in the study area. Therefore, the habitat is not 'core koala habitat' as defined in the SEPP and the provisions of this SEPP therefore do not apply.

9. MITIGATION MEASURES

The following proposed mitigation measures are consistent with the NSW Roads and Traffic Authorities' *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011).

Table 14 provides a summary of potential impacts of the proposal, biodiversity values affected, corresponding mitigation measures and implementation information. This is followed by descriptions of the proposed mitigation measures.

Mitigation measures proposed in the chapter are subject to the approval of Roads and Maritime.

Table 13: Summary of potential impacts and mitigation measures

Impact	Report section	Biodiversity values affected	Relevant mitigation measures	Report section	Responsibility	Timing
Loss of native vegetation	8.1.1	All	All	9	To be advised	Pre-construction to operational phases
Impacts on endangered ecological communities	8.1.2	Murray River EEC and flora and fauna species supported by the EEC	Pre-clearing	9.2.1	To be advised	Pre-construction phase
			Exclusion zones	9.2.2		
			Staged habitat removal	9.2.3		
			Fauna handling	9.2.4		
			Aquatic habitat and riparian zones	9.2.5		Pre-construction to post-construction phases
			Re-establishment of native vegetation	9.2.8		Post-construction phase
			Re-use of woody debris	9.2.10		
			Re-establishment of habitat connectivity	9.2.11		
Impacts on fauna habitat	8.1.3	All fauna species	All	9	To be advised	Pre-construction to operational phases
Impacts on hollow-bearing trees	8.1.4	All hollow-dependant fauna species listed in Table 12.	Pre-clearing	9.2.1	To be advised	Pre-construction phase
			Exclusion zones	9.2.2		
			Staged habitat removal	9.2.3		
			Fauna handling	9.2.4		
			Nest boxes	9.2.9		Construction phase
			Re-use of woody debris	9.2.10		

Impact	Report section	Biodiversity values affected	Relevant mitigation measures	Report section	Responsibility	Timing
Wildlife connectivity and habit fragmentation	8.2	All fauna species to some degree, but less mobile and shy species in particular, such as Squirrel Glider	Re-establishment of native vegetation	9.2.8	To be advised	Post-construction phase
			Re-use of woody debris	9.2.10		
			Re-establishment of habitat connectivity	9.2.11		
Impacts on aquatic habitat	8.3	Murray River EEC and flora and fauna species supported by the EEC	Pre-clearing	9.2.1	To be advised	Pre-construction phase
			Exclusion zones	9.2.2		
			Staged habitat removal	9.2.3		
			Fauna handling	9.2.4		
			Aquatic habitat and riparian zones	9.2.5		Pre-construction to post-construction phases
			Re-establishment of native vegetation	9.2.8		Post-construction phase
			Re-use of woody debris	9.2.10		
			Re-establishment of habitat connectivity	9.2.11		
Injury and mortality	8.4	All fauna species to some degree, but less mobile and manoeuvrable species in particular, such as Squirrel Glider	Re-use of woody debris	9.2.10	To be advised	Post-construction phase
			Re-establishment of habitat connectivity	9.2.11		
Weed invasion impacts	8.5	All species	Weed management	9.2.6	To be advised	Pre-construction to operational phases

Impact	Report section	Biodiversity values affected	Relevant mitigation measures	Report section	Responsibility	Timing
			Re-establishment of native vegetation	9.2.8		Post-construction phase
Pest and pathogen impacts	8.6	Flora species susceptible to die-back caused by Cinnamon Fungus and frog species susceptible to infection with Chytrid fungus	Pathogen management	9.2.7	To be advised	Pre-construction to post-construction phases
Hydrological changes	8.7	Murray River EEC and flora and fauna species supported bt the EEC	Aquatic habitat and riparian zones	9.2.5	To be advised	Pre-construction to post-construction phases
Noise, vibration and light	8.9	All fauna species	Re-establishment of habitat connectivity	9.2.11	To be advised	Post-construction phase
Impacts on key threatening processes	8.10	All species	All	8	To be advised	Pre-construction to operational phases
Cumulative impacts	8.11	All species	All	8	To be advised	Pre-construction to operational phases
Potential impacts on Koala habitat	8.12	Koala	Pre-clearing	9.2.1	To be advised	Pre-construction phase
			Exclusion zones	9.2.2		
			Staged habitat removal	9.2.3		
			Fauna handling	9.2.4		
			Re-establishment of habitat connectivity	9.2.11		Post-construction phase

9.1. Avoid and minimise

The proposed carriageway has been designed to minimise native vegetation clearance where practical and minimise potential impacts on threatened species and ecological communities present in the study area. Specific avoidance and minimisation measures associated with the proposed carriageway comprise:

- Minimise clearance of vegetation/habitat where practical, to minimise impacts on numerous threatened fauna species which potentially utilise such habitat; and
- Minimise impacts on the threatened Murray River ecological community through appropriate bridge design.

9.2. Vegetation and habitat removal

9.2.1. Pre-clearing

The pre-clearing process would involve the development of a *Construction Environmental Management Plan* (CEMP). This would involve pre-clearing field surveys to identify appropriate management measures to minimise impacts on native flora and fauna and their habitats. Appropriate pre-clearing management measures identified in the field surveys would then be incorporated in the CEMP. The following would need to be adequately addressed during pre-clearing surveys:

- A suitably qualified ecologist is to identify nearby habitat that would be suitable for the release of fauna that may be encountered during the pre-clearing process or habitat removal. This may require consultation with the Office of Environment and Heritage (OEH). The pre-determined habitat identified for fauna release is to clearly identified on a map;
- A suitably qualified ecologist should be engaged to undertake the following procedure in the weeks before clearing begins:
    - Confirm the locations of biodiversity features identified in the biodiversity assessment;
    - Identify any fauna that have the potential to be disturbed, injured or killed as a result of clearing activities (eg nesting birds);
    - Check for the presence of threatened flora and fauna species that were identified in the environmental assessment as likely to occur. This check should be:
    - Conducted by qualified ecologists experienced in fauna handling and the identification of local flora and fauna species; and
        - If possible, undertaken during optimal weather conditions, season and time of day/night for identifying targeted flora and fauna species.
        - Confirm the existing details for all hollow-bearing trees, and identify all trees containing threatened fauna and threatened flora;
    - Provide input and mark habitat features to be protected during construction. Use suitable methods (eg flagging tape);
    - Confirm the location of pre-determined habitat identified for the release of any fauna encountered on site; and

  - Submit any updated maps/plans, pre-determined habitat for the release of fauna, habitat features and recommended clearing procedures to the project manager and/or environment manager (or equivalent).

- The following procedure should be followed 24 hours before clearing:
  - Licensed wildlife carers and/or ecologists should capture and/or remove fauna that have the potential to be disturbed, injured or killed as a result of clearing activities. Relocate captured fauna into pre-determined habitat identified for fauna release; and
  - The project manager and/or environment manager should inform clearing contractors of any changes to the sequence of clearing if required. Carry out staged habitat removal as outlined below, in Section 9.2.3.

Refer to the RTA Biodiversity Guidelines (RTA 2011) for further details regarding the pre-clearing process with regards to biodiversity protection.

9.2.2. Exclusion zones

Exclusion zones to avoid damage to adjacent native vegetation and fauna habitats and prevent the distribution of pests, weeds and disease, are to be identified during the pre-clearance surveys and established prior to the commencement of the construction phase. The surveys should also inform the most appropriate type of exclusion zone demarcation fencing to be employed. The location and type of exclusion fencing to be installed would also need to be identified on plans in the CEMP, including the importance of the values to be protected.

Refer to the RTA Biodiversity Guidelines (RTA 2011) for further details regarding the establishment of exclusion zones.

9.2.3. Staged habitat removal

Staged habitat removal is to be conducted in at least two stages, so as to allow respite between the initial disturbance of the clearing process and the final removal of habitat. The works should be timed to minimise the impact on flora and fauna, and if practical, clearing should not occur during times when the majority of fauna species are breeding, i.e. spring for many bird species. The staged habitat removal process is to be incorporated into the CEMP. The staged habitat removal procedure, as detailed in the RTA Biodiversity Guidelines (RTA 2011), is summarised as follows:

1. Vet and/or wildlife carers need to be contacted prior to construction commencing to ensure they are willing to assist in treating injured animals if necessary. Their contact details are to be included in the CEMP, and be given to the site manager and clearly displayed in the site office.
2. A licensed wildlife carer and/or ecologist should be on site during habitat removal. Where necessary, fauna encountered during the clearing process are to be relocated to pre-determined habitat identified for fauna release.
3. Non-habitat vegetation is removed first (i.e. shrubs, regrowth, ground cover and non-habitat trees). Allow fauna at least 24 hours to vacate remaining habitat. Ensure that a wildlife carer and/or an ecologist inspects trees before and after felling. Capture and relocate non-injured fauna that are found in any felled trees to pre-determined habitat identified for fauna release.

4. Fell habitat trees carefully using equipment that allows habitat trees to be lowered to the ground with minimal impact (eg claw extension). Do not fell trees towards exclusion zones. Relocate felled habitat trees as per that described in Section 9.2.10 below.
5. The construction project manager and/or environment manager would ensure that the outcomes of the clearing process are recorded. Reporting is usually the responsibility of an ecologist or environment officer. Reports are to be submitted to relevant personnel (e.g. environment manager or RMS regional environment staff).

During vegetation removal, careful consideration should also be given to minimising impacts on bats, particularly threatened bat species, such as Yellow-bellied Sheath-tailed Bat.

9.2.4. Fauna handling

To prevent injury and mortality of fauna during the clearing of vegetation and drainage of wetlands, an experienced and licensed wildlife carer and/or ecologist would need to be present to supervise the works and capture and relocate fauna if necessary. The following would be implemented to avoid injury and mortality of fauna:

- Contact an animal rescue agency/wildlife care group or vet before works start to ensure they are willing and available to be involved in fauna rescue and assist with injured animals;
- Allow fauna to leave an area without intervention as much as possible;
- Include the procedures to follow if fauna is found or injured on site in project inductions;
- In circumstances where the handling of fauna is completely unavoidable, follow best practice procedures outlined in Guide 9 of the RTA Biodiversity Guidelines (RTA 2011); and
- Keep records of fauna captured and relocated, and report any injury to or death of a threatened species to the RTA's environmental staff.

9.2.5. Aquatic habitat and riparian zones

The proposal would result in some impacts on aquatic habitat, in and adjacent the study area, including the Murray River channel, riparian zone and associated wetlands. In order to minimise impacts on aquatic flora and fauna and their habitats, and to ensure the movement of fish up and downstream is maintained at all times during construction works, appropriate best practice management measure are to be implemented and incorporated in the CEMP. These include the following:

- Avoid activities in aquatic habitats and riparian zones as much as practicable;
- The sensitivity of aquatic habitats and riparian zones and the measures in place to protect them should be regularly communicated to all staff eg during inductions and toolbox talks;
- Protect aquatic habitats and riparian zones where works are not required with exclusion zones;
- The location of aquatic habitat features within or adjacent to the footprint should be clearly identified on environmental management plans;

- Access the waterway so that riparian vegetation removal is minimised and restricted to the minimum amount of bank length required for the construction activity;
- Keep vehicles and machinery away from the banks of a waterway where possible;
- Refuelling of vehicles and plant, and chemical storage and decanting should not take place within 50 metres of aquatic habitats;
- Avoid clearing within the riparian zone during periods when flooding is likely to occur;
- Ensure that any clearing undertaken does not allow the vegetation/trees to fall into the waterway;
- Where feasible, retain the roots of trees on the bank of a waterway in order to maintain bank stability;
- Consult with Department of Primary Industries (DPI)(Fisheries) before clearing to identify any trees proposed to be removed that could potentially be used for re-snagging of a waterway;
- Only the minimum number of snags should be disturbed;
- DPI (Fisheries) must be consulted before works commence where snags require lopping, realignment, relocation and/or removal;
- During rehabilitation, stabilise the banks of the waterway through revegetation and/or armouring according to available landscape plans;
- Protect banks from stock and/or human access using appropriate fencing during the rehabilitation and maintenance period of the work site; and
- Remove all temporary works, flow diversion barriers and sediment control barriers within aquatic habitats as soon as practicable and in a manner that does not promote future channel erosion.

Refer to the RTA Biodiversity Guidelines (RTA 2011) for further details regarding mitigation of potential impacts on aquatic habitat and riparian zones.

In addition to the above, it is recommended that Roads and Maritime consider the construction of artificial wetlands, or enlargement and improvement of existing wetlands, in the vicinity of the study area to compensate for destruction and degradation of wetland habitat in the study area resulting from the proposed action.

9.2.6. Weed management

To prevent or minimise the spread of noxious and environmental weed species in and adjacent the study area during and after the construction phase of the proposal, a weed management plan is to be developed and incorporated into the CEMP. Refer to the RTA Biodiversity Guidelines (RTA 2011) and the *Introductory Weed Management Manual* (Natural Heritage Trust 2004) for guidance on the preparation of the weed management plan.

A site assessment by an ecologist or person trained in weed management and identification would be required to inform the weed management plan, and would involve identification and mapping of weed infestations in and adjacent the study area, particularly noxious species. This would also involve the development of appropriate management actions to be undertaken for each infestation.

The details of the weed management plan would need to be tailored for the site, but should include:

- Type and source of the weed/s;
- Weed management priorities and objectives;
- Sensitive environmental areas within or adjacent to the site;
- Location of weed infested areas;
- Mechanical weed control methods such as slashing or mowing, as well as a range of herbicides to avoid the development of herbicide resistance;
- Measures to prevent the spread of weeds;
- A monitoring program to measure the success of weed management; and
- Communication strategies to improve contractor awareness of weeds and weed management.

9.2.7. Pathogen management

It is not known whether any pathogens with the potential to impact on the environment and biodiversity are present in and adjacent the study area. There is the potential that such pathogens may be introduced and spread during the construction and operational phases of the proposal. Measures to prevent the introduction and/or spread of pathogens are to be incorporated into the CEMP for the proposal. This should be initiated with a check on the DPI website (www.industry.nsw.gov.au) for the most up-to-date hygiene protocols for each pathogen and for the most recent locations of contamination. The project manager and/or environment manager should ensure the risk of spreading pathogens and the mitigation measures required on site are regularly communicated to staff and contractors eg during inductions and toolbox talks.

Preventative measures to minimise the introduction and spread of pathogens are detailed in the RTA Biodiversity Guidelines (RTA 2011) and include:

- Ensure vehicles and footwear are free of soil before entering or exiting the site (i.e. directed to wash down area before entering or exiting the site);
- Provide vehicle and boot wash down facilities; and
- Restrict vehicles to designated tracks, trails and parking areas;

If it is suspected that the site may be harbouring pathogens, testing from a National Association of Testing Authorities (NATA) approved laboratory should be carried out to confirm the presence/absence of pathogens in the soil and/or water. If present, exclusion zones with fencing and signage would need to be established to restrict access to contaminated areas to minimise the spread of the pathogens.

9.2.8. Re-establishment of native vegetation

Re-establishment of native vegetation would be required in disturbed areas throughout the proposed alignment to re-stabilise bare earth, provide additional habitat for local flora and fauna species and mitigate edge effects. To achieve this, a revegetation plan would be developed and incorporated into the CEMP. It should be emphasised that the retention of native through minimisation of the area of the construction footprint will have far better outcomes for biodiversity than over clearing and revegetating. The revegetation plan would need to take into a whole range of site-specific considerations

including collection and propagation of local seed, salvage and reuse of topsoil, leaf litter and woody debris, threatened species habitat, shading caused by the proposed raised carriageway and bridge, Etc.

The RTA Biodiversity Guidelines (RTA 2011) provide detailed guidance on the re-establishment of native vegetation for roads projects in NSW, which is summarised as follows:

- Ecologists and landscape architects should work together on the preparation of revegetation plans and specifications that clearly identify the locations of areas to be revegetated;
- Allocate sufficient time for the collection of seed to be used in revegetation and carry out all seed collection in accordance with *RTA Seed Collection QA Specification R176* and the Florabank Guidelines and Model Code of Practice;
- Use experienced and licensed seed collectors to carry out seed collection and where possible, procured plants should be grown from local provenance seed;
- Consideration should be given to a range of characteristics such as species, height and drought tolerance when procuring native plants;
- Planting operations should be in accordance with *RTA Landscape Planting QA Specification R179* and only use plants that have been certified disease free for revegetation works (refer to *Guide 7: Pathogen management*);
- Collect local native topsoils and leaf litter and store for use in revegetation works;
- Soils in areas to be revegetated should match surrounding soil conditions as closely as possible unless adjacent areas are weedy or contaminated;
- Avoid compaction of soils in areas identified for revegetation. Where compaction has occurred, the soil should be loosened;
- When planting consider seasonal risks of frost, drought, flooding and sun exposure to avoid damaging plants and to encourage growth;
- Ensure plant spacing and diversity follows the landscaping plan for the project, reflects local conditions and is dense enough to ensure plants achieve a timely coverage of the ground;
- Consider appropriate shade and drainage conditions when planting. Provide mulching around plants for dry or potentially weedy sites to help retain moisture and suppress weeds; and
- Inspection, monitoring and maintenance of revegetated areas should be conducted in accordance with the landscape management plan. Outline the roles and responsibilities in landscape management and revegetation plans including the schedule for monitoring and maintenance activities.

It should be noted that this revegetation plan would not contribute to any offset requirements as compensation for native vegetation removal.

9.2.9. Nest boxes

The proposal would require the removal of 11 hollow-bearing trees from the study area, which would potentially impact on 10 listed threatened hollow dependant species in the study area and surrounds (see Table 12), among other non-threatened hollow dependant species. To compensate for this loss, it is proposed that nest boxes be installed on

retained trees and, subject to Roads and Maritime approval, on the proposed bridge structure also. This would require the development of a nest box management strategy, which would be incorporated into the CEMP.

An important consideration when developing a nest box management strategy is determination of the number, quality and size of the hollows proposed to be removed. This was documented during past BL&A field surveying (see Table 4 and Section 8.1.4 above), and should provide sufficient detail to determine the number and type of nest boxes required to compensate for removal.

Detailed guidance regarding the type and size of nest boxes and installation and maintenance are provided in the RTA Biodiversity Guidelines (RTA 2011). Following is a summary of considerations when developing a nest box strategy:

- The target species;
- The tree hollow preferences of native hollow-dependant fauna known or likely to occur in the locality;
- The sizes, types and quantities of potential tree hollows to be removed and the sizes, types and quantities of tree hollows existing in adjacent areas;
- The design, materials and quantity of nest boxes required;
- Whether the nest boxes are required to fill a short term gap in the availability of hollows (eg during construction) or to compensate for the long term reduced availability of hollows;
- Monitoring and maintenance of the nest boxes; and
- An experienced ecologist should be engaged to assist in the implementation of the nest box strategy including installation and monitoring of nest boxes.

9.2.10. Re-use of woody debris

Woody debris (i.e. dead or living tree trunks, root balls, branches and leaves), which would be removed to facilitate construction of the proposed carriageway, should be re-used, where appropriate, to create new habitat in the development area or enhance habitat adjacent the development area. This should be detailed in the landscape management plan and CEMP. Features of the proposal suitable for woody debris deployment may include coarse woody debris (tree trunks, root balls and larger branches) placement in adjacent remnant native vegetation, under the raised carriageway and bridge or within the Murray River or Campaspe River channels; fine woody debris (smaller branches and leaves) placement as natural mulch for revegetation activities.

Detailed guidance for the re-use of woody debris is provided in the RTA Biodiversity Guidelines (RTA 2011), which is summarised as follows:

- Engage a suitably experienced ecologist to provide advice on the re-use of woody debris to ensure it does not have a negative impact on the receiving environment;
- Separated weeds from native vegetation;
- Do not extend the amount of clearing and grubbing to make up for mulch shortfalls;
- Carry out removal, stockpiling, transportation and relocation of woody debris in a manner that minimises disturbance to native vegetation (including the canopy, shrubs, dead trees, fallen timber and groundcover species);

- Avoid the spread of any weeds or pathogens that may be in the soil when relocating woody debris and bushrock from stockpiles;
- Engage a suitably experienced ecologist to provide advice on positioning woody debris in designated relocation areas;
- Keep topsoil disturbance to a minimum;
- When relocating woody debris, place it evenly across the site;
- Manage stockpiles in accordance with RTA's Stockpile Site Management Guideline, *RTA Environmental Protection (Management System) QA Specification G36* and *RTA Vegetation QA Specification R178;* and
- Prepare a mulch tannin management plan for the project where tannins are likely to be generated.

Re-use of bush rock has not been discussed in this chapter as it does not outcrop in the impact area or surrounds.

9.2.11. Re-establishment of habitat connectivity

To alleviate the effects of native vegetation clearance on habitat connectivity, such as habitat fragmentation, edge effects and barrier effects, the following measures should be incorporated into the design of the carriageway and CEMP:

- Native vegetation be retained as close to the proposed carriageway as possible;
- Revegetation works should aim to re-create the original vegetation structure and floristics;
- Artificial lighting along the proposed alignment should be kept to a minimum outside of the urban area;
- Coarse and fine woody debris should be placed under the raised carriageway as fauna 'furniture';
- In order to alleviate Squirrel Glider road mortality and facilitate ease of movement across the proposed carriageway, it is recommended that the habitat linkage strategy developed for the project (BL&A 2015d) be implemented (see Appendix 10). This measure is discussed in more detail below.

The habitat linkage strategy (BL&A 2015d) recommends the use of rope bridges as habitat linkage tools in cases where sufficient canopy cover cannot be maintained — a view supported by van der Ree et al. (2015). The design and exact placement of rope bridges is discussed below, but should be developed and approved by an expert in Squirrel Glider ecology for maximum effectiveness, as per van der Ree et al. (2015).

Habitat links must be formed with consideration of the average glide distance of ~20 m for Squirrel Gliders, rather than their maximum glide capability.

Whether canopy cover can be maintained will need to be determined at the detailed design phase, and take into consideration lopping and/or impacts to the root zone of trees adjacent to the road. Canopy connectivity may be maintained over the initial, single carriage-way alignment, however it is likely that ultimate duplication of the alignment will present a barrier to movement of Squirrel Gliders across the road (van der Ree et al., 2015). It is therefore recommended that rope bridges be instated at the initial alignment construction phase with consideration for the ultimate duplication design.

Where possible, maintenance or planting of eucalypts should be considered adjacent to the single-carriageway road where ultimately the median strip will be located in the final duplicated road design. This will maximise gliding opportunities across the ultimately duplicated road. The timeframe for road duplication may permit planted trees to grow to a height suitable for use by gliding Squirrel Gliders before duplication is required, minimising the risk that road duplication will reduce habitat connectivity through a lack of canopy cover.

Recommended placement of crossing zones is shown in Figure 20. Crossing zones have been placed based with consideration to the following:

- Connection of areas of high quality habitat;
- Connection of areas that address different habitat requirements (eg. connection of good den habitat with good foraging habitat);
- Connection of areas that provide different winter food sources (eg. connection of habitat that supports a high cover of Silver Wattles with that dominated by Grey Box); and
- Connection of large patches of habitat with good connectivity to adjacent patches.

Trees adjacent to the middle crossing zone shown in Figure were not mapped during the field assessment, and will need to be identified during rope bridge design in consultation with an expert on Squirrel Gliders.

Design and monitoring considerations for crossing zones and rope bridges are detailed in the habitat linkage strategy (BL&A 2015d).

9.3. Offset strategy

A biodiversity offset strategy would need to be developed in consultation with Roads and Maritime to compensate for residual impacts of the proposed action.

Perricoota Road
Murray River
Campaspe River
Warren Street
A
B
C
D
E
F
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 23 24 25 26 27 28 29 30 31 32 33

Legend

- Study area
- Midwest Alignment
- Important habitat trees
- Recommended crossing zone

Habitat Quality

- High
- Medium
- Low

0 200 400 800 Metres

Figure 20: Habitat connectivity recommendations

Project: Murray River Crossing Echuca

Client: Roads and Maritime Services

Project No.: 8194	Date: 28/07/2015	Created By: M. Ghasemi / A. Brennan

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N

10. ASSESSMENTS OF SIGNIFICANCE

Significance assessments for potential impacts on Commonwealth and NSW listed threatened ecological communities, populations and species are summarised in this section and the detailed assessments are provided in Appendix 7. NSW listed values are summarised in Table 15 and Commonwealth listed values are summarised in Table 16.

The findings of the significance assessments were that there is unlikely to be any significant impact on any species. As such, Species Impact Statements are not required.

Table 14: Summary of findings for assessments of significance – TSC Act

Threatened species or communities	Significance assessment question*							Likely significant impact?
	a	b	c	d	e	f	g	
Ecological communities								
Murray River EEC	X	X	Y	Y	X	Y	Y	No
Birds								
Masked Owl	N	X	X	Y	X	Y	Y	No
Brown Treecreeper	Y	X	X	Y	X	X	Y	No
Grey-crowned Babbler	N	X	X	Y	X	X	Y	No
Black-chinned Honeyeater	N	X	X	Y	X	X	Y	No
Hooded Robin	N	X	X	Y	X	X	Y	No
Diamond Firetail	N	X	X	Y	X	X	Y	No
Speckled Warbler	N	X	X	Y	X	X	Y	No
Varied Sittella	N	X	X	Y	X	X	Y	No
Swift Parrot	N	X	X	Y	X	X	Y	No
Superb Parrot	N	X	X	Y	X	X	Y	No
Turquoise parrot	N	X	X	Y	X	X	Y	No
Mammals								
Squirrel Glider	N	X	X	N	X	X	N	No
Koala	N	X	X	Y	X	N	Y	No
Yellow–bellied Sheathtail Bat	N	X	X	Y	X	X	Y	No
Freshwater fish								

Threatened species or communities	Significance assessment question*							Likely significant impact?
	a	b	c	d	e	f	g	
Trout Cod	Y	X	X	Y	X	X	Y	No

Table notes: **Y**= Yes (negative impact), **N**= No (no or positive impact), **X**= not applicable.

***** Significance Assessment Questions as set out in the *Environmental Planning and Assessment Act 1979:*

a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,

b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

   (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

   (ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

d) in relation to the habitat of a threatened species, population or ecological community:

   (i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

   (ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

   (iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Table 15: Summary of findings for assessments of significance – EPBC Act

Threatened species or communities	Significant impact criteria (1/3/5)									Likely significant impact?	2Critical habitat?	4Important population?
	a	b	c	d	e	f	g	h	i			
1Critically endangered (CE) and endangered (EN) species or communities												
Swift Parrot (EN)	U	U	U	U	U	U	U	U	U	Unlikely	No	N/A
Silver Perch (CE)	U	U	U	U	U	U	U	U	U	Unlikely	Unlikely	N/A
Trout Cod (EN)	U	U	U	U	U	U	U	U	U	Unlikely	Unlikely	N/A
3Vulnerable species or communities												
Superb Parrot	U	U	U	U	U	U	U	U	U	Unlikely	Unlikely	N/A
Koala	U	U	U	U	U	U	U	U	U	Unlikely	No	No
Murray Cod	U	U	U	U	U	U	U	U	U	Unlikely	Unlikely	N/A
5Migratory species												
Rainbow Bee-eater	U	U	U	X	X	X	X	X	X	Unlikely	N/A	N/A
Eastern Great Egret	U	U	U	X	X	X	X	X	X	Unlikely	N/A	N/A
White-bellied Sea-eagle	U	U	U	X	X	X	X	X	X	Unlikely	N/A	N/A
White-throated Needletail	U	U	U	X	X	X	X	X	X	Unlikely	N/A	N/A
Fork-tailed Swift	U	U	U	X	X	X	X	X	X	Unlikely	N/A	N/A

Table notes: L = Likely significant impact; P = Potential significant impact; U = Unlikely significant impact; X or N/A = Not applicable.

Significant impact criteria:

1) 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:
   a) lead to a long-term decrease in the size of a population
   b) reduce the area of occupancy of the species
   c) fragment an existing population into two or more populations
   d) adversely affect habitat critical to the survival of a species
   e) disrupt the breeding cycle of a population
   f) modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
   g) result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat
   h) introduce disease that may cause the species to decline, or
   i) interfere with the recovery of the species.
2) Habitat critical to the survival of a species or ecological community' refers to areas that are necessary:

a) for activities such as foraging, breeding, roosting, or dispersal
b) for the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators)
c) to maintain genetic diversity and long term evolutionary development, or
d) for the reintroduction of populations or recovery of the species or ecological community.

3) An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:
   a) lead to a long-term decrease in the size of an important population of a species
   b) reduce the area of occupancy of an important population
   c) fragment an existing important population into two or more populations
   d) adversely affect habitat critical to the survival of a species
   e) disrupt the breeding cycle of an important population
   f) modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
   g) result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat
   h) introduce disease that may cause the species to decline, or
   i) interfere substantially with the recovery of the species.

4) An 'important population' is a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:
   a) key source populations either for breeding or dispersal
   b) populations that are necessary for maintaining genetic diversity, and/or
   c) populations that are near the limit of the species range.

5) An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will:
   a) 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
   b) 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
   c) seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

11. CONCLUSIONS

Commonwealth

- No Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) listed species were recorded in the study area. However, based on the analysis of calls recorded during the bat surveys, it was initially determined that the EPBC Act-listed South-eastern Long-eared Bat was present within the study area. A subsequent peer review of these findings found that the habitat present was not suitable for this species and that the recorded calls could not be attributed to South-eastern Long-eared Bat — as such, it was determined that this bat was not likely to occur within the study area (Gration 2015 — see Appendix 9).
- Based on the initial findings in relation to South-eastern Long-eared Bat, a Referral under the Environment Protection and Biodiversity Conservation Act 1999 was undertaken in respect of potential impacts upon this bat. Given the information provided, the Project was determined by the Commonwealth Department of Environment to be a 'controlled action' that would require assessment by Preliminary Documentation.
- Preliminary Documentation is currently being prepared based on the current understanding that South-eastern Long-eared Bat is not likely to occur within the study area and therefore the project is highly unlikely to have a significant impact on this species.

New South Wales

- The alignment in the New South Wales section of the study area is fixed and will result in the removal of 5.08 hectares of native vegetation, including seven hollow-bearing trees.
- A biodiversity offset strategy would need to be developed in consultation with Roads and Maritime to compensate for residual impacts of the proposed action.
- No flora species listed under the NSW *Threatened Species Conservation Act 1995* (TSC Act) were recorded and none are considered likely to occur in the study area due to either a lack of suitable habitat or the results of targeted surveys.
- A total of 15 fauna species listed under the NSW TSC Act and FM Act were recorded or considered likely to occur in the study area due to the availability of suitable habitat. In the addition to these threatened fauna species one EEC — Lower Murray River Aquatic Ecological Community — was also identified as occurring within the study area.
- While some threatened species and EEC habitat will be impacted to facilitate the proposed development, impacts are not considered to be significant (i.e. result in the extinction of any local populations or reduce the long-term existence of any of these species). For example, long-term impacts on the local Squirrel Glider population are unlikely to be significant provided mitigation measures outlined in Van Der Ree *et al* (2015 — see Appendix 8) and BL&A (2015d — see Appendix 10) are implemented.

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Appendix 1: EPBC Act Protected Matters Search Tool Report (06/08/14)

Australian Government

Department of the Environment

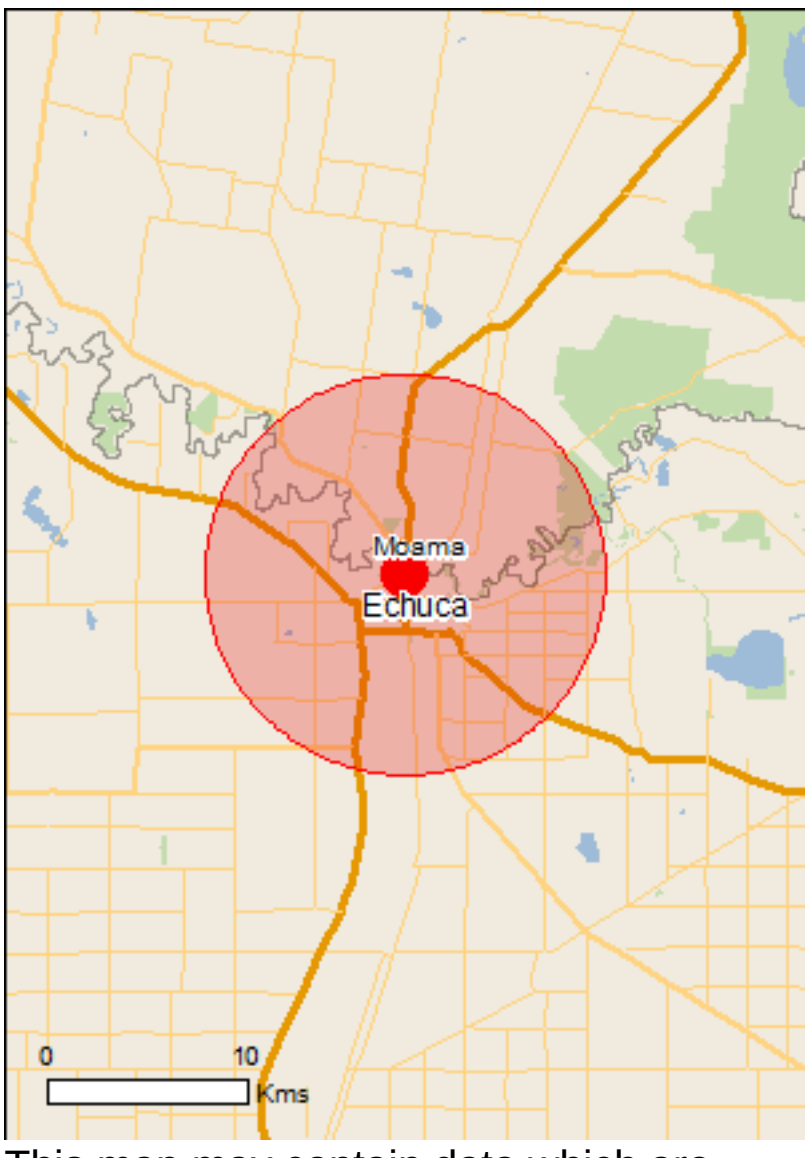
EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

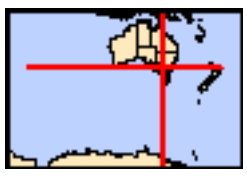
Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 06/08/14 15:26:52



Coordinates

Buffer: 10.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	1
Wetlands of International Importance:	6
Great Barrier Reef Marine Park:	None
Commonwealth Marine Areas:	None
Listed Threatened Ecological Communities:	5
Listed Threatened Species:	22
Listed Migratory Species:	10

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate.

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	2
Commonwealth Heritage Places:	None
Listed Marine Species:	12
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

Place on the RNE:	23
State and Territory Reserves:	5
Regional Forest Agreements:	None
Invasive Species:	30
Nationally Important Wetlands:	1
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

National Heritage Properties [Resource Information]

Name	State	Status
Historic		
Echuca Wharf	VIC	Listed place

Wetlands of International Importance (RAMSAR) [Resource Information]

Name	Proximity
Banrock station wetland complex	Upstream from Ramsar
Barmah forest	Upstream from Ramsar
Coorong and lakes alexandrina and albert	Upstream from Ramsar
Gunbower forest	Upstream from Ramsar
Nsw central murray state forests	Within 10km of Ramsar
Riverland	Upstream from Ramsar

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Buloke Woodlands of the Riverina and Murray-Darling Depression Bioregions	Endangered	Community may occur within area
Grey Box (Eucalyptus microcarpa) Grassy Woodlands and Derived Native Grasslands of South-eastern Australia	Endangered	Community likely to occur within area
Natural Grasslands of the Murray Valley Plains	Critically Endangered	Community likely to occur within area
Weeping Myall Woodlands	Endangered	Community may occur within area
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	Critically Endangered	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat likely to occur within area
Lathamus discolor Swift Parrot [744]	Endangered	Species or species habitat likely to occur within area
Pedionomus torquatus Plains-wanderer [906]	Vulnerable	Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Polytelis swainsonii Superb Parrot [738]	Vulnerable	Species or species habitat likely to occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area
Fish		
Bidyanus bidyanus Silver Perch, Bidyan [76155]	Critically Endangered	Species or species habitat likely to occur within area
Craterocephalus fluviatilis Murray Hardyhead [56791]	Endangered	Species or species habitat may occur within area
Maccullochella peelii Murray Cod [66633]	Vulnerable	Species or species habitat may occur within area
Macquaria australasica Macquarie Perch [66632]	Endangered	Species or species habitat may occur within area
Frogs		
Litoria raniformis Growling Grass Frog, Southern Bell Frog, Green and Golden Frog, Warty Swamp Frog [1828]	Vulnerable	Species or species habitat likely to occur within area
Insects		
Synemon plana Golden Sun Moth [25234]	Critically Endangered	Species or species habitat may occur within area
Mammals		
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT) Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat known to occur within area
Plants		
Amphibromus fluitans River Swamp Wallaby-grass, Floating Swamp Wallaby-grass [19215]	Vulnerable	Species or species habitat may occur within area
Caladenia tensa Greencomb Spider-orchid, Rigid Spider-orchid [24390]	Endangered	Species or species habitat likely to occur within area
Callitriche cyclocarpa Western Water-starwort [7477]	Vulnerable	Species or species habitat likely to occur within area
Myriophyllum porcatum Ridged Water-milfoil [19919]	Vulnerable	Species or species habitat likely to occur within area
Pimelea spinescens subsp. spinescens Plains Rice-flower, Spiny Rice-flower, Prickly Pimelea [21980]	Critically Endangered	Species or species habitat known to occur within area
Pterostylis despectans Lowly Greenhood [6272]	Endangered	Species or species habitat may occur within area
Sclerolaena napiformis Turnip Copperbur [11742]	Endangered	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Swainsona murrayana Slender Darling-pea, Slender Swainson, Murray Swainson-pea [6765]	Vulnerable	Species or species habitat likely to occur within area
Swainsona plagiotropis Red Darling-pea, Red Swainson-pea [10804]	Vulnerable	Species or species habitat likely to occur within area
Reptiles		
Delma impar Striped Legless Lizard [1649]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species

[Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Hirundapus caudacutus White-throated Needletail [682]		Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat likely to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Ardea alba Great Egret, White Egret [59541]		Species or species habitat known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat likely to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land - Australian Telecommunications Corporation
Defence - BOBDUBI BARRACKS - ECHUCA

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat likely to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Hirundapus caudacutus White-throated Needletail [682]		Species or species habitat may occur within area
Lathamus discolor Swift Parrot [744]	Endangered	Species or species habitat likely to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat likely to occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat likely to occur within area

Extra Information

Places on the RNE [Resource Information]

Note that not all Indigenous sites may be listed.

Name	State	Status
Natural		
Cobb Highway Travelling Stock Route Grasslands	NSW	Indicative Place
Echuca Aerodrome Remnant Grasslands	VIC	Indicative Place
Indigenous		
Scarred Tree and Mileage Tree	NSW	Indicative Place
Historic		
The Mount Alexander - Murray Valley Railway Line	VIC	Indicative Place
Bank of NSW (former)	VIC	Registered
Customs House (former)	VIC	Registered
Echuca Club	VIC	Registered
Echuca Conservation Area	VIC	Registered
Echuca Conservation Area Revised	VIC	Registered
Echuca Courthouse (former)	VIC	Registered
Echuca Flour Mill	VIC	Registered
Echuca Post Office	VIC	Registered
Echuca Road and Rail Bridge	NSW	Registered
Echuca Wharf	VIC	Registered
Hopewood Hotel	VIC	Registered
Library	VIC	Registered
Locomotive Engine Shed	VIC	Registered
Moama Courthouse	NSW	Registered
Permewan Wright Building	VIC	Registered
Perri Place	VIC	Registered
Police Station (former) now Museum	VIC	Registered
Pumping Station	VIC	Registered
Shackells Bond Store (former)	VIC	Registered

State and Territory Reserves [Resource Information]

Name	State
Echuca West B.R.	VIC
Goulburn River H.R.	VIC
Murray Valley	NSW
River Murray Reserve	VIC
River Murray Reserve (non-PV)	VIC

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		

Name	Status	Type of Presence
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Alauda arvensis Skylark [656]		Species or species habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis European Goldfinch [403]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Turdus merula Common Blackbird, Eurasian Blackbird [596]		Species or species habitat likely to occur within area
Mammals		
Capra hircus Goat [2]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Lepus capensis Brown Hare [127]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Plants		
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Asparagus scandens Asparagus Fern, Climbing Asparagus Fern [23255]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Genista monspessulana Montpellier Broom, Cape Broom, Canary Broom, Common Broom, French Broom, Soft Broom [20126]		Species or species habitat likely to occur within area
Lycium ferocissimum African Boxthorn, Boxthorn [19235]		Species or species habitat likely to occur within area
Nassella neesiana Chilean Needle grass [67699]		Species or species habitat likely to occur within area
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur within area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Sagittaria platyphylla Delta Arrowhead, Arrowhead, Slender Arrowhead [68483]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Solanum elaeagnifolium Silver Nightshade, Silver-leaved Nightshade, White Horse Nettle, Silver-leaf Nightshade, Tomato Weed, White Nightshade, Bull-nettle, Prairie-berry, Satansbos, Silver-leaf Bitter-apple, Silverleaf-nettle, Trompillo [12323]		Species or species habitat likely to occur within area
Ulex europaeus Gorse, Furze [7693]		Species or species habitat likely to occur within area

Nationally Important Wetlands	[Resource Information]
Name	State
Lower Goulburn River Floodplain	VIC

Coordinates

-36.11982 144.75082

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Department of Environment, Climate Change and Water, New South Wales
-Department of Sustainability and Environment, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment and Natural Resources, South Australia
-Parks and Wildlife Service NT, NT Dept of Natural Resources, Environment and the Arts
-Environmental and Resource Management, Queensland
-Department of Environment and Conservation, Western Australia
-Department of the Environment, Climate Change, Energy and Water
-Birds Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-SA Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Atherton and Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
-State Forests of NSW
-Geoscience Australia
-CSIRO
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Appendix 2: Flora Species Recorded from the Atlas of NSW Wildlife search region (06/08/14)

Scientific Name	Common Name	Exotic species	NSW legal status	Records
Acacia dealbata	Silver Wattle			3
Acacia montana	Mallee Wattle			1
Acacia pycnantha	Golden Wattle			1
Aira spp.	A Hairgrass	*		1
Allocasuarina luehmannii	Bulloak			1
Alternanthera denticulata	Lesser Joyweed			5
Amphibromus nervosus	Common Swamp Wallaby Grass			1
Aphanes australiana	Australian Pert			1
Arctotheca calendula	Capeweed	*		4
Arthropodium milleflorum	Pale Vanilla-lily			1
Arthropodium minus	Small Vanilla Lily			2
Asperula conferta	Common Woodruff			2
Atriplex semibaccata	Creeping Saltbush			2
Austrostipa aristiglumis	Plains Grass			1
Austrostipa blackii				1
Austrostipa nodosa	A Speargrass			1
Austrostipa scabra	Speargrass			1
Austrostipa spp.	A Speargrass			2
Avena spp.	Oats	*		1
Bothriochloa macra	Red Grass			1
Brachyscome chrysoglossa				1
Brachyscome lineariloba	Hard-headed Daisy			1
Bromus molliformis	Soft Brome	*		1
Bulbine bulbosa	Bulbine Lily			1
Bulbine semibarbata	Wild Onion			1
Bursaria spinosa	Native Blackthorn			1
Calocephalus citreus	Lemon Beauty-heads			2
Calocephalus sonderi	Pale Beauty-heads			1
Calotis anthemoides	Cut-leaved Burr-daisy			1
Calotis cuneifolia	Purple Burr-Daisy			1
Calotis scabiosifolia	Rough Burr-daisy			2
Calotis scapigera	Tufted Burr-daisy			3
Calytrix tetragona	Common Fringe-myrtle			1
Cardamine paucijuga				1
Carex inversa	Knob Sedge			2
Carex spp.				1
Carex tereticaulis				2

Scientific Name	Common Name	Exotic species	NSW legal status	Records
Cassinia arcuata	Sifton Bush			2
Casuarina spp.				1
Centaurium tenuiflorum	Branched Centaury, Slender centaury	*		1
Centipeda cunninghamii	Common Sneezeweed			2
Chamaesyce drummondii	Caustic Weed			3
Cheilanthes austrotenuifolia	Rock Fern			1
Cheilanthes sieberi subsp. sieberi	Rock Fern			1
Chenopodium desertorum	Desert Goosefoot			1
Chenopodium desertorum subsp. microphyllum				1
Chenopodium desertorum subsp. virosum				1
Chloris truncata	Windmill Grass			2
Chrysocephalum apiculatum	Common Everlasting			1
Chrysocephalum semipapposum	Clustered Everlasting			1
Cirsium vulgare	Spear Thistle	*		6
Convolvulus erubescens	Pink Bindweed			2
Convolvulus wimmerensis				1
Conyza bonariensis	Flaxleaf Fleabane	*		1
Cotula bipinnata	Ferny Cotula	*		3
Crassula colorata	Dense Stonecrop			1
Crassula decumbens var. decumbens	Spreading Stonecrop			1
Crassula peduncularis	Purple Stonecrop			1
Crassula sieberiana	Australian Stonecrop			1
Cynodon dactylon	Common Couch			2
Daucus glochidiatus	Native Carrot			3
Dianella revoluta var. revoluta	A Blue Flax Lily			1
Dillwynia cinerascens				1
Dittrichia graveolens	Stinkwort	*		1
Drosera peltata	A Sundew			1
Duma florulenta	Lignum			2
Echium plantagineum	Patterson's Curse	*		3
Eclipta platyglossa	Yellow Twin-heads			1
Einadia nutans	Climbing Saltbush			6
Eleocharis pusilla				1
Elymus scaber	Common Wheatgrass			1
Enchylaena tomentosa	Ruby Saltbush			3

Scientific Name	Common Name	Exotic species	NSW legal status	Records
Enteropogon acicularis	Curly Windmill Grass			3
Epilobium hirtigerum				1
Eremophila deserti	Turkeybush			1
Eriochlamys squamata				1
Erodium crinitum	Blue Crowfoot			2
Erodium moschatum	Musky Crowfoot	*		1
Eryngium rostratum	Blue Devil			2
Eryngium spp.		*		1
Eucalyptus camaldulensis	River Red Gum			11
Eucalyptus microcarpa	Western Grey Box			4
Euchiton sphaericus	Star Cudweed			1
Eulalia aurea	Silky Browntop			1
Euphrasia collina				1
Eutaxia microphylla				1
Exocarpos aphyllus	Leafless Ballart			1
Fraxinus angustifolia subsp. angustifolia	Desert Ash	*		1
Galium aparine	Goosegrass	*		1
Goodenia fascicularis	Mallee Goodenia			1
Goodenia macbarronii	Narrow Goodenia			1
Goodenia pusilliflora				1
Hakea leucoptera	Needlewood			1
Haloragis aspera	Rough Raspwort			1
Haloragis spp.	A Raspwort			1
Helminthotheca echioides	Ox-tongue	*		1
Hordeum leporinum	Barley Grass	*		3
Hordeum spp.	A Barley Grass	*		1
Hyalosperma praecox				1
Hyalosperma semisterile				1
Hypochaeris glabra	Smooth Catsear	*		5
Isoetopsis graminifolia	Grass Cushion			1
Juncus amabilis				3
Juncus spp.	A Rush			1
Juncus subsecundus	Finger Rush			2
Lactuca serriola	Prickly Lettuce	*		3
Leiocarpa leptolepis	Pale Plover-daisy			1
Leiocarpa panaetioides	Wooly Buttons			2
Leptorhynchos squamatus	Scaly Buttons			1
Leptorhynchos squamatus subsp. squamatus				1

Scientific Name	Common Name	Exotic species	NSW legal status	Records
Leptorhynchos tetrachaetus	Beauty Buttons			1
Lolium perenne	Perennial Ryegrass	*		9
Lomandra effusa	Scented Mat-rush			3
Lomandra spp.	Mat-rush			1
Maireana enchylaenoides	Wingless Fissure-weed			1
Maireana microphylla	Small-leaf Bluebush			1
Maireana pentagona	Hairy Bluebush, Slender Fissure-weed			3
Marrubium vulgare	White Horehound	*		1
Medicago spp.	A Medic	*		4
Mentha australis	River Mint			2
Moraea setifolia	Thread Iris	*		1
Ophioglossum lusitanicum	Adder's Tongue			1
Oxalis perennans				5
Oxalis pes-caprae	Soursob	*		1
Panicum decompositum	Native Millet			1
Paspalidium jubiflorum	Warrego Grass			3
Persicaria lapathifolia	Pale Knotweed			1
Persicaria prostrata	Creeping Knotweed			4
Phyla canescens	Lippia	*		1
Plantago cunninghamii	Sago-weed			1
Plantago gaudichaudii	Narrow Plantain			1
Plantago lanceolata	Lamb's Tongues	*		1
Poa bulbosa	Bulbous Poa	*		1
Poa fordeana	Sweet Swamp-grass			1
Poa sieberiana	Snowgrass			3
^Prasophyllum sp. Moama			E4A,P,2	2
Pseudognaphalium luteoalbum	Jersey Cudweed			4
^Pterostylis despectans			E4A,P,2	1
Ptilotus semilanatus	Lambs tails			1
Pycnosorus globosus	Drumsticks		P	3
Ranunculus pachycarpus	Thick-fruit Buttercup			1
Ranunculus spp.				1
Rhodanthe corymbiflora	Small White Sunray			1
Romulea rosea var. australis	Onion Grass	*		3
Rumex brownii	Swamp Dock			1
Rumex crispus	Curled Dock	*		1
Rumex dumosus	Wiry Dock			1
Rumex spp.	Dock	*		1

Scientific Name	Common Name	Exotic species	NSW legal status	Records
Rutidosis multiflora				1
Rytidosperma caespitosum	Ringed Wallaby Grass			1
Rytidosperma setaceum	Small-flowered Wallaby-grass			4
Rytidosperma spp.				1
Salsola kali var. kali	Buckbush			2
Sclerolaena muricata	Black Rolypoly			1
Sclerolaena napiformis	Turnip Copperburr		E1,P	103
Sclerolaena parviflora				1
Sclerolaena stelligera	Star Copperburr			1
Senecio glossanthus	Streaked Poverty Bush			1
Senecio quadridentatus	Cotton Fireweed			5
Sida corrugata	Corrugated Sida			3
Silybum marianum	Variegated Thistle	*		1
Sisymbrium erysimoides	Smooth Mustard	*		1
Solanum nigrum	Black-berry Nightshade	*		1
Sonchus oleraceus	Common Sowthistle	*		6
Spergularia rubra	Sandspurry	*		2
Sporobolus caroli	Fairy Grass			1
Stackhousia monogyna	Creamy Candles			1
Stellaria media	Common Chickweed	*		1
Swainsona murrayana	Slender Darling Pea		V,P	4
Swainsona procumbens	Broughton Pea			2
Swainsona spp.				1
Teucrium racemosum	Grey Germander			2
Trifolium angustifolium	Narrow-leaved Clover	*		1
Trifolium arvense	Haresfoot Clover	*		2
Trifolium spp.	A Clover	*		1
Trifolium tomentosum	Woolly Clover	*		2
Triptilodiscus pygmaeus	Common Sunray			2
Vittadinia cuneata	A Fuzzweed			3
Vittadinia cuneata var. cuneata f. cuneata				1
Vittadinia gracilis	Woolly New Holland Daisy			2
Vulpia bromoides	Squirrel Tail Fesque	*		1
Wahlenbergia fluminalis	River Bluebell			3
Wahlenbergia gracilenta	Annual Bluebell			1

Scientific Name	Common Name	Exotic species	NSW legal status	Records
Wahlenbergia spp.	Bluebell			1
Walwhalleya proluta				2
Wurmbea dioica subsp. dioica	Early Nancy			1
Xerochrysum bracteatum	Golden Everlasting			1

Appendix 3: Noxious Weeds list for Murray local Council area

Common Name	Scientific Name	Class
African boxthorn	*Lycium ferocissimum*	4
African feathergrass	*Pennisetum macrourum*	5
African turnip weed	*Sisymbrium runcinatum*	5
African turnip weed	*Sisymbrium thellungii*	5
Alligator weed	*Alternanthera philoxeroides*	2
Anchored water hyacinth	*Eichhornia azurea*	1
Annual ragweed	*Ambrosia artemisiifolia*	5
Arrowhead	*Sagittaria montevidensis*	4
Artichoke thistle	*Cynara cardunculus*	5
Athel pine	*Tamarix aphylla*	5
Bathurst Burr and other burrs	*Xanthium species*	4
Bear-skin fescue	*Festuca gautieri*	5
Black knapweed	*Centaurea nigra*	1
Black willow	*Salix nigra*	2
Blackberry	*Rubus fruticosus aggregate species*	4
Boneseed	*Chrysanthemoides monilifera subspecies monilifera*	2
Bridal creeper	*Asparagus asparagoides*	4
Broomrapes	*Orobanche species*	1
Buffalo burr	*Solanum rostratum*	4
Burr ragweed	*Ambrosia confertiflora*	5
Cabomba	*Cabomba species*	5
Cape broom	*Genista monspessulana*	2
Cape tulip	*Moraea species*	4
Cayenne snakeweed	*Stachytarpheta cayennensis*	5
Chilean needle grass	*Nassella neesiana*	3
Chinese violet	*Asystasia gangetica subspecies micrantha*	1
Clockweed	*Gaura parviflora*	5
Columbus grass	*Sorghum x almum*	4
Coolatai grass	*Hyparrhenia hirta*	3
Corn sowthistle	*Sonchus arvensis*	5
Creeping knapweed	*Rhaponticum repens*	4
Devil's claw (purple-flowered)	*Proboscidea louisianica*	4
Devil's claw (yellow-flowered)	*Ibicella lutea*	4
Dodder	*Cuscuta species*	5
East Indian hygrophila	*Hygrophila polysperma*	4
Espartillo	*Amelichloa brachychaeta, Amelichloa caudata*	5
Eurasian water milfoil	*Myriophyllum spicatum*	1
Fine-bristled burr grass	*Cenchrus brownii*	5
Fountain grass	*Pennisetum setaceum*	5

Common Name	Scientific Name	Class
Gallon's curse	*Cenchrus biflorus*	5
Glaucous starthistle	*Carthamus glaucus*	5
Golden dodder	*Cuscuta campestris*	4
Golden thistle	*Scolymus hispanicus*	5
Harrisia cactus	*Harrisia species*	4
Hawkweed	*Hieracium species*	1
Heteranthera	*Heteranthera reniformis*	1
Horehound	*Marrubium vulgare*	4
Horsetail	*Equisetum species*	1
Hydrocotyl	*Hydrocotyl ranunculoides*	1
Hymenachne	*Hymenachne amplexicaulis and hybrids*	1
Johnson grass	*Sorghum halepense*	4
Karoo thorn	*Acacia karroo*	1
Kochia	*Bassia scoparia*	1
Kosters curse	*Clidemia hirta*	1
Lagarosiphon	*Lagarosiphon major*	1
Lantana	*Lantana species*	4
Leafy elodea	*Egeria densa*	4
Lippia	*Phyla canescens*	4
Long-leaf willow primrose	*Ludwigia longifolia*	4
Mesquite	*Prosopis species*	2
Mexican feather grass	*Nassella tenuissima*	1
Mexican poppy	*Argemone mexicana*	5
Miconia	*Miconia species*	1
Mikania	*Mikania micrantha*	1
Mimosa	*Mimosa pigra*	1
Mossman River grass	*Cenchrus echinatus*	5
Onion weed	*Asphodelus fistulosus*	4
Parkinsonia	*Parkinsonia aculeata*	2
Parthenium weed	*Parthenium hysterophorus*	1
Paterson's curse and other echium	*Echium species*	4
Perennial ground cherry	*Physalis virginiana*	4
Pond apple	*Annona glabra*	1
Prairie ground cherry	*Physalis hederifolia*	4
Prickly acacia	*Acacia nilotica*	1
Prickly pear	*Cylindropuntia species*	4
Prickly pear	*Opuntia species*	4
Red rice	*Oryza rufipogon*	5
Rhus tree	*Toxicodendron succedaneum*	4
Rubber vine	*Cryptostegia grandiflora*	1
Sagittaria	*Sagittaria platyphylla*	4

Common Name	Scientific Name	Class
Salvinia	*Salvinia molesta*	2
Scotch Thistle and other thistles	*Onopordum species*	4
Senegal tea plant	*Gymnocoronis spilanthoides*	1
Serrated tussock	*Nassella trichotoma*	3
Siam weed	*Chromolaena odorata*	1
Silk forage sorghum	*Sorghum species hybrid cultivar*	4
Silverleaf nightshade	*Solanum elaeagnifolium*	4
Smooth-stemmed turnip	*Brassica barrelieri subspecies oxyrrhina*	5
Soldier thistle	*Picnomon acarna*	5
Spiny burrgrass	*Cenchrus incertus*	4
Spiny burrgrass	*Cenchrus longispinus*	4
Spiny emex	*Emex australis*	4
Spotted knapweed	*Centaurea stoebe subspecies micranthos*	1
St. John's wort	*Hypericum perforatum*	3
Texas blueweed	*Helianthus ciliaris*	5
Tree-of-heaven	*Ailanthus altissima*	4
Tropical soda apple	*Solanum viarum*	2
Water caltrop	*Trapa species*	1
Water hyacinth	*Eichhornia crassipes*	2
Water lettuce	*Pistia stratiotes*	1
Water soldier	*Stratiotes aloides*	1
Willows	*Salix species*	5
Witchweed	*Striga species*	1
Yellow burrhead	*Limnocharis flava*	1
Yellow nutgrass	*Cyperus esculentus*	5

KEY TO CONTROL CLASS:

Control Class	Weed type	Example control requirements
Class 1	Plants that pose a potentially serious threat to primary production or the environment and are not present in the State or are present only to a limited extent.	The plant must be eradicated from the land and the land must be kept free of the plant.
		The weeds are also "notifiable" and a range of restrictions on their sale and movement exist.
Class 2	Plants that pose a potentially serious threat to primary production or the environment of a region to which the order applies and are not present in the region or are present only to a	The plant must be eradicated from the land and the land must be kept free of the plant.
		The weeds are also "notifiable" and a range of restrictions on their sale and movement exist.

Control Class	Weed type	Example control requirements
	limited extent.	
Class 3	Plants that pose a potentially serious threat to primary production or the environment of a region to which the order applies, are not widely distributed in the area and are likely to spread in the area or to another area.	The plant must be fully and continuously suppressed and destroyed.*
Class 4	Plants that pose a potentially serious threat to primary production, the environment or human health, are widely distributed in an area to which the order applies and are likely to spread in the area or to another area.	The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its reproduction*
Class 5	Plants that are likely, by their sale or the sale of their seeds or movement within the State or an area of the State, to spread in the State or outside the State.	There are no requirements to control existing plants of Class 5 weeds. However, the weeds are "notifiable" and a range of restrictions on their sale and movement exists.

Appendix 4: Fauna Species Recorded from the Atlas of NSW Wildlife search region (06/08/14)

Scientific Name	Common Name	Exotic	NSW legal status	Records
Birds				
Acanthiza chrysorrhoa	Yellow-rumped Thornbill		P	1
Accipiter fasciatus	Brown Goshawk		P	1
Acrocephalus australis	Australian Reed-Warbler		P	3
Aegotheles cristatus	Australian Owlet-nightjar		P	1
Anas gracilis	Grey Teal		P	5
Anas superciliosa	Pacific Black Duck		P	6
Anthochaera carunculata	Red Wattlebird		P	1
Aquila audax	Wedge-tailed Eagle		P	2
Ardea intermedia	Intermediate Egret		P	2
Artamus cyanopterus	Dusky Woodswallow		P	1
Artamus leucorynchus	White-breasted Woodswallow		P	1
Burhinus grallarius	Bush Stone-curlew		E1,P	1
Cacatua galerita	Sulphur-crested Cockatoo		P	9
Cacatua sanguinea	Little Corella		P	3
Cacatua tenuirostris	Long-billed Corella		P	4
Chenonetta jubata	Australian Wood Duck		P	5
Chthonicola sagittata	Speckled Warbler		V,P	1
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)		V,P	6
Colluricincla harmonica	Grey Shrike-thrush		P	7
Columba livia	Rock Dove	*		1
Coracina novaehollandiae	Black-faced Cuckoo-shrike		P	3
Coracina papuensis	White-bellied Cuckoo-shrike		P	1
Corcorax melanorhamphos	White-winged Chough		P	9
Cormobates leucophaea	White-throated Treecreeper		P	2
Corvus coronoides	Australian Raven		P	7
Coturnix ypsilophora	Brown Quail		P	1
Cracticus nigrogularis	Pied Butcherbird		P	1
Cracticus tibicen	Australian Magpie		P	11
Cygnus atratus	Black Swan		P	2
Dacelo novaeguineae	Laughing Kookaburra		P	6

Scientific Name	Common Name	Exotic	NSW legal status	Records
Dicaeum hirundinaceum	Mistletoebird		P	1
Egretta novaehollandiae	White-faced Heron		P	4
Entomyzon cyanotis	Blue-faced Honeyeater		P	3
Eolophus roseicapillus	Galah		P	12
Eurystomus orientalis	Dollarbird		P	1
Falco cenchroides	Nankeen Kestrel		P	1
Falcunculus frontatus frontatus	Eastern Shrike-tit		P	2
Fulica atra	Eurasian Coot		P	1
Gallinula tenebrosa	Dusky Moorhen		P	2
Geopelia striata	Peaceful Dove		P	1
Gerygone fusca	Western Gerygone		P	1
Grallina cyanoleuca	Magpie-lark		P	8
Haliastur sphenurus	Whistling Kite		P	4
Hirundo neoxena	Welcome Swallow		P	4
Lichenostomus penicillatus	White-plumed Honeyeater		P	7
Malurus cyaneus	Superb Fairy-wren		P	7
Manorina melanocephala	Noisy Miner		P	3
Melanodryas cucullata cucullata	Hooded Robin (south-eastern form)		V,P	1
Melithreptus brevirostris	Brown-headed Honeyeater		P	2
Melithreptus gularis gularis	Black-chinned Honeyeater (eastern subspecies)		V,P	1
Merops ornatus	Rainbow Bee-eater		P	1
Microcarbo melanoleucos	Little Pied Cormorant		P	2
Microeca fascinans	Jacky Winter		P	3
Neochmia temporalis	Red-browed Finch		P	3
^^*Ninox connivens*	Barking Owl		V,P,3	1
Ninox novaeseelandiae	Southern Boobook		P	8
Northiella haematogaster	Blue Bonnet		P	1
Ocyphaps lophotes	Crested Pigeon		P	4
Oriolus sagittatus	Olive-backed Oriole		P	1
Pachycephala rufiventris	Rufous Whistler		P	3
Pardalotus punctatus	Spotted Pardalote		P	2
Pardalotus striatus	Striated Pardalote		P	4
Petrochelidon nigricans	Tree Martin		P	1
Phalacrocorax sulcirostris	Little Black Cormorant		P	3

Scientific Name	Common Name	Exotic	NSW legal status	Records
Phaps chalcoptera	Common Bronzewing		P	3
Philemon citreogularis	Little Friarbird		P	4
Philemon corniculatus	Noisy Friarbird		P	1
Platalea flavipes	Yellow-billed Spoonbill		P	1
Platycercus elegans flaveolus	[Yellow Rosella]		P	5
Platycercus eximius	Eastern Rosella		P	5
^^*Polytelis swainsonii*	Superb Parrot		V,P,3	2
Pomatostomus superciliosus	White-browed Babbler		P	1
Pomatostomus temporalis temporalis	Grey-crowned Babbler (eastern subspecies)		V,P	4
Psephotus haematonotus	Red-rumped Parrot		P	2
Rhipidura albiscapa	Grey Fantail		P	3
Rhipidura leucophrys	Willie Wagtail		P	5
Stagonopleura guttata	Diamond Firetail		V,P	1
Sturnus vulgaris	Common Starling	*		2
Tadorna tadornoides	Australian Shelduck		P	1
Threskiornis molucca	Australian White Ibis		P	2
Threskiornis spinicollis	Straw-necked Ibis		P	1
Todiramphus sanctus	Sacred Kingfisher		P	3
Turdus merula	Eurasian Blackbird	*		2
Tyto javanica	Eastern Barn Owl		P	1
Zosterops lateralis	Silvereye		P	1
Mammals				
Antechinus flavipes	Yellow-footed Antechinus		P	8
Austronomus australis	White-striped Freetail-bat		P	7
Chalinolobus gouldii	Gould's Wattled Bat		P	2
Chalinolobus morio	Chocolate Wattled Bat		P	2
Macropus giganteus	Eastern Grey Kangaroo		P	2
Mormopterus planiceps	Little Mastiff-bat		P	1
Nyctophilus corbeni	Corben's Long-eared Bat		V,P	1
Nyctophilus geoffroyi	Lesser Long-eared Bat		P	1
Nyctophilus gouldi	Gould's Long-eared Bat		P	1
Nyctophilus sp.	long-eared bat		P	1
Petaurus breviceps	Sugar Glider		P	1
Petaurus norfolcensis	Squirrel Glider		V,P	1

Scientific Name	Common Name	Exotic	NSW legal status	Records
Pseudocheirus peregrinus	Common Ringtail Possum		P	4
Rattus rattus	Black Rat	*		5
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat		V,P	1
Scotorepens balstoni	Inland Broad-nosed Bat		P	1
Trichosurus sp.	brushtail possum		P	2
Trichosurus vulpecula	Common Brushtail Possum		P	4
Vespadelus darlingtoni	Large Forest Bat		P	2
Vespadelus regulus	Southern Forest Bat		P	2
Vespadelus vulturnus	Little Forest Bat		P	2
Vulpes vulpes	Fox	*		5
Reptiles				
Christinus marmoratus	Marbled Gecko		P	1
Pseudechis porphyriacus	Red-bellied Black Snake		P	1
Ramphotyphlops bituberculatus	Prong-snouted Blind Snake		P	1
Frogs				
Crinia parinsignifera	Eastern Sign-bearing Froglet		P	1
Crinia signifera	Common Eastern Froglet		P	1
Limnodynastes dumerilii	Eastern Banjo Frog		P	1
Limnodynastes fletcheri	Long-thumbed Frog		P	1
Limnodynastes tasmaniensis	Spotted Grass Frog		P	3
Litoria peronii	Peron's Tree Frog		P	1

* = introduced species; P = listed as protected under the *National Parks and Wildlife Act 1974*; E1 = listed as endangered under the TSC Act V = listed as vulnerable under the TSC Act.

Appendix 5: Endangered Ecological Communities Recorded from the Atlas of NSW Wildlife search region (06/08/14)

Community Name	NSW status	Commonwealth status	Records
Acacia melvillei Shrubland in the Riverina and Murray-Darling Depression bioregions	E3		K
Allocasuarina luehmannii Woodland in the Riverina and Murray-Darling Depression Bioregions	E3	E	K
Inland Grey Box Woodland in the Riverina, NSW South Western Slopes, Cobar Peneplain, Nandewar and Brigalow Belt South Bioregions	E3	E	K
Myall Woodland in the Darling Riverine Plains, Brigalow Belt South, Cobar Peneplain, Murray-Darling Depression, Riverina and NSW South Western Slopes bioregions	E3	E	K
Sandhill Pine Woodland in the Riverina, Murray-Darling Depression and NSW South Western Slopes bioregions	E3		K

Appendix 6: Further information requested by the Department of the Environment

BL&A Brett Lane & Associates Pty. Ltd.
Ecological Research & Management

June 11th 2013

Andrew Milvain
VicRoads
Acting Planning Studies Manager
Planning Investigations
Locked Bag 23 Camberwell VIC 3124

Attention: Andrew Milvain
Email: .Milvain@roads.vic.gov.au (**Phone** 03 9811 8168)

Dear Andrew,

RE: MURRAY RIVER CROSSING ECHUCA: ECHUCA-MOAMA BRIDGE (EPBC 2013/6850)
BL&A PROJECT NUMBER 8194.10

The Department of Sustainability, Environment, Water, Population and Communities (DSEWPC) has requested additional information with regards to the referral for the above project (letter dated May 22nd 2013). More specifically, the following further information was requested:

> *"1) The referral documentation identifies the South-Eastern Long-eared Bat… also known as Corben's Long-eared Bat, as being present on Anabat® call recording identification. The department requires further clarification as to the presence or absence of this species in the project area, including to confirm whether the bat(s) recorded are likely to be the South-Eastern Long-eared Bat or another species of Long-eared Bat.*
>
> *2) The department requires further information to confirm the presence or absence of the Superb Parrot… including discussion on any potential impacts to this species and mitigation measures to address these.*

Brett Lane and Associates Pty. Ltd. (BL&A) has been commissioned by VicRoads to provide ecological input to the response to the request for further information.

Corben's Long-eared Bat

The bat call analysis was undertaken by Dr. Greg Richards. In response to the request for further information, Dr. Richards was asked to provide more information on whether the bat species was considered as being present in the study area. His response is presented in Appendix 1.

In summary, the species is considered likely to occur in the region (i.e. along the Murray River and the Echuca-Moama area), based on its distribution and habitats present in the region.

The reference calls used for the analysis were published by Drs Pennay, Lay and Reiholt in '*Bat Calls of New South Wales*" (Churchill 2000). Although it is very difficult to distinguish between a number of long-eared bat species, *N. corbeni* can be distinguished by having a lower minimum call frequency compared with other *Nyctophilus* species. Its minimum call frequency is around 35 kHz, whilst

for other species it is 40 kHz. Graphic examples of call frequency extracted from Churchill (2000) are provided in Appendix 1. The letter provided by Dr. Richards also included two example calls from the data collected in the study area, attributed to *N. corbeni*. The examples clearly show in both cases that the minimum frequency is 35 kHz, as shown in Churchill (2000).

Based on the information provided it is considered that *N. corbeni* is present in the study area.

Superb Parrot

During the initial stages of the project, existing information was reviewed to determine whether Superb Parrot was likely to occur in the study area. Sources included the EPBC Act protected matters search tool and the Atlas of Victorian Wildlife. These sources indicated that the species was likely to occur given the presence of suitable habitat.

To inform this response to the request for further information two additional sources were searched: the Birds Australia Atlas and Victorian Biodiversity Atlas (VBA). As expected, the Birds Australia Atlas distribution map of Superb Parrot shows that the species has been recorded, albeit at a low reporting rate (i.e. less than 11%) (Figure 1).

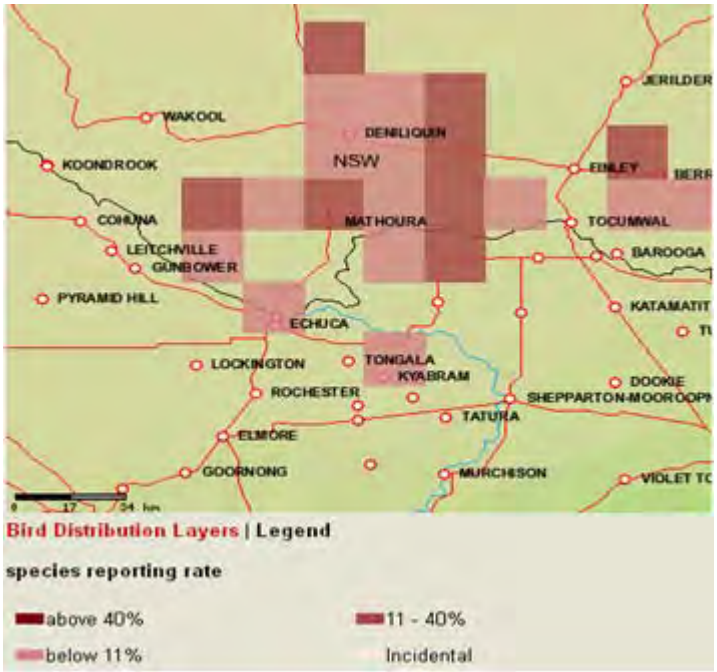

Figure 1: Distribution Map of Superb Parrot – Birds Australia Atlas

A search for Superb Parrot records was undertaken from the VBA using a 50 kilometre radius search region with Echuca being the centre point. A total of 337 Superb Parrot records have been recorded within 50 kilometres from Echuca (Figure 2).

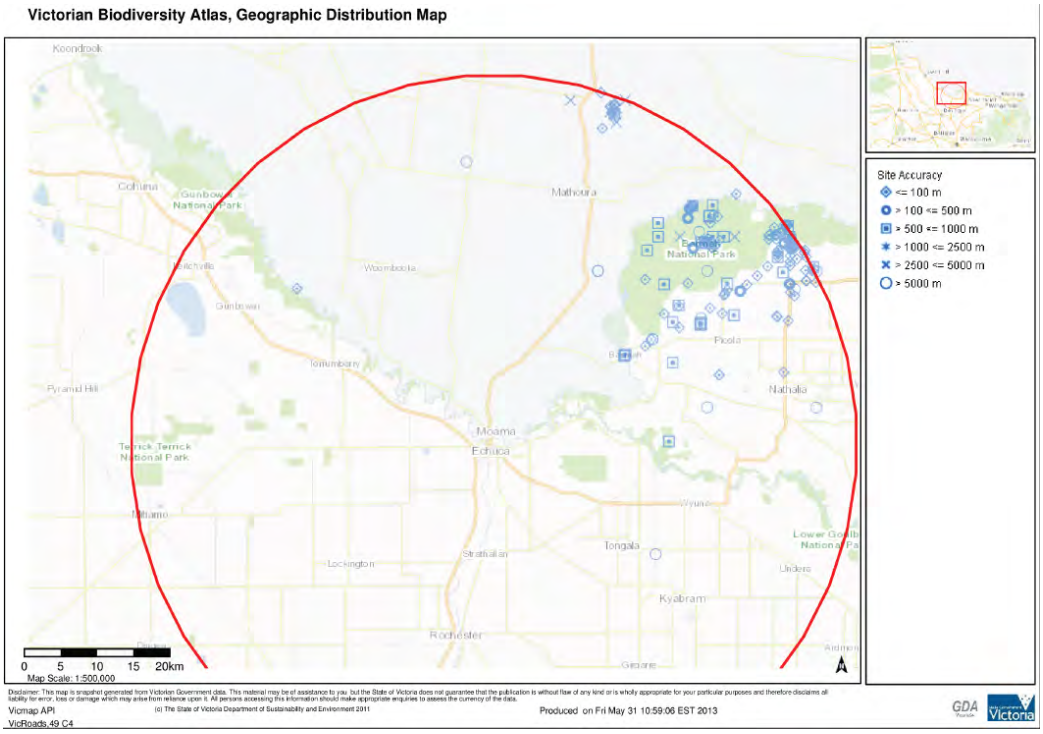

Figure 2: Distribution map of Superb Parrot records from the VBA

As is demonstrated by Figure 2, the majority of records originate from the Barmah State Forest which is a well-known breeding site for the species. The closest records to the study area were located 21.5 kilometres north-east. There were no records of Superb Parrot from the VBA within the study area or in the surrounding 20 kilometre radius (Appendix 1).

These observations are corroborated by observations from BL&A zoologists. BL&A has undertaken a suite of comprehensive ecological assessments within the study area between October 2008 and October 2012. Zoologists and ecologists have spent approximately 197 hours (Table 1) in the field during daylight hours within the study area covering seven months. Eighty-four percent of the surveys were undertaken by zoologists (i.e. 165 hours of survey time). Although no targeted surveys were undertaken for the species, Superb Parrot was not recorded on any of these occasions.

Table 1: Total number of person hours spent surveying at the study area

Date	Assessment	Zoologist present?	Survey Hours Day	Survey Hours Night
13th - 15th October 2008	Flora and Fauna Assessment	Yes	36	
6th - 8th January 2009	Targeted surveys for Bush-Stone Curlew and Squirrel Glider	Yes	9	13.5
21st & 22nd July 2010	Botanical survey	No	12	
26th - 30th September 2011	Flora and Fauna Assessment	Yes	36	
26th & 27th September	Spotlighting and call playback and setting up Anabat systems	Yes	12	8

Date	Assessment	Zoologist present?	Survey Hours Day	Survey Hours Night
	and Hair Tubes			
8th - 17th November 2011	Spotlighting and call playback and setting up Anabat systems	Yes	8	18
21st - 23rd November 2011	Targeted Flora Surveys	No	20	
22nd & 23rd November 2011	Decommissioning Anabats and Hair Tubes	Yes	12	
23rd & 24th February 2012	Setting up Anabat systems	Yes	8	
5th & 6th March 2012	Setting up Anabat systems	Yes	8	
14th & 15th March 2012	Decommissioning Anabat systems	Yes	8	
15th - 18th October 2012	Targeted Squirrel Glider Survey	Yes	16	16
17th October 2012	Hollow Tree Assessment	Yes	12	
17th & 18th October 2012	Targeted Growling Grass Frog Survey	Yes		16
Total			197	71.5

The study area and Echuca-Moama townships are not considered to be core habitat for this species which prefers larger intact forests such as Barmah State Forest. The study area supports a low habitat quality for this species particularly as it is a significant distance away from core breeding habitat.

Figure 3 presents the location of Barmah Forest and Gunbower Forest in relation to Echuca, both of which support suitable habitat for Superb Parrot (red boxes). A large area of native vegetation is present south of Barmah Forest (light blue box), though it is approximately eight kilometres from the proposed works. Remaining areas are highly cultivated agricultural land that supports little or no native vegetation. Considering the absence of suitable habitat within the region, apart from Barmah and Gunbower Forests, it is highly unlikely that significant numbers of Superb Parrot would regularly move across the landscape.

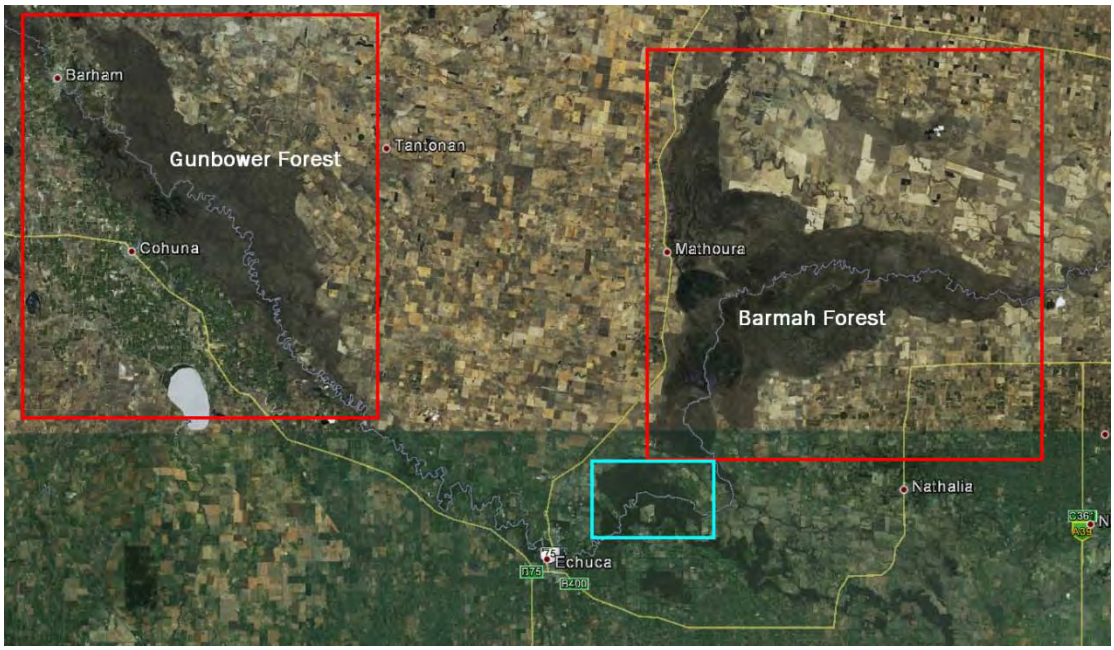

Figure 3: Areas of native vegetation or areas likely to comprise native vegetation in the region

As previously mentioned, the majority of VBA records originated from Barmah State Forest, which is a River Red-gum forest. Other records were from similar habitats at lagoons, waterholes and along water courses. Although there is suitable habitat for the species in the study area the lack of recent and regular records suggests that this species does not regularly occur. Superb Parrot may occasionally use the area as a wildlife corridor to travel to Gunbower National Park however most movements are recorded to the north of Echuca in NSW through Mathoura (Figure 3).

Considering the above, impacts on Superb Parrot such as the removal of sub-optimal habitat would be minimal and temporary and would not be significant under the EPBC Act significant impact guidelines as outlined in the EPBC Act Referral (EPBC Reference 2013/6850).

Although no mitigation measures of have been designed to specifically target the Superb Parrot, the clearance of native vegetation would be restricted to the physical footprint of the road and bridge construction.

If we can be of further assistance or if you have any other enquiries please do not hesitate to call me.

Yours sincerely,

Gabrielle Graham
Project Manager and Senior Ecologist
Brett Lane & Associates Pty. Ltd.

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Appendix 1: Further information provided by Dr. Richards in relation to *N. corbeni*

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TO WHOM IT MAY CONCERN
RE ECHUCA-MOAMA BRIDGE PROPOSAL BY VIC ROADS

I have been asked to provide further information with regards to Corben's Long-eared Bat because the Commonwealth regulator has been advised that it is unlikely that the species is present in the Echuca-Moama area, particular given their distribution and the habitats present. I am of the opinion that the alternative advice provided to the Commonwealth by other parties is incorrect, and is in opposition to the information publicly available on the Commonwealth's own EPBC Act website. Shown below is a copy of the relevant page about Corben's Longeared Bat (Figure 1).

Figure 1: Commonwealth website page relating to distribution of, and habitats utilised by, Corben's Longeared Bat

Corben's Long-eared Bat - profile

Scientific name: *Nyctophilus corbeni*
Conservation status in NSW: Vulnerable
Commonwealth status: Vulnerable
Profile last updated: 07 Sep 2012

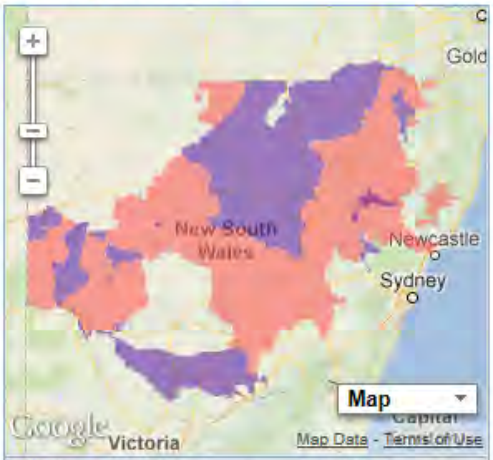
Description

The south eastern form of the Greater Long-eared Bat is also known as Eastern Long-eared Bat and has recently been described as new species Corben's Long-eared Bat *(N. corbeni)*. It is uniformly dark grey-brown. The ears are about 3 cm long and larger than the head. It has a low ridge of skin running between the eyes and across the nose. It has a head and body length of 5 - 7 cm and weighs about 14 grams.

Distribution

Overall, the distribution of the south eastern form coincides approximately with the Murray Darling Basin with the Pilliga Scrub region being the distinct stronghold for this species.

Indicative distribution



Key: known predicted

The areas shown in pink and/purple are the sub-regions where the species or community is known or predicted to occur. They may not occur thoughout the sub-region but may be restricted to certain areas. (click here to see geographic restrictions). The information presented in this map is only indicative and may contain errors and omissions.

Habitat and ecology

- Inhabits a variety of vegetation types, including mallee, bulloke *Allocasuarina leuhmanni* and box eucalypt dominated communities, but it is distinctly more common in box/ironbark/cypress-pine vegetation that occurs in a north-south belt along the western slopes and plains of NSW and southern Queensland.
- Roosts in tree hollows, crevices, and under loose bark.
- Slow flying agile bat, utilising the understorey to hunt non-flying prey - especially caterpillars and beetles - and will even hunt on the ground.
- Mating takes place in autumn with one or two young born in late spring to early summer.

It is apparent then, that this species would be present in habitats along the Murray River, and the species is known from the Echuca-Moama area. Regardless, the calls recorded by staff from Brett Lane and Associates included some that I considered to be *Nyctophilus corbeni.*

It is well known amongst bat experts that calls from all species of Longeared bats are difficult to separate past genus level unless the bat is very close to the bat detector microphone. Hence, in most surveys, all Longeared bat calls are lumped into a category often labelled "*Nyctophilus* sp." or similar. However, at least (in my opinion and that of several others) *N. corbeni* can be distinguished somewhat by having a lower minimum call frequency than other, smaller *Nyctophilus*. *N. corbeni* is the only one that has a minimum frequency around 35 kHz, others are usually above 40 kHz. Features of the calls are shown in Figures 2 and 3, which are reference calls published by eminent scientists Drs Michael Pennay, Bradley Law and Linda Reinholt in "*Bat Calls of New South Wales*"

Figure 2: Echolocation calls of *Nyctophilus corbeni* (previously known as *N. timoriensis*)

Nyctophilus timoriensis

Almost identical in shape and characteristics to other *Nyctophilus* species. Steep, near vertical, starting at between 60 and 80 kHz, usually dropping to between 31 to 37 kHz (n = 16). Soft callers, fragmentary calls typical.

Call characteristics and frequencies almost completely overlap with *Nyctophilus geoffroyi, N. bifax, and N. timoriensis* making them indistinguishable using standard Anabat / Analook parameters.

Bullen and McKenzie (2002) have devised a method to differentiate Western Australian *Nyctophilus* species using spectral analysis of the frequency domain to differentiate Western Australian *Nyctophilus* species. This technique may help to differentiate these species.

Available data shows little indication of variation in call characteristics for this species in New South Wales.

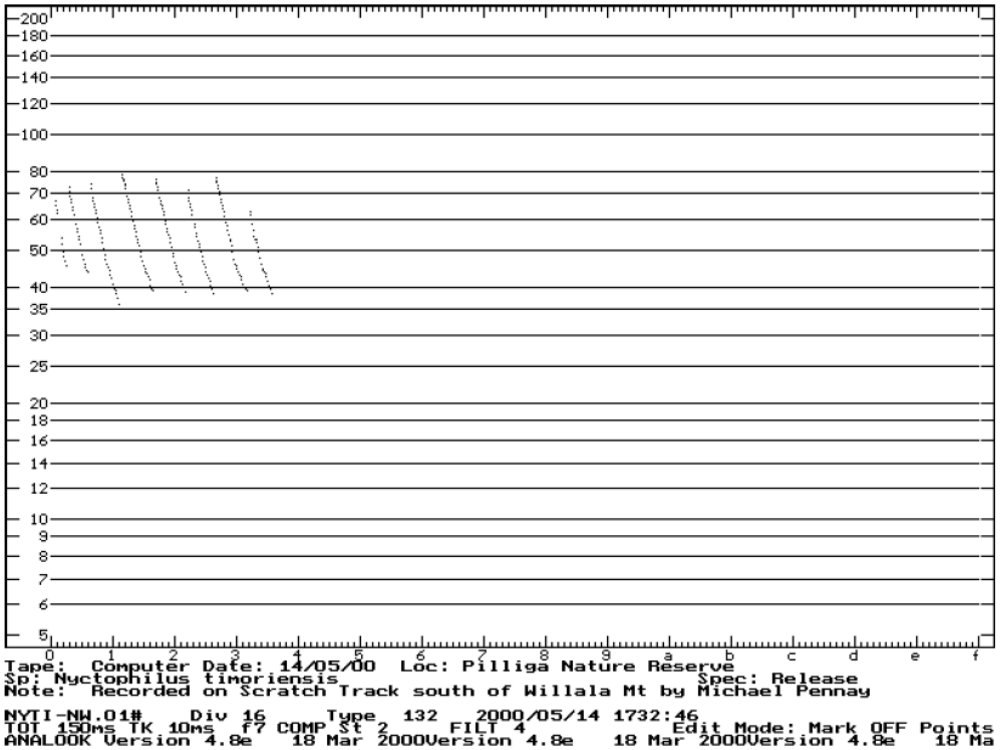
Regional Information

Western Slopes & Plains: Average starting frequency 71 kHz dropping to 43 kHz, mean frequency 53 kHz (n = 7).

Far West: Average starting frequency 70.5 kHz dropping to 42 kHz, mean frequency 53 kHz (n = 9).

North East, Sydney Basin, Southern, Riverina: No reference calls from these regions.

Western Slopes & Plains



Far west

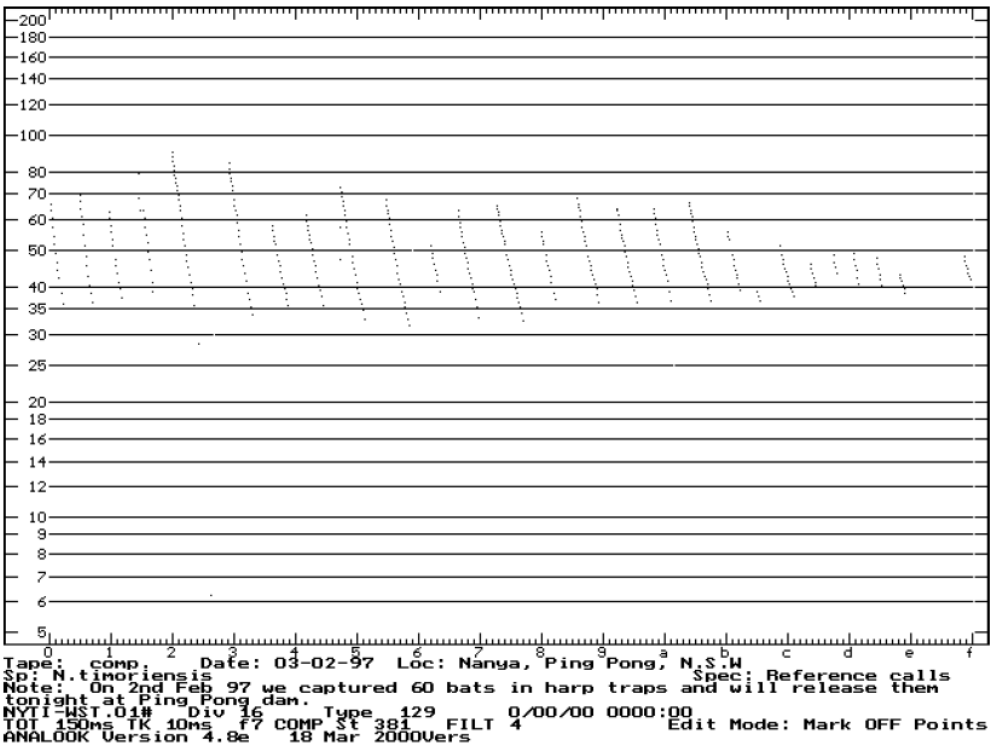


Figure 3: Echolocation calls of *Nyctophilus geoffroyi* which is sympatric with *N. corbeni*.

Nyctophilus geoffroyi

Steep, near vertical, starting at between 65 to 80 kHz, usually dropping to between 35 to 47 kHz (n = 51). Good quality calls usually have two changes in the slope in the middle or lower half. The first section is longest and steepest followed by a flatter section and then a steeper tail.

All *Nyctophilus* spp. are soft callers so short fragmentary calls are typical.

Call characteristics and frequencies almost completely overlap with *Nyctophilus gouldi, N. bifax, and N. timoriensis* making them indistinguishable using standard Anabat / Analook parameters.

Bullen and McKenzie (2002) have devised a method to differentiate Western Australian *Nyctophilus* species using spectral analysis of the frequency domain to differentiate Western Australian *Nyctophilus* species. This technique may help to differentiate these species.

Easily confused with *Myotis macropus*, but may be distinguished by several features. Pulse interval is usually greater than 95 ms and initial slope less than 300 OPS. If interval is between 75 and 95 ms and slope between 300 and 400 OPS then cannot be distinguished from *Myotis*.

Superficially similar to *Kerivoula,* but much lower in frequency.

Available data shows little indication of variation in call characteristics for this species in New South Wales. However, calls from west of the Great Dividing Range, particularly the Riverina and Far west regions are generally lower in frequency with longer durations.

Regional Information

North East: Average starting frequency 72 kHz dropping to 42 kHz, mean frequency 57 kHz (n = 2).

Western Slopes & Plains: Average starting frequency 66 kHz dropping to 46 kHz, mean frequency 53.5 kHz (n = 14).

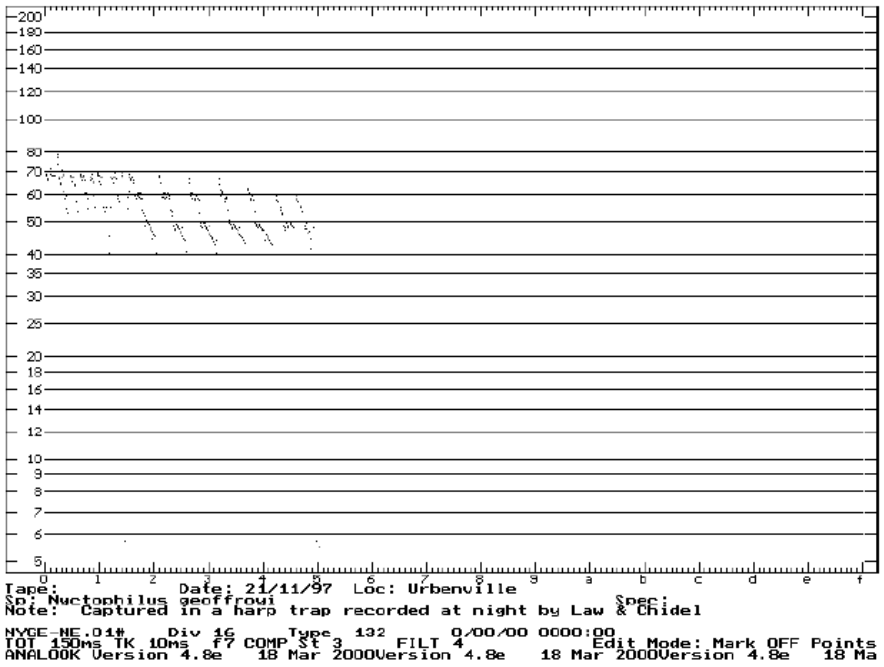
Sydney Basin: Average starting frequency 71 kHz dropping to 39 kHz, mean frequency 47 kHz (n = 3).

Southern: Average starting frequency 67 kHz dropping to 45 kHz, mean frequency 53.5 kHz (n = 10).

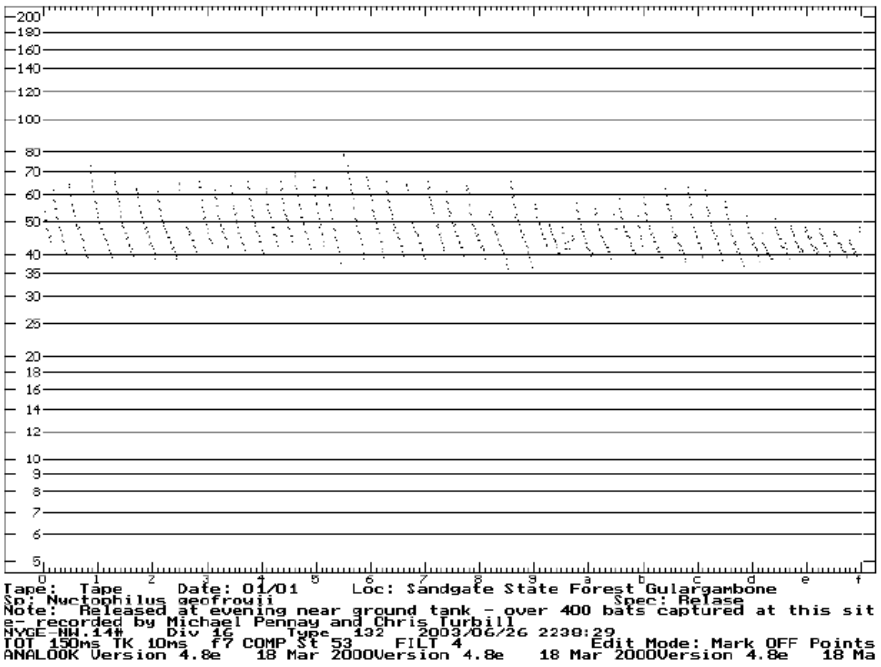
Riverina: Average starting frequency 65.5 kHz dropping to 39 kHz, mean frequency 49 kHz (n = 11). Occasionally calls display distinctive "social" non search pulses, long (> 10 ms), curved, dropping from 45 to 50 kHz to 20 to 25 kHz.

Far West: Average starting frequency 65 kHz dropping to 45 kHz, mean frequency 46 kHz (n = 11).

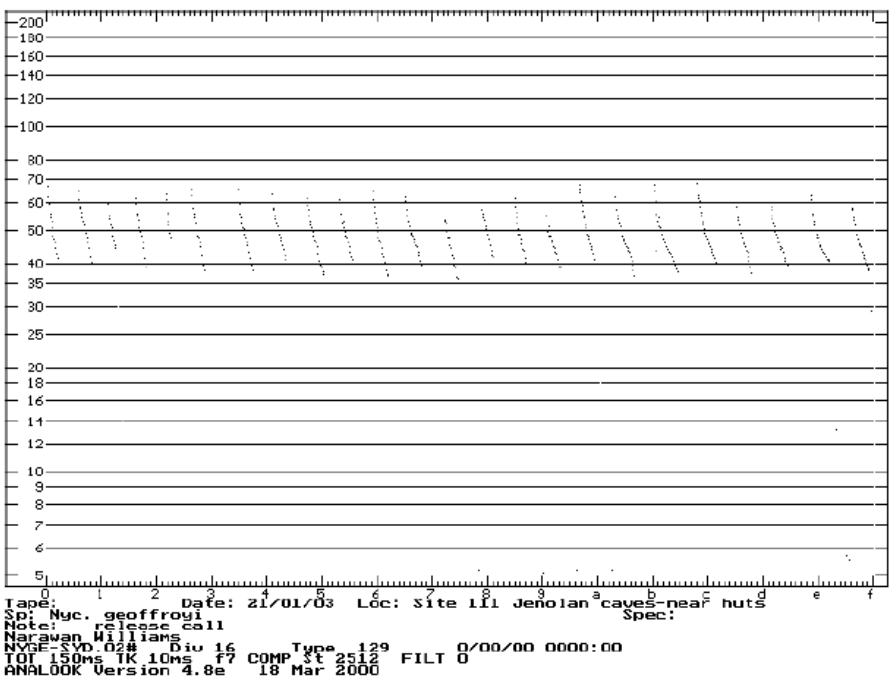
North East



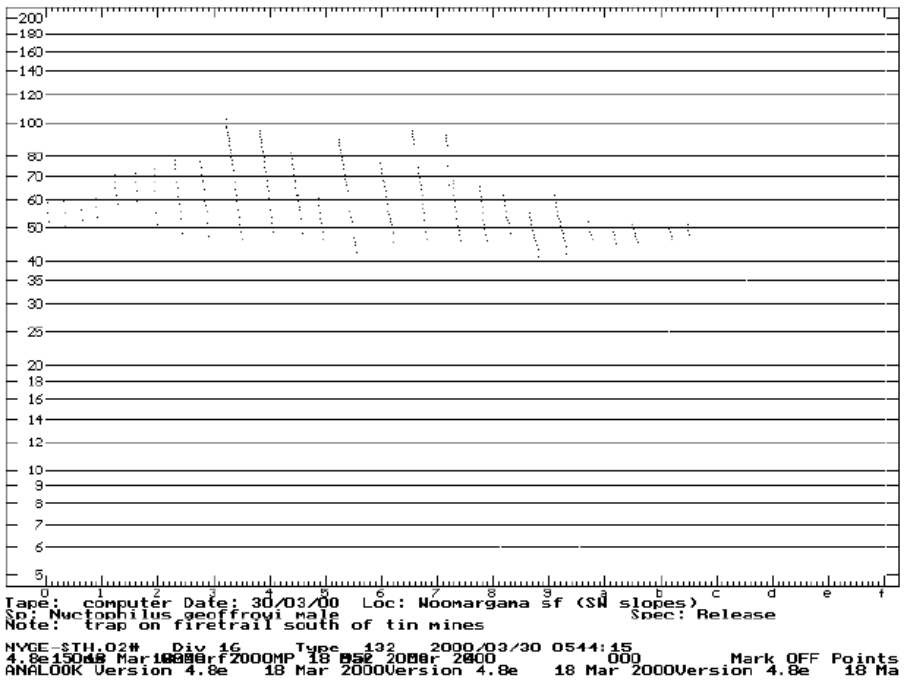
Western Slopes & Plains



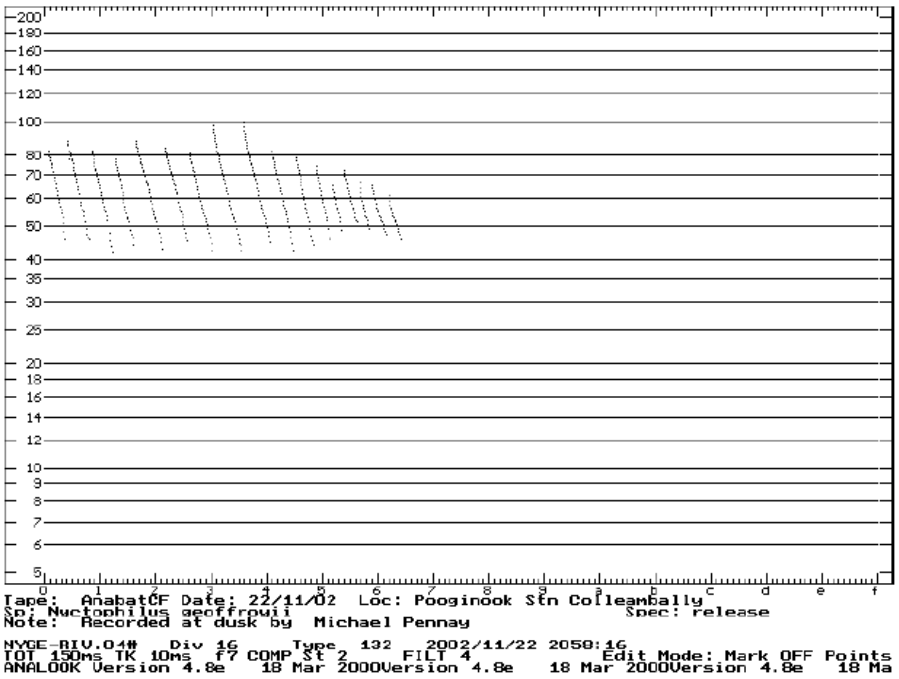
Sydney Basin



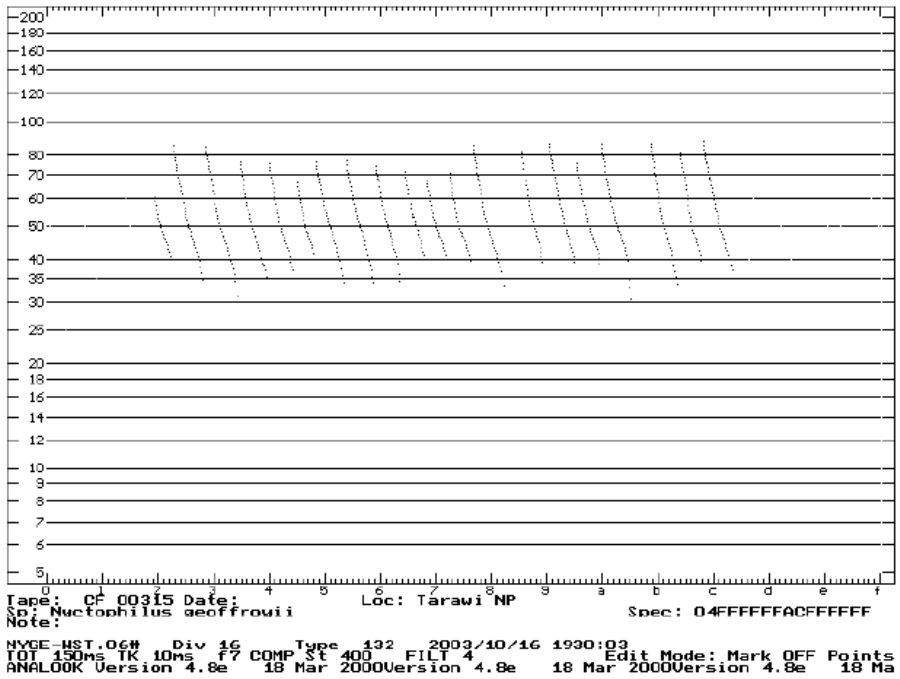
Southern



Riverina

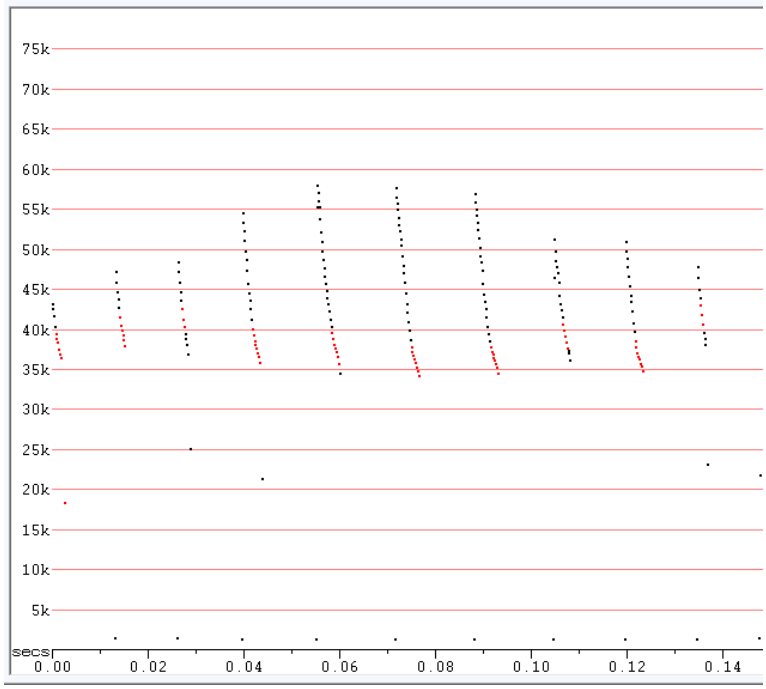


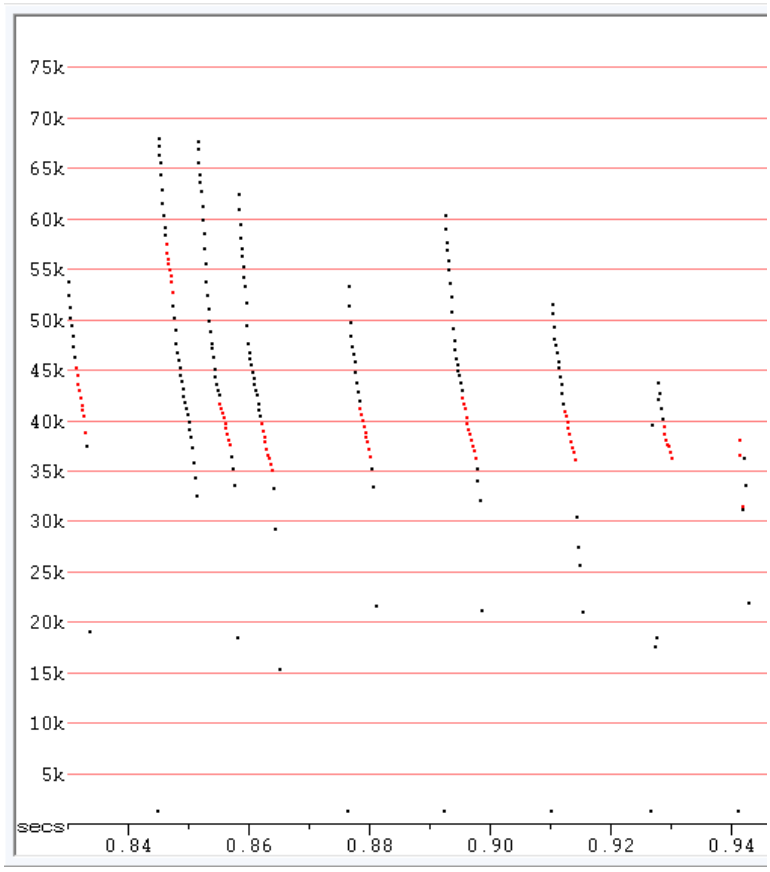
Far west



Examples of the calls that I identified as most likely being Corben's Longeared Bat are shown in Figure 4. These were recorded at site 4 during the Brett Lane and Associates bat surveys. Proprietary software (Analook-W) was used to view the call files. The y-axis in the displays shown in Figures 2 and 3 are logarithmic, and in Figure 4 it is linear. Whatever the scale, the salient feature (minimum frequency around 35 kHz) is obvious.

Figure 4: Two examples of calls attributed to Nyctophilus corbeni on the basis of a minimum frequency of 35 kHz, as shown in Churchill (2000).





It can be concluded that Brett Lane and Associates reported accurately that Corben's Longeared Bat is present in the area which is the subject of the Commonwealth EPBC Act Referral. It should also be noted that I agree that any impacts upon this species through the project will be minimal and will not be significant.

Dr G.C. Richards, 7 June 2013

Appendix 7: Detailed significance assessments

The significance assessments, particularly concerning fauna species, took into consideration impacts throughout the entire extent of proposed carriageway and adjacent areas, in both the NSW and Victorian jurisdictions. The reason for this was that for more mobile species (such as birds and bats), impacts over the entire proposed development must be considered, not just impacts within either of the two jurisdictions concerned, as impacts one mobile species in one jurisdiction are highly likely to affect the species in the other jurisdiction. The significance assessments did not take mitigation measures into account unless they had been clearly demonstrated to be effective for the subject species in similar situations elsewhere.

TSC Act

Following are the Significance Assessment Questions, as set out in the *Threatened Species Conservation Act 1995/ Environmental Planning and Assessment Act 1979:*

a) *in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*

b) *in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*

c) *in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*

   (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

   (ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

d) *in relation to the habitat of a threatened species, population or ecological community:*

   (i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

   (ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

   (iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

e) *whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),*

f) *whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,*

g) *whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*

Each TSC Act listed threatened species or community, which was either recorded in the study area and surrounds, or was considered to potentially occur there, were assessed

against these criteria in relation to potential impacts resulting from the proposal. These are presented in the following sections.

FM Act listed ecological communities

<u>Aquatic Ecological Community in the Natural Drainage System of the Lower Murray River Catchment (Murray River EEC)</u>

Status in the study area

The FM act listed ecological community: *Aquatic Ecological Community in the Natural Drainage System of the Lower Murray River Catchment* (Murray River EEC) was identified as occurring in the study area and comprised the Murray River Channel and the flooded woodland wetland area.

Potential impacts

Potential impacts on the Murray River EEC are discussed in Section 8.3. In summary these impacts include:

- Murray River channel:
  - loss or disturbance to riparian vegetation;
  - increased sedimentation and bank erosion;
  - increased rate of water runoff from the road;
  - increased nutrient inputs from road water runoff; and
  - shading of the water column and riparian vegetation from the bridge.

Natural river flow alteration and obstruction to fish passage would be minimal.

- Flooded woodland wetland area:
  - loss or severe disturbance to the wetland;
  - displacement and mortality of aquatic and riparian biota;
  - loss or disturbance to riparian vegetation;
  - increased sedimentation;
  - increased rate of water runoff from the road;
  - increased nutrient inputs from road water runoff;
  - severe shading of the wetlands from the [raised] road carriageway.

The Proposal would also likely impact on other wetlands adjacent the study area.

Impact significance

Significance Assessment Questions, as set out in the *Threatened Species Conservation Act 1995/ Environmental Planning and Assessment Act 1979,* and responses for the Murray River EEC*:*

a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,

Not applicable

b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the

endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

Not applicable

c) *in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*

   (i) *is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*

   While no proposed carriageway infrastructure would be situated within the Murray River channel, the proposed bridge would permanently shade the Murray River channel and riparian zone under the bridge. This would have a negligible adverse effect on the community and would certainly not place it at risk of extinction.

   (ii) *is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,*

   As above.

d) *in relation to the habitat of a threatened species, population or ecological community:*

   (i) *the extent to which habitat is likely to be removed or modified as a result of the action proposed, and*

   As the proposed bridge would permanently shade the Murray River channel and riparian zone under the bridge, it would be expected that EEC habitat in those areas would be modified to some degree.

   (ii) *whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and*

   The proposed action would unlikely fragment or isolate any of the EEC habitat.

   (iii) *the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,*

   While the EEC habitat which would likely be modified by bridge shading would be considered important habitat in the broader sense of the community, such localised modification would be of little importance to the long term survival of the EEC as a whole.

e) *whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),*

Not applicable

f) *whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,*

A number of recovery and abatement plans have been prepared for the lower Murray River catchment, of which damage or modification of riparian vegetation is cited as a threatening process. As such the proposal is not consistent with the objectives of such plans.

g) *whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*

The proposed action would, or potentially would, initiate or contribute to a number of key threatening processes (KTP's) which may have an adverse effect on this EEC, degradation (or modification) of native riparian vegetation being the most pertinent. However, such localised modification of riparian vegetation in the study area would have a negligible impact on the EEC as a whole.

Conclusion

While the proposal met all of the relevant significant impact criteria for the Murray River EEC, in that there would be some negative impact under each criteria, overall impacts on the Murray River EEC resulting from the proposal would not be significant and a *species impact statement* would unlikely be required.

TSC Act listed bird species

Masked Owl

Status in the study area

According to the NSW recovery plan for the Masked Owl (DEC 2006), records of the species are very scarce in the Echuca/Moama region. Similarly, there are very few records in the Victorian AVW for the region. Therefore it is likely to occur in low numbers in the region. Targeted surveying was not conducted for this species, due to its low likelihood of occurrence. However, one individual was recorded incidentally in the study area during frog surveying.

Potential impacts

The proposal may result in the following potential impacts on Masked Owl:

- Clearance of habitat, including hollow-bearing trees and fallen timber;
- Degradation of habitat due to edge effects, particularly weed invasion;
- Noise, vibration and light; and
- Mortality and injury due to collision with vehicles.

Impact significance

Significance Assessment Questions, as set out in the *Threatened Species Conservation Act 1995/ Environmental Planning and Assessment Act 1979,* and responses for Masked Owl*:*

a) *in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*

The study area provides suitable habitat for Masked Owl and the species was detected incidentally in the study area during frog surveying. However, considering the historic scarcity of this species in the Echuca/Moama region, it is likely to only occasional occur in the study area and surrounds and probably not breed there. As such, the proposed action is unlikely to have a significant adverse effect on the life cycle of this species.

b) *in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the*

endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

Not applicable

c) *in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Not applicable

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable

d) *in relation to the habitat of a threatened species, population or ecological community:*

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

Approximately 5.080 hectares of Masked Owl habitat is proposed to be directly removed under the proposal. When considering the modifying effects on habitat resulting from edge effect, significantly more habitat would likely be degraded.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

Masked Owl habitat would become fragmented as a result of the proposal, as the carriageway would dissect it and result in an area of that habitat being structurally isolated from adjacent habitat.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

While Masked Owl was detected in the study area, it is known to be very scarce in the Echuca/Moama region, and is thus likely to only occasional occur in the study area and surrounds and probably not breed there. It was therefore considered unlikely that habitat for this species in and adjacent the study area would be important to its long-term survival in the locality.

e) *whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),*

Not applicable

f) *whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,*

A recovery plan has been prepared for Masked Owl (DEC 2006). The plan cites 'clearing of native vegetation' and 'removal of dead wood and dead trees' as having an adverse affect on the Masked Owl. The proposed action would result in both of the above, which would not be consistent with the objectives or actions of the recovery plan. However, considering that Masked Owl was deemed likely to only occasional occur in the study area and surrounds and probably not breed there, the proposed action is unlikely to significantly interfere with the recovery of the species.

g) *whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*

The proposed action would, or potentially would, initiate or contribute to a number of key threatening processes (KTP's) which may have an adverse effect on Masked Owl. However, considering that Masked Owl was deemed likely to only occasional occur in the study area and surrounds and probably not breed there, it is unlikely that such KTP's would have a significant impact on the species.

Conclusion

While the proposal met three out of four relevant significant impact criteria for the Masked Owl (there would be some negative impact under each of the three criteria), overall impacts on this species would not be significant, primarily because it was considered unlikely to make significant use of the habitat in the study area. Therefore, a *species impact statement* would unlikely be required.

Brown Treecreeper

Status in the study area

A large and viable Brown Treecreeper population is resident in the study area and surrounds. During field investigations, it was observed that the population occupied habitat in the Victorian component of the proposed alignment far more than habitat in the NSW component, presumably due to higher quality habitat for the species. Brown Treecreeper were also observed nesting in suitable hollows in the study area on a number of occassions.

The taxonomic status of the Brown Treecreeper population at Echuca/Moama was questioned as part of a peer review by Envirokey (2012), as Echuca lies in a distributional transition zone between the threatened *Victoriae* sub-species and the non-threatened *picumnus* sub-species, according to Shodde and Mason (1999). As such, in the absence of detailed taxonomic studies of the population, and under the precautionary principle, the Echuca/Moama Brown Treecreeper population was considered as the threatened *Victoriae* sub-species. Further analysis could be undertaken (and consultation with the Office of Environment and Heritage (OEH) to provide more confidence in whether the Brown Treecreeper recorded at the study area is the threatened sub-species.

Potential impacts

The proposal may result in the following potential impacts on Brown Treecreeper:

- Clearance of habitat, particularly hollow-bearing trees and fallen timber;
- Degradation of habitat due to edge effects, particularly weed invasion;
- Increased predation by feral cats and the Red Fox;
- Noise, vibration and light; and
- Mortality and injury due to collision with vehicles.

Impact significance

Significance Assessment Questions, as set out in the *Threatened Species Conservation Act 1995/ Environmental Planning and Assessment Act 1979,* and responses for Brown Treecreeper*:*

a) *in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*

Given the relatively high mobility of Brown Treecreeper, and its dispersal characteristics, it is presumed that the population resident in the study area would occupy all suitable habitat along the wildlife corridor linking the Barmah and Gunbower forest blocks (of which the study area is part of), and that those forest blocks would provide core habitat for the population - as attested by the very large number of historical records there. Should that be the case, the viable local Brown Treecreeper population would be very large and occupy a very large area of habitat.

While the proposed action is likely to have a very localised adverse effect on the life cycle of the local population, primarily through destruction and modification of its breeding and foraging habitat, it is very unlikely to place that population at risk of extinction. Impacts such as barrier effects, noise, vibration and light and mortality and injury through collision with vehicles are likely to be less severe for Brown Treecreeper than other, less mobile or shy species, and shouldn't restrict effective dispersal of the population across the proposed carriageway.

b) *in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*

Not applicable

c) *in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Not applicable

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable

d) *in relation to the habitat of a threatened species, population or ecological community:*

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

Approximately 5.080 hectares of Brown Treecreeper habitat is proposed to be directly removed under the proposal. When considering the modifying effects on habitat resulting from edge effect, significantly more habitat would likely be degraded.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

Brown Treecreeper habitat would become fragmented as a result of the proposal, as the carriageway would dissect it and result in an area of that habitat being structurally isolated from adjacent habitat. However, given the relatively high mobility of the species, such habitat fragmentation would not isolate any part of the population.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

While the role of the habitat to be affected in the study area in sustaining Brown Treecreeper habitat connectivity in the locality (being part of an important wildlife corridor) is likely to be important for maintaining genetic diversity in the local population, the proposal is unlikely to compromise the long-term survival of the species in the locality. Core habitats for the local population (i.e. the Barmah and Gunbower forest blocks) would be unaffected by the proposal and the proposal would unlikely significantly restrict movement of the population through the wildlife corridor that connects those core habitats.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

Not applicable.

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

A Brown Treecreeper recovery plan has not been prepared.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The proposed action would, or potentially would, initiate or contribute to a number of key threatening processes (KTP's) which may have an adverse effect on Brown Treecreeper. However, it is unlikely that such KTP's would have a significant impact on the species in the locality.

Conclusion

While the proposal met three out of four relevant significant impact criteria for Brown Treecreeper (there would be some level of negative impact under each of the three criteria), overall impacts on this species would not be significant, as the proposal would unlikely comprise the function and integrity of the local Brown Treecreeper population. A *species impact statement* would unlikely be required.

Grey-crowned Babbler

Status in the study area

There were four records of Grey-crowned Babbler in the search region, from 2004 and 2005, according to the ANSWW.

All woodland and forest habitat in the study area was considered to be potential habitat for this species, and it was considered to potentially occur in woodland habitat in the study area and surrounds. However, no evidence was found for the occurrence of Grey-crowned Babbler during any of the field surveys. Neither individuals, colonies or nests (Grey-crowned Babbler nests are highly conspicuous) were located in the study area and surrounds (in both components of the proposed alignment). Information obtained from the Murray Shire indicated that this species is occasionally observed along the proposed alignment on the New South Wales side of the Murray River (BL&A 2011). Such occurrences are likely to be that of dispersing individuals, not permanent residents. It is therefore unlikely that a breeding population of Grey-crowned Babbler occurs in the vicinity of the proposed alignment, although they may occur elsewhere along the wildlife

corridor between the Barmah and Gunbower forest blocks and in those forest blocks, as there are numerous historic records of the species in that region.

Potential impacts

The proposal may result in the following potential impacts on Grey-crowned Babbler:

- Clearance of habitat, particularly fallen timber;
- Degradation of habitat due to edge effects, particularly weed invasion;
- Increased predation by feral cats and the Red Fox;
- Noise, vibration and light; and
- Mortality and injury due to collision with vehicles.

Impact significance

Significance Assessment Questions, as set out in the *Threatened Species Conservation Act 1995/ Environmental Planning and Assessment Act 1979,* and responses for Grey-crowned Babbler*:*

a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,

The study area and surrounds provides suitable potential habitat for Grey-crowned Babbler. However, this species was not detected during any of the field surveys (both components of the study area) and is therefore considered unlikely to occur in the study area as a breeding population. And given the relatively high mobility of Grey-crowned Babbler, and its dispersal characteristics, it is presumed that impacts such as barrier effects, noise, vibration and light and mortality and injury through collision with vehicles are not likely to restrict effective dispersal of individuals across the proposed carriageway.

As such, the proposed action is unlikely to have an adverse effect on the life cycle of Grey-crowned Babbler in the region.

b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

Not applicable

c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Not applicable

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable

d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

Approximately 5.080 hectares of potential Grey-crowned Babbler habitat is proposed to be directly removed under the proposal. When considering the modifying effects on habitat resulting from edge effect, significantly more habitat would likely be degraded.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

Potential Grey-crowned Babbler habitat would become fragmented as a result of the proposal, as the carriageway would dissect it and result in an area of that habitat being structurally isolated from adjacent habitat. However, given the relatively high mobility of the species, such habitat fragmentation would not isolate any dispersing individuals or colonies.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

Considering that Grey-crowned Babbler was not recorded during extensive field surveying, and that it was considered unlikely to regularly occur in the study area, it is unlikely that the potential habitat for this species would be important to its long-term survival in the locality, particularly as it did not support any breeding colonies.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

Not applicable

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

A Grey-crowned Babbler recovery plan has not been prepared.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The proposed action would, or potentially would, initiate or contribute to a number of key threatening processes (KTP's) which may have an adverse effect on Grey-crowned Babbler. However, it is unlikely that such KTP's would have a significant impact on the species in the locality.

Conclusion

While the proposal met two out of four relevant significant impact criteria for the Grey-crowned Babbler (there would be some negative impact under each of the two criteria), overall impacts on this species would not be significant, primarily because it was considered unlikely to make significant use of the habitat in the study area. Therefore, a *species impact statement* would unlikely be required.

Black-chined Honeyeater, Hooded Robin, Diamond Firetail, Speckled Warbler and Varied Sittella

Status in the study area

Black-chinned Honeyeater was not recorded in the study area, although it was recorded in the Victorian component of the alignment. Therefore Black-chinned Honeyeater is likely to make some use of the habitat in the study area. Potential suitable habitat also occurs for several other woodland species, such as the Diamond Firetail, Speckled Warbler and Hooded Robin. The ANSWW contains one record for each of these within the

search region. Therefore, although these species may occasionally utilise habitat in the study area, they are unlikely to occur regularly or in significant numbers. Varied Sittella was recorded in the study area one occasion, therefore it is likely occur in low numbers in the study area.

Potential impacts

The proposal may result in the following potential impacts on these bird species:

- Clearance of habitat, particularly fallen timber;
- Degradation of habitat due to edge effects, particularly weed invasion;
- Increased predation by feral cats and the Red Fox;
- Noise, vibration and light; and
- Mortality and injury due to collision with vehicles.

Impact significance

Significance Assessment Questions, as set out in the *Threatened Species Conservation Act 1995/ Environmental Planning and Assessment Act 1979,* and responses for the above-listed species*:*

a) *in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*

   Given the relatively high mobility of these woodland bird species, and their dispersal characteristics, it is presumed that populations which utilise habitat in the study area would occupy all suitable habitat along the wildlife corridor linking the Barmah and Gunbower forest blocks (of which the study area is part of), and that those forest blocks would provide core habitat for these populations. Should that be the case, viable local populations of these woodland bird species would be very large and occupy a very large area of habitat.

   While the proposed action is likely to have a very localised adverse effect on the life cycle of local populations of these species, primarily through destruction and modification of their habitat, it is very unlikely to place those populations at risk of extinction. Impacts such as barrier effects, noise, vibration and light and mortality and injury through collision with vehicles are likely to be less severe for these woodland bird species than other, less mobile or shy species, and shouldn't restrict their effective dispersal across the proposed carriageway.

b) *in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*

   Not applicable

c) *in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*

   (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

   Not applicable

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable

d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

Approximately 5.080 hectares of potential habitat for these woodland bird species is proposed to be directly removed under the proposal. When considering the modifying effects on habitat resulting from edge effect, significantly more habitat would likely be degraded.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

Potential habitat for these woodland bird species would become fragmented as a result of the proposal, as the carriageway would dissect it and result in an area of that habitat being structurally isolated from adjacent habitat. However, given the relatively high mobility of these species, such habitat fragmentation would not isolate any dispersing individuals or groups.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

Considering that these woodland bird species were considered unlikely to make significant use of habitat in the study area, it is unlikely that the potential habitat for these species would be important to their long-term survival in the locality.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

Not applicable

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

Recovery plans have not been prepared for any of these woodland bird species.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The proposed action would, or potentially would, initiate or contribute to a number of key threatening processes (KTP's) which may have an adverse effect on these woodland bird species. However, it is unlikely that such KTP's would have a significant impact on the species in the locality.

Conclusion

While the proposal met two out of four relevant significant impact criteria for these woodland bird species (there would be some negative impact under each of the two criteria), overall impacts on these species would not be significant, primarily because they were considered unlikely to make significant use of the habitat in the study area. Therefore, a *species impact statement* would unlikely be required.

Swift Parrot

Status in the study area

Although the Swift Parrot may occasionally pass through the study area, it is highly unlikely it would occur regularly or in significant numbers. There are no records of the species in the AVW but one record in the ANSWW, and although the study area supports potential foraging habitat, the preferred food trees of this species in this region, such as Red Ironbark, Grey Box, Yellow Gum and White Box, are absent.

Potential impacts

The proposal may result in the following potential impacts on Swift Parrot:

- Clearance of habitat, particularly foraging tree species;
- Degradation of habitat due to edge effects, particularly weed invasion;
- Noise, vibration and light; and
- Mortality and injury due to collision with vehicles.

Impact significance

Significance Assessment Questions, as set out in the *Threatened Species Conservation Act 1995/ Environmental Planning and Assessment Act 1979,* and responses for Swift Parrot*:*

a) *in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*

   Swift Parrot may occasionally visit habitat in and adjacent the study area when searching for flowering Eucalypts during migration, although considering their preferred food trees - Red Ironbark, Grey Box, Yellow Gum and White Box, do not occur in the area, they are unlikely to make significant use of the habitat. As such, the proposed action is unlikely to have an adverse effect on the life cycle of this species.

b) *in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*

   Not applicable

c) *in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*

   (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

   Not applicable

   (ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

   Not applicable

d) *in relation to the habitat of a threatened species, population or ecological community:*

(i) *the extent to which habitat is likely to be removed or modified as a result of the action proposed, and*

Approximately 5.080 hectares of potential sub-optimal Swift Parrot habitat is proposed to be directly removed under the proposal. When considering the modifying effects on habitat resulting from edge effect, significantly more habitat would likely be degraded.

(ii) *whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and*

Potential sub-optimal Swift Parrot habitat would become fragmented as a result of the proposal, as the carriageway would dissect it and result in an area of that habitat being structurally isolated from adjacent habitat. Given the high mobility of Swift Parrot, such fragmentation would have little or no effect on the species.

(iii) *the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,*

Considering that Swift Parrot was considered unlikely to regularly occur in the study area, it is unlikely that the potential sub-optimal habitat for this species in the study area and surrounds would be important to its long-term survival in the locality.

e) *whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),*

Not applicable

f) *whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,*

While a recovery plan has been prepared for Swift Parrot (Swift Parrot Recovery Team 2001), it is unlikely that the proposal would have any bearing on the recovery of the species, given the marginal suitability of habitat in the area.

g) *whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*

The proposed action would, or potentially would, initiate or contribute to a number of key threatening processes (KTP's) which may have an adverse effect on Swift Parrot. However, it is unlikely that such KTP's would have a significant impact on the species.

Conclusion

While the proposal met two out of four relevant significant impact criteria for Swift Parrot (there would be some negative impact under each of the two criteria), overall impacts on these species would not be significant, primarily because they were considered unlikely to make significant use of the habitat in the study area. Therefore, a *species impact statement* would unlikely be required.

Superb Parrot and Turquoise Parrot

Status in the study area

The known Superb Parrot range includes the Barmah-Millewa Forest, within approximately 20km of the study area. It is possible this species may occasionally occur in the study area due to the presence of suitable foraging habitat, however numbers are

unlikely to be significant, especially since there are no records within the search region. The centre of the population occurs in habitats further east along the Murray River, associated with the Barmah – Millewa forests.

There are no records of Turquoise Parrot in search region in the ANSWW, although there are three old records of this species in the Atlas of Victorian Wildlife, between 1984 and 1986. Although this species may occur in the study area as suitable habitat is present, it is unlikely to occur there regularly, as evidenced by the lack of recent database records, despite records being submitted regularly to most of these databases.

Potential impacts

The proposal may result in the following potential impacts on these bird species:

- Clearance of habitat, particularly fallen timber;
- Degradation of habitat due to edge effects, particularly weed invasion;
- Increased predation by feral cats and the Red Fox;
- Noise, vibration and light; and
- Mortality and injury due to collision with vehicles.

Impact significance

Significance Assessment Questions, as set out in the *Threatened Species Conservation Act 1995/ Environmental Planning and Assessment Act 1979,* and responses for these parrot species*:*

a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,

Both parrot species may occasionally occur in the River Red–gum dominated habitat in the study area and surrounds. Both species were considered to be infrequent visitors in the area and it is unlikely that the proposal would have an adverse effect on their life cycle.

b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

Not applicable

c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Not applicable

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable

d) in relation to the habitat of a threatened species, population or ecological community:

(i) *the extent to which habitat is likely to be removed or modified as a result of the action proposed, and*

Approximately 5.080 hectares of potential sub-optimal habitat for these parrot species is proposed to be directly removed under the proposal. When considering the modifying effects on habitat resulting from edge effect, significantly more habitat would likely be degraded.

(ii) *whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and*

Potential sub-optimal habitat for these parrot species would become fragmented as a result of the proposal, as the carriageway would dissect it and result in an area of that habitat being structurally isolated from adjacent habitat. Given the high mobility of these parrot species, such fragmentation would have little or no effect on the species.

(iii) *the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,*

Considering that these parrot species were considered unlikely to regularly occur in the study area, it is unlikely that the potential sub-optimal habitat for them in the study area and surrounds would be important to their long-term survival in the locality.

e) *whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),*

Not applicable

f) *whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,*

Recovery plans have not been prepared for either of these parrot species.

g) *whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*

The proposed action would, or potentially would, initiate or contribute to a number of key threatening processes (KTP's) which may have an adverse effect on these parrot species. However, it is unlikely that such KTP's would have a significant impact on them.

Conclusion

While the proposal met two out of four relevant significant impact criteria for these parrot species (there would be some negative impact under each of the two criteria), overall impacts on these species would not be significant, primarily because they were considered unlikely to make significant use of the habitat in the study area. Therefore, a *species impact statement* would unlikely be required.

TSC Act listed mammal species

Squirrel Glider

A significance assessment for potential impacts on Squirrel Gliders has been undertaken in light of the recommended mitigation measures set out in BL&A (2015d) in accordance with Part 1, Section 5A (2) of the EP&A Act. This assessment is documented below. The assessment has found that with the implementation of the habitat linkage

recommendations contained within the habitat linkage strategy (BL&A 2015d) and van der Ree et al. (2015) there is unlikely to be a significant impact on Squirrel Gliders. As such, a Species Impact Statement is not required.

Status in the study area

Squirrel Gliders have previously been observed within the study area both during spotlighting and trapping (van der Ree et al., 2015). It is considered that the study area supports a small, low-density but healthy population of the species (van der Ree et al., 2015).

Potential impacts

The proposal may result in the following potential impacts on Squirrel Glider:

- Clearance of habitat, including hollow-bearing trees;
- Degradation of habitat due to edge effects, particularly weed invasion;
- Increased predation;
- Noise, vibration and light; and
- Mortality and injury due to collision with vehicles.

Impact significance

Significance Assessment Questions, as set out in the *Threatened Species Conservation Act 1995/ Environmental Planning and Assessment Act 1979,* are included below, along with responses for Squirrel Gliders in relation to the proposal.

a) *in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*

   It is considered that the study area supports a small, low-density but healthy Squirrel Glider population. The proposed alignment passes through areas of high quality Squirrel Glider habitat both in Victoria and NSW, as well as areas of sub-optimal habitat (BL&A 2015d; Appendix 9) Areas of high quality habitat extend for several hundred meters either side of the proposed alignment in the northern section of the study area, and several hundred meters to the west in Victoria (BL&A 2015d; Appendix 9) and are contiguous with riparian vegetation and known Squirrel Glider habitat along the Campaspe (Kent & Hodgens, 2010) and Murray (Korodaj et al., 2014) Rivers. It has been assumed that Squirrel Glider are likely to occupy all suitable habitat within several kilometers of the project along the wildlife corridor linking the Barmah and Gunbower forest blocks (of which the study area is a part), and that those forest blocks would provide core habitat for the species in the region.

   Critical to the reproductive success of Squirrel Glider populations are the presence of large trees with abundant hollows for denning and nesting, and a reliable year-round food supply of nectar, pollen and plant exudates (sap). Predation and mortality also has a considerable influence on reproductive success.

   The construction phase of the proposal may have an adverse effect on the reproductive success of the local Squirrel Glider population through the removal of hollow-bearing trees and food resources, as well as noise and vibration. The

loss of hollow-bearing trees will be compensated with the provision of nest boxes. The operational phase is considered unlikely to compromise reproductive success as the provision of crossing zones will avoid road mortality and injury, and maintain connectivity between sub-populations.

It is recognised that the already small Squirrel Glider population is at particular risk of extinction (van der Ree et al., 2015), but that Squirrel Gliders are known to use multiple dens (van der Ree, 2000; Crane et al., 2010). The study area provides large areas of good quality den and foraging habitat (see Appendix 3) and habitat links to known Squirrel Glider populations along the Campaspe and Murray Rivers. Squirrel Gliders are thought to have a maximum lifespan of at least five years (van der Ree, 2002) and construction represents a small proportion of the species' life span. It is therefore considered that while the proposal may have some short-term impacts on Squirrel Glider reproductive success, this is unlikely to place the local population at risk of extinction.

b) *in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*

Not applicable

c) *in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*

(i) *is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*

Not applicable

(ii) *is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,*

Not applicable

d) *in relation to the habitat of a threatened species, population or ecological community:*

(i) *the extent to which habitat is likely to be removed or modified as a result of the action proposed, and*

Approximately 5.080 hectares of Squirrel Glider habitat is proposed to be directly removed under the proposal ((BL&A, 2015). When considering the modifying effects on habitat resulting from edge effects, a greater area of habitat would likely be degraded. Based on the current investigation, the nearby study area supports a total of 114.285 hectares of high quality and 48.374 hectares of medium quality habitat for the species. The habitat removed by the road represents three percent of this habitat, a proportion that is unlikely to endanger the status of the species in the area.

(ii) *whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and*

The proposal has the potential to fragment Squirrel Glider habitat, as the carriageway would dissect it and result in an area of habitat being structurally isolated from adjacent habitat. This habitat linkage strategy seeks to address this fragmentation by providing several crossing zones along the alignment,

based on proven mitigation measures for Squirrel Gliders. Such measures have been shown to re-establish but not fully restore movement across roads (Soanes et al., 2013). As such, habitat is likely to be somewhat separated but not completely isolated.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

The proposed carriageway will be situated in one of the wider sections of a wildlife corridor that extends between the Barmah and Gunbower forest blocks, and will impact high, medium and low quality Squirrel Glider habitat within the study area. Of particular concern is the large number of hollow-bearing trees that will be affected by the proposed alignment (BL&A, 2015). The high quality habitat proposed for removal within the footprint is almost certainly currently be used by Squirrel Gliders, particularly as dens in hollow-bearing trees, however given the availability of other areas of high quality habitat, the proposed measures to maintain a degree of connectivity between these, and the links provided to other known Squirrel Glider populations along the Murray and Campaspe Rivers, it is considered unlikely that habitat removal will affect the long-term survival of the species in the locality.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

Not applicable

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

A Squirrel Glider recovery or threat abatement plan has not been prepared.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The proposed action would, or potentially would, initiate or contribute to a number of key threatening processes (KTPs) which may have an adverse effect on Squirrel Gliders. However, it is unlikely that such KTP's would have a significant impact on the species in the locality as a consequence of the proportion of habitat affected and the provision of habitat connectivity measures to mitigate potential habitat isolation caused by the project.

Conclusion

While the proposal met all of the three relevant significant impact criteria for the Squirrel Glider, in that there would be some negative impact under each criteria, overall impacts on the Squirrel Glider resulting from the proposal are considered to have been mitigated through implementation of the mitigation measures described in BL&A (2015d) and in van der Ree (2015) such that impacts would not be significant and a *species impact statement* would not be required.

Koala

Status in the study area

The AVW contained no records of the species and the ANSWW contained one record from the search region, approximately 10 kilometres west of the study area. No Koalas have been detected in or adjacent the study area during any of the extensive flora and fauna

field investigations for this project since 2008. This indicates that there is no evidence of either a current or historical population of the Koala in the vicinity of the study area. It is therefore unlikely that a viable population of the species exists in the study area and locality.

Potential impacts

The proposal may result in the following potential impacts on Koala:

- Clearance of habitat, including hollow-bearing trees;
- Degradation of habitat due to edge effects, particularly weed invasion;
- Increased predation by feral cats and the Red Fox;
- Noise, vibration and light; and
- Mortality and injury due to collision with vehicles.

Impact significance

Significance Assessment Questions, as set out in the *Threatened Species Conservation Act 1995/ Environmental Planning and Assessment Act 1979,* and responses for Koala*:*

a) *in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*

   While the study area provides suitable habitat for Koala, it was not detected during extensive field investigations for this project since 2008 (both components of the study area), and it is therefore considered unlikely that a viable Koala population exists in the study area and locality. As such, the proposed action is unlikely to have an adverse effect on the life cycle of this species.

b) *in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*

   Not applicable

c) *in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*

   (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

   Not applicable

   (ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

   Not applicable

d) *in relation to the habitat of a threatened species, population or ecological community:*

   (i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

   Approximately 5.080 hectares of potential Koala habitat is proposed to be directly removed under the proposal. When considering the modifying effects on habitat resulting from edge effect, significantly more habitat would likely be degraded.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

Potential Koala habitat would become fragmented as a result of the proposal, as the carriageway would dissect it and result in an area of that habitat being structurally isolated from adjacent habitat.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

It was considered unlikely that a viable Koala population exists in the study area and locality. it is therefore unlikely that the potential habitat for this species would be important to its long-term survival in the locality.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

Not applicable

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

There is an approved Recovery Plan for the Koala. This plan calls for Koala management activities to be implemented in areas where key populations of the Koala occur. As the study area does not support a population of the Koala, the proposed project will not prejudice achievement of the objectives and actions in the Koala Recovery Plan.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The proposed action would, or potentially would, initiate or contribute to a number of key threatening processes (KTP's) which may have an adverse effect on Koala. However, it is highly unlikely that such KTP's would have a significant impact on the species in the locality.

Conclusion

While the proposal met two out of four relevant significant impact criteria for the Koala (there would be some negative impact under each of the two criteria), overall impacts on this species would not be significant, primarily because it was considered unlikely to make significant use of the habitat in the study area. Therefore, a *species impact statement* would unlikely be required.

Yellow-bellied Sheathtail Bat

Status in the study area

The Yellow-bellied Sheathtail Bat is a wide-ranging species found across northern and eastern Australia. In the most southerly part of its range, it is a rare visitor in summer and autumn. They roost singularly or in groups of up to six, in tree hollows and buildings; in treeless areas they are known to utilise mammal burrows. Seasonal movements are unknown; there is speculation about a migration to southern Australia in late summer and autumn. The review of existing information revealed that one record existed in the search region for Yellow-bellied Sheathtail Bat. This was in the Atlas of NSW Wildlife database. Yellow-bellied Sheathtail Bat was recorded in both components of the study area. A much lower number of calls were recorded for this species in the second survey (Feb-March 2012) as compared to the first survey (Nov 2011). This data supports the

speculative seasonal movements of the species. The review of existing information and results of the surveys suggest that while the Yellow-bellied Sheathtail Bat may infrequently occur in the region, it is unlikely to be a permanent resident there, considering the dispersive characteristics of the species. It is also unlikely that the species breeds in the region either, as very few captured specimens in southern Australia have been in breeding condition.

Potential impacts

Potential impacts on Yellow-bellied Sheathtail Bat include:

- Clearance of habitat, including hollow-bearing trees;
- Degradation of habitat due to edge effects, particularly weed invasion;
- Increased predation by feral cats and the Red Fox;
- Noise, vibration and light; and
- Mortality and injury due to collision with vehicles.

Impact significance

Significance Assessment Questions, as set out in the *Threatened Species Conservation Act 1995/ Environmental Planning and Assessment Act 1979,* and responses for Yellow-bellied Sheathtail Bat*:*

a) *in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*

   Regarding the nature of the Yellow-bellied Sheathtail Bat population in the study area and locality, it was assumed through interpretation of recent aerial photography that Yellow-bellied Sheathtail Bat would likely periodically occupy all suitable habitat along the wildlife corridor linking the Barmah and Gunbower forest blocks (of which the study area is part of), and that those forest blocks would likely provide optimal habitat for the species in the region. Considering the high mobility of this species, its wide-ranging seasonal movements and the paucity of knowledge of its status in the southern parts of its range, it would be impossible to predict the geographical extent of the local population, perhaps even superfluous to consider the species as occurring in discreet populations in the region. Therefore, for the purpose of this assessment, the local population was considered to occupy all suitable habitat within at least 100 kilometres of the study area.

   Little is known about the life cycle of Yellow-bellied Sheathtail Bat in the southern parts of its range, other than very few individuals have been captured in breeding condition. This suggests that in this part of its breeding is likely to be infrequent.

   As such, the proposal was considered unlikely to adversely affect the life cycle of Yellow-bellied Sheathtail Bat such that a viable local population of the species would likely to be placed at risk of extinction.

b) *in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*

   Not applicable

c) *in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Not applicable

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable

d) *in relation to the habitat of a threatened species, population or ecological community:*

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

Approximately 5.080 hectares of Yellow-bellied Sheathtail Bat habitat is proposed to be directly removed under the proposal. When considering the modifying effects on habitat resulting from edge effect, significantly more habitat would likely be degraded.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

Yellow-bellied Sheathtail Bat habitat would become fragmented as a result of the proposal, as the carriageway would dissect it and result in an area of habitat being structurally isolated from adjacent habitat. Although, given the high mobility of the species, such fragmentation would have little, if any, effect on the species.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

Given the high mobility of Yellow-bellied Sheathtail Bat, its wide-ranging seasonal movements and the unlikelihood that breeding activity is significant in the region, habitat in the study and surrounds would not be considered important to the long-term survival of the species in the locality.

e) *whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),*

Not applicable.

f) *whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,*

A recovery plan has not been prepared for Yellow-bellied Sheathtail Bat.

g) *whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*

The proposed action would, or potentially would, initiate or contribute to a number of key threatening processes (KTP's) which may have an adverse effect on Yellow-bellied Sheathtail Bat. However, it is unlikely that such KTP's would have a significant impact on the species in the locality.

Conclusion

While the proposal met two out of four relevant significant impact criteria for Yellow-bellied Sheathtail Bat (there would be some negative impact under each of the two criteria), overall impacts on this species would not be significant, primarily because it was considered unlikely to make significant use of the habitat in the study area. Therefore, a *species impact statement* would unlikely be required.

TSC Act listed freshwater fish

Trout Cod

Status in the study area

The TPFSRV contained records for one of these species - Trout Cod. While not recorded during the aquatic survey undertaken in the study area (GHD 2012), the above fish species was considered to have the potential to occur in the study area, within the Murray River channel.

Potential impacts

The proposal may result in the following potential impacts on these fish species:

- The degradation of native riparian vegetation along the Murray River;
- The removal of large woody debris from the Murray River channel;
- Alteration to the natural flow regimes of the Murray River; and
- Noise, vibration and light.

Impact significance

Significance Assessment Questions, as set out in the *Threatened Species Conservation Act 1995/ Environmental Planning and Assessment Act 1979,* and responses for the above-listed fish species*:*

a) *in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*

   Under the proposed development, the Murray River channel will not be altered, and flow paths and volumes will not be affected. In addition, works will be confined to the river banks or above the water and, together with environmental management measures (e.g. debris trap below bridge spans during construction and storage of chemicals and fuels where there is no risk of spills in these waterway) this will ensure minimal impacts on fish habitat. While the proposed bridge would permanently shade the Murray River channel and riparian zone under the bridge, this would have a negligible adverse effect on the life cycle of these fish species and would certainly not place it at risk of extinction.

b) *in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*

   Not applicable

c) *in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*

   (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

Not applicable

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

Not applicable

d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

As the proposed bridge would permanently shade the Murray River channel and riparian zone under the bridge, it would be expected that habitat for these fish species in those areas would be modified to some degree.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposed action would unlikely fragment or isolate any of the habitat for these fish species.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

While the habitat for these fish species, which would likely be modified by bridge shading, would be considered important habitat in the broader sense of these fish populations, such localised modification would be of little importance to the long term survival of them.

e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

Not applicable

f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

Recovery plans have not been prepared for any of these fish species.

g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The proposed action would, or potentially would, initiate or contribute to a number of key threatening processes (KTP's) which may have an adverse effect on fish species: degradation (or modification) of native riparian vegetation being the most pertinent. However, such localised modification of riparian vegetation in the study area would have a negligible impact on these fish species.

Conclusion

While the proposal met three out of four relevant significant impact criteria for these fish species (there would be some negative impact under each of the three criteria), overall impacts on them would not be significant, primarily because the proposed infrastructure would be unlikely to compromise the size and integrity of populations of these fish species. Therefore, a *species impact statement* would unlikely be required.

EPBC Act

No EPBC Act-listed ecological communities were detected and nor is any expected to occur in the study area. Therefore there are no impacts on any EPBC Act-listed ecological communities.

No EPBC Act-listed flora species were detected and nor is any expected to occur in the study area. Therefore there are no impacts on any EPBC Act-listed flora species.

No EPBC Act-listed threatened fauna species were recorded and nor is any expected to occur in the study area.

The relevant significant impact criteria are as follows (Department of the Environment 2013):

1) 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:
   a) lead to a long-term decrease in the size of a population
   b) reduce the area of occupancy of the species
   c) fragment an existing population into two or more populations
   d) adversely affect habitat critical to the survival of a species
   e) disrupt the breeding cycle of a population
   f) modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
   g) result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat
   h) introduce disease that may cause the species to decline, or
   i) interfere with the recovery of the species.
2) Habitat critical to the survival of a species or ecological community' refers to areas that are necessary:
   a) for activities such as foraging, breeding, roosting, or dispersal
   b) for the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators)
   c) to maintain genetic diversity and long term evolutionary development, or
   d) for the reintroduction of populations or recovery of the species or ecological community.
3) An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:
   a) lead to a long-term decrease in the size of an important population of a species
   b) reduce the area of occupancy of an important population
   c) fragment an existing important population into two or more populations
   d) adversely affect habitat critical to the survival of a species
   e) disrupt the breeding cycle of an important population
   f) modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

g) result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat
h) introduce disease that may cause the species to decline, or
i) interfere substantially with the recovery of the species.

4) An 'important population' is a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:
   a) key source populations either for breeding or dispersal
   b) populations that are necessary for maintaining genetic diversity, and/or
   c) populations that are near the limit of the species range.

5) An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will:
   a) 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
   b) 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
   c) seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species."

Critically endangered or endangered MNES values

<u>Swift Parrot (endangered):</u>

Significant impact criterion	Assessment	Significant impact likelihood	Critical habitat?	Important population ?
a) Lead to a long-term decrease in the size of a population	The Swift Parrot migrates to Victoria from Tasmania in winter to feed on the flowering eucalypts of the inland slopes of the Great Divide. The species is considered as nomadic in Victoria, with movements being determined by flowering eucalypts (Emison *et al.* 1987; Higgins *et al.* 2001). Although the Swift Parrot may occasionally pass through the study area, it is highly unlikely it would occur regularly or in significant numbers. Therefore, very few individuals would be exposed to impacts across a very small proportion of the available habitat in the Echuca region.	Unlikely	N/A	N/A
b) Reduce the area of occupancy of the species	As the species does not occupy this area regularly and it lacks many of its preferred food trees, the project will not reduce the usual area of occupancy for the species.	Unlikely	N/A	N/A
c) Fragment an existing population into two or more	The study area is in an area where the species occurs infrequently and it will not fragment any population of this species.	Unlikely	N/A	N/A

Significant impact criterion	Assessment	Significant impact likelihood	Critical habitat?	Important population ?
populations				
d) Adversely affect habitat critical to the survival of a species	Habitats critical to the survival of Swift Parrot have been identified in the National Swift Parrot Recovery Plan (Saunders & Tzaros 2011) as 'priority habitats'. While habitat in the study area and search region has not been identified as priority Swift Parrot habitat in Victoria, priority habitat has been identified in the Murray CMA in NSW. However, such habitat would most likely be the Gunbower and Barmah forest blocks north-west and north-east of the search region. As such, habitat in the study area is unlikely to be habitat critical to the survival of Swift Parrot.	Unlikely	Unlikely	N/A
e) Disrupt the breeding cycle of a population	While the removal of hollow trees may present a potential impact to the Swift Parrot, the parrot breeds in south eastern Tasmania, so disruption to its breeding cycle will not occur.	Unlikely	N/A	N/A
f) Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	For the reasons explained above, the site is not a habitat regularly used by the parrot. Therefore, the proposal is unlikely to modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.	Unlikely	N/A	N/A
g) Result in invasive species that are harmful to critically endangered or endangered species becoming established in the critically endangered or endangered species' habitat	The proposal is unlikely to initiate or facilitate the invasion of any species harmful to Swift Parrot.	Unlikely	N/A	N/A
h) Introduce disease that may cause the species to decline	The proposal is unlikely to introduce any disease that may cause Swift Parrot to decline.	Unlikely	N/A	N/A
i) Interfere with the recovery of the species	The project does not occur in an area where work on the parrots' recovery is likely to be implemented, given that the area is not part of the regularly occupied habitats of the species. Therefore, the proposal will not interfere with	Unlikely	N/A	N/A

Significant impact criterion	Assessment	Significant impact likelihood	Critical habitat?	Important population ?
	the recovery of the parrot population.			
Overall assessment of likelihood of significant impact		Unlikely	Unlikely	N/A

Freshwater fish

Silver Perch (critically endangered), Trout Cod (endangered)

Significant impact criterion	Assessment	Significant impact likelihood	Critical habitat?	Important population ?
a) Lead to a long-term decrease in the size of a population	It is unlikely that the proposed development would have an impact on populations of these fish species. The minor disturbances expected during construction would still allow abundant access underneath the bridge and there are expected to be no impediments to fish passage or net loss of fish habitat.	Unlikely	N/A	N/A
b) Reduce the area of occupancy of the species	It is unlikely that the proposed development would have an impact on the occupancy of these fish species, as the minor disturbances expected during construction would still allow abundant access underneath the bridge.	Unlikely	N/A	N/A
c) Fragment an existing population into two or more populations	The proposed development would not significantly alter passage in the waterway and hence the fragmentation of populations of these fish species is unlikely to occur.	Unlikely	N/A	N/A
d) Adversely affect habitat critical to the survival of a species	Minimal habitat is expected to be impacted within the waterway (if any at all) and the disturbance footprint of the proposed works would be insignificant in comparison to available surrounding habitat. Works are not proposed to occur in-stream, however, any required removal of in-stream habitat (such as snags) would be reinstated once the works have been completed.	Unlikely	Unlikely	N/A
e) Disrupt the breeding cycle of a population	Works are proposed to be undertaken outside of the key breeding/migration period (spring to early summer).	Unlikely	N/A	N/A
f) Modify, destroy, remove, isolate or decrease the availability or quality	Little, if any habitat would be removed or destroyed in the construction process, there for fish species are unlikely to decline.	Unlikely	N/A	N/A

Significant impact criterion	Assessment	Significant impact likelihood	Critical habitat?	Important population ?
of habitat to the extent that the species is likely to decline				
g) Result in invasive species that are harmful to critically endangered or endangered species becoming established in the critically endangered or endangered species' habitat	It is unlikely that an invasive aquatic species would be introduced during the construction process, with barge use the only likely vector for transportation of introduced species, any vessels used would likely be local and if not, would be subject to usual interstate quarantine processes.	Unlikely	N/A	N/A
h) Introduce disease that may cause the species to decline	The proposal is unlikely to introduce any disease that may cause these fish species to decline.	Unlikely	N/A	N/A
i) Interfere with the recovery of the species	It is unlikely the proposal would affect the recovery of these fish species in any way, with only minor impacts expected, if any at all.	Unlikely	N/A	N/A
Overall assessment of likelihood of significant impact		Unlikely	Unlikely	N/A

Vulnerable MNES values

<u>Superb Parrot</u>

Significant impact criterion	Assessment	Significant impact likelihood	Critical habitat?	Important population ?
a) Lead to a long-term decrease in the size of an important population of a species	This species occurs mainly in mature healthy River Red-gums in forest growing on river flats along with Yellow Box, Black Box and Cypress Pine (Higgins 1999). The species' stronghold in the region includes Barmah-Millewa Forest, within approximately 20km of the study area. The centre of the Victorian population occurs in habitats further east along the Murray River, associated with the Barmah – Millewa forests. It is possible that this species may occasionally occur in the study area due to the presence of suitable foraging habitat but numbers are unlikely to be significant. The Superb Parrot National Recovery Plan (Baker-Gabb 2011) does not single out important populations of	Unlikely	N/A	N/A

Significant impact criterion	Assessment	Significant impact likelihood	Critical habitat?	Important population ?
	Superb Parrot, and it is inferred from this that the species exists as a more or less single population throughout its range. In conclusion, the proposal is unlikely to lead to a decline in the Superb Parrot population as its core habitat in the region is well east of the study area.			
b) Reduce the area of occupancy of an important population	The proposal will likely result in some reduction in the area of occupancy of Superb Parrot through the removal of some of its potential habitat. However, as core Superb Parrot habitats lie further to the east at the Barmah–Millewa forests, the proposal will have a negligible effect on the area of occupancy of the species.	Unlikely	N/A	N/A
c) Fragment an existing important population into two or more populations	While the proposal will result in some fine-scale habitat fragmentation, it will not result in fragmentation of the Superb Parrot population, given its long distance mobility.	Unlikely	N/A	N/A
d) Adversely affect habitat critical to the survival of a species	The Superb Parrot National Recovery Plan (Baker-Gabb 2011) broadly describes areas of habitat critical to the survival of Superb Parrot in terms of breeding and foraging habitat. As there are no Superb Parrot breeding records in the vicinity of the study area. While the study area does support Superb Parrot foraging habitat, it was considered marginal in comparison to the large core foraging habitats in the Barmah–Millewa forests. As such, the habitat in and adjacent the study area would not be critical to the survival of Superb Parrot. Therefore, no adverse effects on critical habitat are anticipated to occur as a result of the proposal.	Unlikely	Unlikely	N/A
e) Disrupt the breeding cycle of an important population	The parrot nests in the hollows of large trees (dead or alive), mainly in tall, riparian River Red-gum forest or woodland. While the removal of large hollow trees from the study area may present a potential impact to the Superb Parrot, all known nesting sites are from the Barmah–Millewa forests, with no records from in or near the study area. Therefore, the proposal is unlikely to disrupt the breeding cycle of Superb Parrot.	Unlikely	N/A	N/A
f) Modify, destroy, remove, isolate or decrease the	For the reasons explained above, the site is not a core habitat for Superb Parrot. Therefore, the proposal will not modify, destroy, remove,	Unlikely	N/A	N/A

Significant impact criterion	Assessment	Significant impact likelihood	Critical habitat?	Important population ?
availability or quality of habitat to the extent that the species is likely to decline	isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.			
g) Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	The proposal is unlikely to initiate or facilitate the invasion of any species harmful to Superb Parrot.	Unlikely	N/A	N/A
h) Introduce disease that may cause the species to decline	The proposal is unlikely to introduce any disease that may cause Superb Parrot to decline.	Unlikely	N/A	N/A
i) Interfere substantially with the recovery of the species	The proposal wolud not occur in an area where work on the parrots' recovery is likely to be implemented, given that the area is not part of the core range of the species. Therefore, the proposal is unlikely to interfere with the recovery of the Superb Parrot population.	Unlikely	N/A	N/A
Overall assessment of likelihood of significant impact		Unlikely	Unlikely	N/A

<u>Koala</u>

Significant impact criterion	Assessment	Significant impact likelihood	Critical habitat?	Important population ?
a) Lead to a long-term decrease in the size of an important population of a species	Given the paucity of historical Koala records in the search region (one record in the ANSWW), members of any population that may periodically inhabit the study area would not meet any of the Department of the Environments' criteria of an 'important population' (Department of the Environment 2013). Therefore, the proposal would unlikely lead to a long-term decrease in the size of an important Koala population.	Unlikely	N/A	No
b) Reduce the area of occupancy of an important population	As stated above, any koala inhabiting the study area would not be part of an important population. Therefore, the proposal would unlikely reduce the area of occupancy of an	Unlikely	N/A	No

Significant impact criterion	Assessment	Significant impact likelihood	Critical habitat?	Important population ?
	important Koala population.			
c) Fragment an existing important population into two or more populations	As stated above, any koala inhabiting the study area would not be part of an important population. Therefore, the proposal would unlikely fragment an existing important Koala population.	Unlikely	N/A	No
d) Adversely affect habitat critical to the survival of a species	A national Koala recovery plan has not been prepared as yet. The NSW Recovery Plan for the Koala (DECC 2008b) does not describe habitat critical for the survival of Koala, with the exception of two important areas for Koala (Pittwater LGA and Hawks Nest/Tea Gardens). Given the paucity of historical Koala records in the search region, habitat in the study area would not meet any of the Department of the Environments' criteria of 'habitat critical to the survival of a species' (Department of the Environment 2013). As such, the habitat in and adjacent the study area would not be critical to the survival of Koala. Therefore, no adverse effects on critical habitat are anticipated to occur as a result of the proposal.	Unlikely	No	N/A
e) Disrupt the breeding cycle of an important population	As stated above, any koala inhabiting the study area would not be part of an important population. Therefore, the proposal would unlikely disrupt the breeding cycle of an important Koala population.	Unlikely	N/A	No
f) Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	As Koala has rarely been recorded in the search region, and the NSW recovery plan does not indicate that the region is important for the species, it is unlikely that modification, destruction, removal, isolation or a reduction in the availability or quality of habitat in the study area would cause a decline in the overall population of the Koala.	Unlikely	N/A	N/A
g) Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	The proposal is unlikely to initiate or facilitate the invasion of any species harmful to Koala.	Unlikely	N/A	N/A

Significant impact criterion	Assessment	Significant impact likelihood	Critical habitat?	Important population ?
h) Introduce disease that may cause the species to decline	The proposal is unlikely to introduce any disease that may cause the Koala to decline as a species.	Unlikely	N/A	N/A
i) Interfere substantially with the recovery of the species	The proposal would not occur in an area where work on Koala recovery is likely to be implemented, given that the area is not part of the core range of the species. Therefore, the proposal is unlikely to interfere with the recovery of the Koala population.	Unlikely	N/A	N/A
Overall assessment of likelihood of significant impact		Unlikely	No	No

Murray Cod (Vulnerable)

Significant impact criterion	Assessment	Significant impact likelihood	Critical habitat?	Important population ?
a) Lead to a long-term decrease in the size of an important population of a species	It is unlikely that the proposed development would have an impact on an important population of Murray Cod. The minor disturbances expected during construction would still allow abundant access underneath the bridge and there are expected to be no impediments to fish passage or net loss of fish habitat.	Unlikely	N/A	Likely
b) Reduce the area of occupancy of an important population	It is unlikely that the proposed development would have an impact on the occupancy of an important population of Murray Cod, as the minor disturbances expected during construction would still allow abundant access underneath the bridge.	Unlikely	N/A	Likely
c) Fragment an existing important population into two or more populations	The proposed development would not significantly alter passage in the waterway and hence the fragmentation of an important population of Murray Cod is unlikely to occur.	Unlikely	N/A	Likely
d) Adversely affect habitat critical to the survival of a species	Minimal habitat is expected to be impacted within the waterway (if any at all) and the disturbance footprint of the proposed works would be insignificant in comparison to available surrounding habitat. Works are not proposed to occur in-stream, however, any required removal of in-stream habitat (such as snags) would be reinstated once the works have	Unlikely	Unlikely	N/A

Significant impact criterion	Assessment	Significant impact likelihood	Critical habitat?	Important population ?
	been completed.			
e) Disrupt the breeding cycle of an important population	Works are proposed to be undertaken outside of the key Murray Cod breeding/migration period (spring to early summer).	Unlikely	N/A	Likely
f) Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Little, if any habitat would be removed or destroyed in the construction process, therefore Murray Cod are unlikely to decline as a species.	Unlikely	N/A	N/A
g) Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	It is unlikely that an invasive aquatic species would be introduced during the construction process, with barge use the only likely vector for transportation of introduced species, any vessels used would likely be local and if not, would be subject to usual interstate quarantine processes.	Unlikely	N/A	N/A
h) Introduce disease that may cause the species to decline	The proposal is unlikely to introduce any disease that may cause Murray Cod to decline as a species.	Unlikely	N/A	N/A
i) Interfere substantially with the recovery of the species	It is unlikely the proposal would affect the recovery of Murray Cod in any way, with only minor impacts expected, if any at all.	Unlikely	N/A	N/A
Overall assessment of likelihood of significant impact		Unlikely	Unlikely	N/A

Migratory bird species

Rainbow Bee-eater, Eastern Great Egret, Fork-tailed swift, White-throated Needle-tail and White-bellied Sea-eagle

Significant impact criterion	Assessment	Significant impact likelihood
a) 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	It is highly unlikely that the proposal would modify, destroy or isolate an area of important habitat for these migratory birds, as habitat in the study area does not meet any of the Department of the Environments' criteria for 'important habitat for a migratory species' for these migratory birds	Unlikely

Significant impact criterion	Assessment	Significant impact likelihood
	(Department of the Environment 2013).	
b) Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species	As above, habitat in the study area is not important habitat for these migratory birds.	Unlikely
c) Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species	The study area and surrounds is highly unlikely to host an ecologically significant proportion of the populations of these migratory birds at any given time. Therefore, the proposal is unlikely to Seriously disrupt the lifecycle of these birds.	Unlikely
Overall assessment of likelihood of significant impact		Unlikely

Appendix 8: van der Ree (2015)

4/6/2015

PREPARED FOR ROADS AND MARITIME SERVICES, NSW

FINAL REPORT OF TARGETED SQUIRREL GLIDER SURVEYS FOR SECOND MURRAY RIVER BRIDGE CROSSING - MID WEST ALIGNMENT, AUTUMN 2015

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EXECUTIVE SUMMARY

The Australian Research Centre for Urban Ecology (ARCUE) was commissioned by New South Wales Roads and Maritime Services (Roads and Maritime) to survey Squirrel Gliders *(Petaurus norfolcensis)* for a proposed second Echuca to Moama Murray River bridge crossing, focusing on the mid-west alignment.

The surveys aimed to determine the number and distribution of Squirrel Gliders within and close to the mid-west alignment, as well as throughout the wider (≤5 km from mid-west alignment) Murray River corridor. This report summarises results of surveys conducted from the 16th to the 27th of March, 2015. In addition, we discuss the likely impacts of the proposed road project on Squirrel Gliders and provide a suite of strategies to avoid, minimise and mitigate impacts on the species. Any residual impacts should be offset.

A total of 15 sites were surveyed, with nine focused on the mid-west alignment and the remaining six sites more widely distributed along the Murray River corridor. Seven Squirrel Gliders were captured at five sites from 1,068 trap nights, with a maximum of two gliders at any one site. An almost equal number of males and females were captured, as well as animals from all age-classes and the two adult females were pregnant or carrying pouch young. Body weights were also typical, suggesting a healthy population, albeit at low density.

The proposed road and bridges along the mid-west alignment have the potential to significantly impact the local Squirrel Glider population and potentially resulting in local extinction. However, these impacts are not likely to be significant if the mitigation strategies described in this report are adequately implemented. The impacts and strategies include:

1) The loss of habitat due to clearing is substantial as most of the alignment is through woodland, most of which is likely to be used as habitat by Squirrel Gliders. While the quality of the woodland along the alignment is variable, it is all likely being used by gliders. Every effort should be made during the detailed design stage to identify areas of high quality habitat (e.g. large old trees) that can be avoided with slight changes to the alignment and by not constructing temporary stockpiles, sediment ponds and offices in areas of woodland. However, the primary strategy to negate the loss of habitat is to strategically revegetate it elsewhere in areas that will benefit Squirrel Gliders. Additional works to improve the quality of the habitat in the immediate vicinity of the project by planting understorey, closing unnecessary tracks and weed removal would also be beneficial. A two-stage clearing process should be employed to protect wildlife within hollow and reduce mortality during the clearing process.

2) The loss of large and hollow-bearing trees will be a major impact along the entire alignment because Squirrel Gliders den in tree hollows. Natural hollows can take 100 – 150 years to form in *Eucalyptus* trees and the availability of sufficient suitable hollows is a critical resource for the species. The use of nest boxes to replace the hollows that are removed is an effective short-term mitigation measure. Rather than maintain nest boxes into perpetuity, we recommend installing nest

boxes at the start of the project, maintaining them during construction and for five years afterwards, and then installing a new suite of boxes at the same locations but in different trees at the end of the five years, without any maintenance. We also recommend implementing strategies to initiate the accelerated formation of hollows in existing trees, such as by creating incisions with the use of chainsaws by qualified, experienced arborists. This strategy is experimental, and we recommend that this mitigation be undertaken as an experiment, with monitoring of the development of the incised hollows over time to evaluate the effectiveness of this approach.

3) The proposed road will be a barrier to the movement of Squirrel Gliders where the gap in canopy cover exceeds the glide capacity of the species. Typical maximum glide lengths in woodland are in the order of 50 – 70 m, and effective glide length will be shorter when the road is elevated or trees are shorter/located further from the road, as the landing height must be above the height of vehicles. This barrier to movement can significantly impact the species if they are no longer able to access critical food or denning resources, as well as limit their ability to disperse and (re)colonise new areas. It is impossible to specify exactly which sections of the road will be a barrier without detailed surveys of tree locations and heights relative to the detailed design of the road. However, a number of simple solutions exist, such as the maintenance of continuous or near continuous canopy cover above the road, and installation of crossing structures such as rope bridges and glider poles. We recommend the use of rope bridges over glider poles, and both mitigation techniques need to be carefully designed and installed in accordance with an approved connectivity strategy to ensure they are optimally located and are fully integrated into the existing habitat. Key locations to maintain connectivity include the full length of the alignment in NSW, and in Victoria includes along the banks of the Murray and Campaspe Rivers, through/around the Caravan Park and across Warren St (near the Murray Valley Highway) to the Campaspe River.

4) Increased mortality of Squirrel Gliders due to collision with vehicles is likely because gliders will attempt to glide across the road at any location where the glide may be achievable. This is problematic in locations where the glide trajectory passes in front of vehicles. While fencing is traditionally used to prevent wildlife mortality by preventing wildlife accessing the road, there are no adequate fence designs for Squirrel Gliders or other arboreal mammals. Therefore, the only strategy to prevent glider-vehicle collision is to provide numerous and frequent crossing opportunities along the length of the road and bridges, where possible.

5) Mortality of wildlife may occur during clearing if animals remain in tree hollows as trees are felled. The standard two-stage clearing process and supervision by qualified and experienced ecologists during clearing will minimise this risk.

6) Excessive road noise and lighting may affect Squirrel Glider populations by reducing habitat quality, but the size of the effect is unknown. At present, the lighting plans only include lighting at intersections and low-level lighting along the shared user path, which is unlikely to adversely impact Squirrel Gliders. However, the road is being designed to accommodate lighting at a later date, if required. Future lighting should be designed to minimise light spill into adjacent habitats.

7) Entanglement of Squirrel Gliders with barbed-wire fencing occurs when such fences are installed within their glide paths, resulting in injury and death. Barbed wire fences should not be installed anywhere along the project where there is a risk of glider entanglement.

8) Additional surveys and ongoing monitoring is an important component of all mitigation strategies where there is some uncertainty about effectiveness. Rigorous surveys along the Hume Highway duplication demonstrated that while rope bridges and glider poles are readily used by gliders, the population has still declined. Because we don't know the cause of the decline, it is important to monitor the effect of road construction and operation in Echuca-Moama and determine effectiveness of mitigation on the conservation prospects for the species. Monitoring at Echuca-Moama should include trapping surveys and the collection of sufficient DNA samples to reliably estimate population size and connectivity levels before and 5-years after the project has been completed.

In conclusion, the proposed second bridge crossing of the Murray River project is unlikely to significantly impact the local Squirrel Glider population provided the recommended mitigation strategies are implemented. We strongly recommend that road designers work closely with species experts during the concept and detailed design stages as well as during construction to ensure the mitigation measures are adequate, comprehensive and optimally located.

INTRODUCTION

The proposed second bridge crossing of the Murray River at Echuca-Moama involves the construction of a new roadway and multiple bridge structures across the Murray and Campaspe Rivers and floodplain. The preferred alignment passes through areas of woodland to the west of Echuca and Moama. The proposed road will be elevated on embankments and bridges across the Campaspe and Murray River channels and floodplains. Three alignments were initially proposed and investigated, with the mid-west alignment now the preferred option.

Brett Lane and Associates previously undertook a biodiversity assessment for the proposed second bridge crossing that encompassed the three original alignments options. In 2011 they detected a single Squirrel Glider during spotlighting on a property on Boundary Road, Moama. However, the woodland along the alignment is suitable for Squirrel Gliders and is within their geographic range, so it appeared likely that Squirrel Gliders were more abundant and widespread than the surveys by Brett Lane and Associate suggested. Therefore, the main objective of the current survey was to undertake additional targeted surveys of Squirrel Gliders to determine their distribution and density within and adjacent to the mid-west alignment. The second objective was to evaluate and discuss the likely potential impact of the proposed project on the species and offer avoidance and mitigation strategies.

METHODS

Design of the proposed road and second bridge crossing of the Murray River

The assessment of significance of impacts on Squirrel Gliders is based on the current proposed design of the road provided by NSW RMS, and summarized below.

The current preferred alignment, known as the mid-west alignment, is approximately 4.1 km in length and extends along Warren St from the intersection with the Murray Valley Hwy until approximately Payne St, where it extends in a north-west direction across Campaspe Esplanade and the Campaspe River. The alignment then goes in a north-east direction across the old Echuca High School site, towards the Echuca Sports and Recreation Reserve and continues north through Victoria Park to near the boat ramp, crossing the Murray River before joining Forbes St, Moama. It will cease at the intersection of Pericoota Rd and the Cobb Hwy, NSW.

The first stage to be built consists of a single carriageway (with one vehicle lane and bicycle lane in each direction) with a single pedestrian/shared use path. When crossing the woodland and floodplains of the Campaspe and Murray Rivers, the road will primarily be elevated on fill, ranging from at-grade to approximately 7 m above the adjacent land. Batters are designed with a 2:1 slope to minimise the footprint of the road. When crossing the Murray River, the clearance of the bridge ranges from approximately 7 m (where the road transitions from being on fill to bridge structure) to 12 m (at the bank of the Murray River – above the channel). A 35 m long bridge with a clearance of

approximately 6 m from ground level to the underside of the bridge deck is also proposed for NSW to span some flood prone areas. Allowance for the construction of a second carriageway in 40 – 50 years has been made, effectively doubling the width of the Stage 1 road.

The maximum speed limit on the road will be 80 km/hr, with a modeled traffic volume of approximately 10,000 and 11,500 vehicles per day in 2029 and 2044, respectively. Street lighting is only proposed for intersections, and low-level strip lighting/LEDS is proposed to illuminate the shared use path. However, it is noted that "provision for vehicle lighting will be included in the design to allow the installation of lighting at a later date, if required".

Squirrel Glider ecology

The Squirrel Glider is a medium sized (190–300 g) arboreal marsupial from eastern Australia, often found in remnant and roadside patches of *Eucalyptus* woodland. Squirrel Gliders are nocturnal and feed mainly on arboreal insects, nectar, pollen and tree sap. Squirrel Gliders primarily move through their home range by gliding from tree to tree (Figure 1). The average glide length is 30–40 m, with a maximum glide length of approximately 70 m (van der Ree, Bennett, & Gilmore, 2003). Sparse vegetation cover can force Squirrel Gliders to the ground, leaving them open to predation from owls, foxes or cats. The home range of Squirrel Gliders in high quality habitat is between 1.5 and 3.5 ha, but is larger (up to 10–12 ha) in low quality habitat (Quin, 1995; van der Ree & Bennett, 2003). Squirrel Gliders live in social groups of typically two to seven related individuals and den communally in multiple hollow-bearing trees within their home range. Hollow bearing trees are a critical resource: without hollows Squirrel Gliders are unable to shelter or raise young. Female Squirrel Gliders typically give birth to one or two young between April and November.

Figure 1. The Squirrel Glider (left), and a Squirrel Glider mid glide after being released from a trap (right). Images courtesy of Lochman Transparencies (left) and Kylie Soanes (right).

Site selection and Squirrel Glider surveys

Fifteen sites spread across the NSW and Victorian sides of the Murray River were selected for Squirrel Glider surveys (Figures 2–6, Table 1). Nine sites were located within and immediately adjacent to the mid-west alignment (hereafter referred to as "mid-west zone"), with the remaining

six sites distributed more broadly along the Murray River, but within 5 km of the mid-west alignment (hereafter "outer zone").

Trapping surveys were undertaken between the 16th and 27th of March 2015 using wire cage traps (Wiretainers, 20 cm x 20 cm x 50 cm) set on the trunks of trees at approximately 3–5 m above the ground. The number of traps set at each site varied from 5 to 33, and most sites were trapped for seven consecutive nights (outer zone sites set for 5 nights) (Table 2). Sites with a high level of public use were not trapped on weekends in order to reduce the risk of theft of traps. Traps were baited with a mixture of honey, rolled oats and peanut butter and diluted honey was sprayed on the tree trunk around the trap to attract animals. Traps were placed approximately 100 m (+/- 20 m) apart, with a preference for placing traps on large and/or hollow-bearing trees. Traps were set as linear transects or in a grid, depending on the shape and extent of woodland habitat at each site. Additional traps were deployed during the seven nights of trapping in locations where gliders were trapped in an effort to detect a greater proportion of the resident population. The GPS location of each trap tree (Datum: GDA), its species and diameter at breast height (DBH) were recorded.

All traps were checked at dawn each morning, and any captured animals were processed (removed from trap, identified, weighed, sexed and reproductive condition noted) and immediately released after processing. We marked each arboreal mammal captured by tattooing the ear and implanting a microchip beneath the skin between the shoulder blades (Appendix 3). The reproductive condition and tooth wear was only recorded for Squirrel Gliders. Two small (~2 mm diameter) tissue samples were removed from the margins of the ear-flap of all mammal species for DNA testing. Any other species that were captured unintentionally (e.g. birds) were assessed for injury and released immediately. If the same individual was captured in the same trap for three consecutive nights, the trap was closed for the following night.

Table 1. Site descriptions and their locations. Site numbers correspond to Figure 2.

Site no.	Site name	Symbol on map
1	Boundary Road property	Filled yellow circles
2	Boundary Road dams	Filled deep pink circles
3	Forbes Street	Filled royal blue circles
4	Middle (Victoria Park)	Filled aqua circles
5	Middle North East	Filled red circles
6	Crofton Street	Filled lime green circles
7	Warren Street	Unfilled purple diamonds
8	Parks VIC land	Unfilled aqua diamonds
9	Campaspe Esplanade	Unfilled red diamonds
10	South	Unfilled yellow diamonds
11	South North West	Unfilled orange diamonds
12	River Park Drive Reserve	Filled orange circles
13	Horseshoe Lagoon	Unfilled lime green diamond
14	Sutton Street (Banyule Park State Forest)	Unfilled deep pink diamond
15	Burnanga Bend	Unfilled royal blue diamond

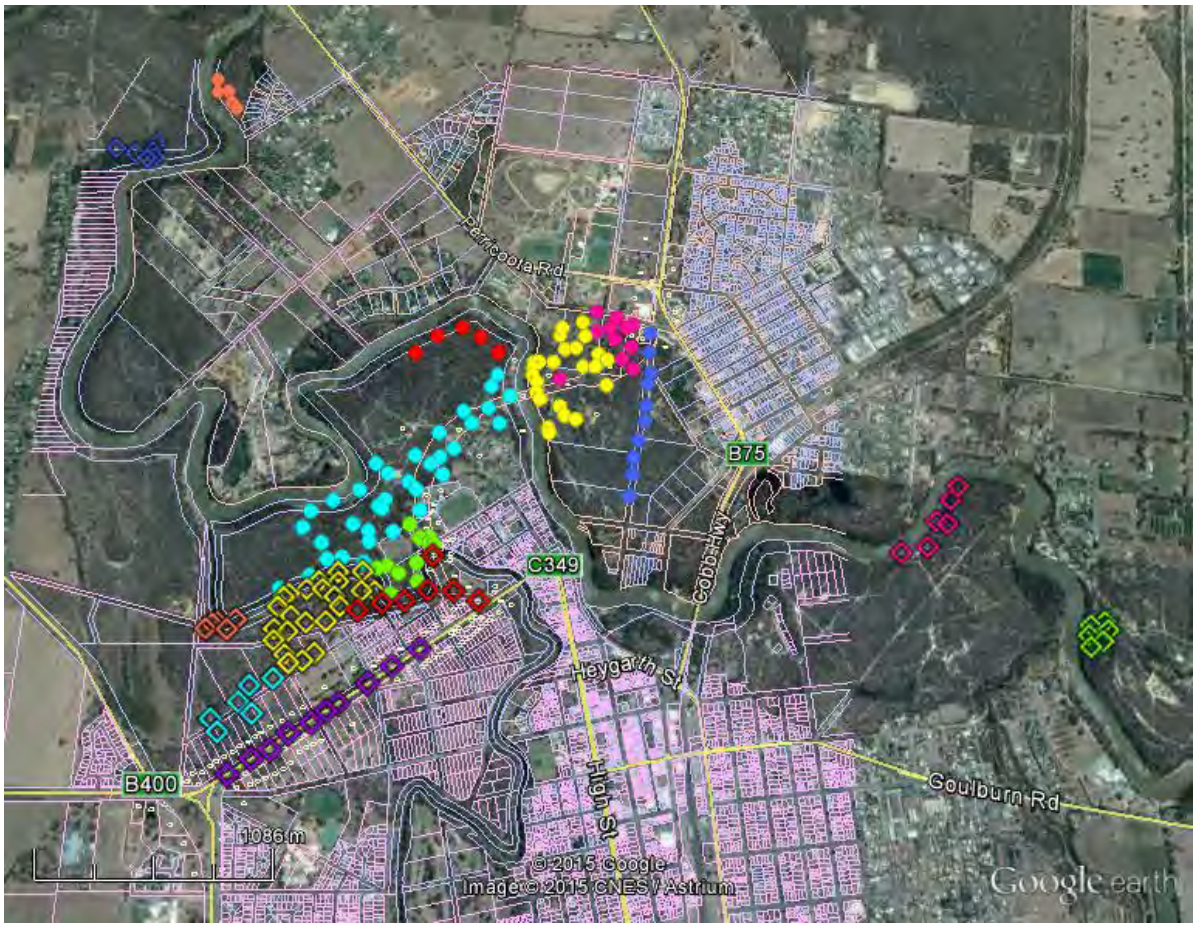

Figure 2. Overview of trapping locations for Squirrel Gliders, March 2015. Refer to Table 1 for symbol legend and site names. Source of background image: Google Earth.

Figure 3. Close up of trapping locations at River Park Drive (filled orange circles) and Burnanga Road (unfilled royal blue diamonds) sites. Source of background image: Google Earth.

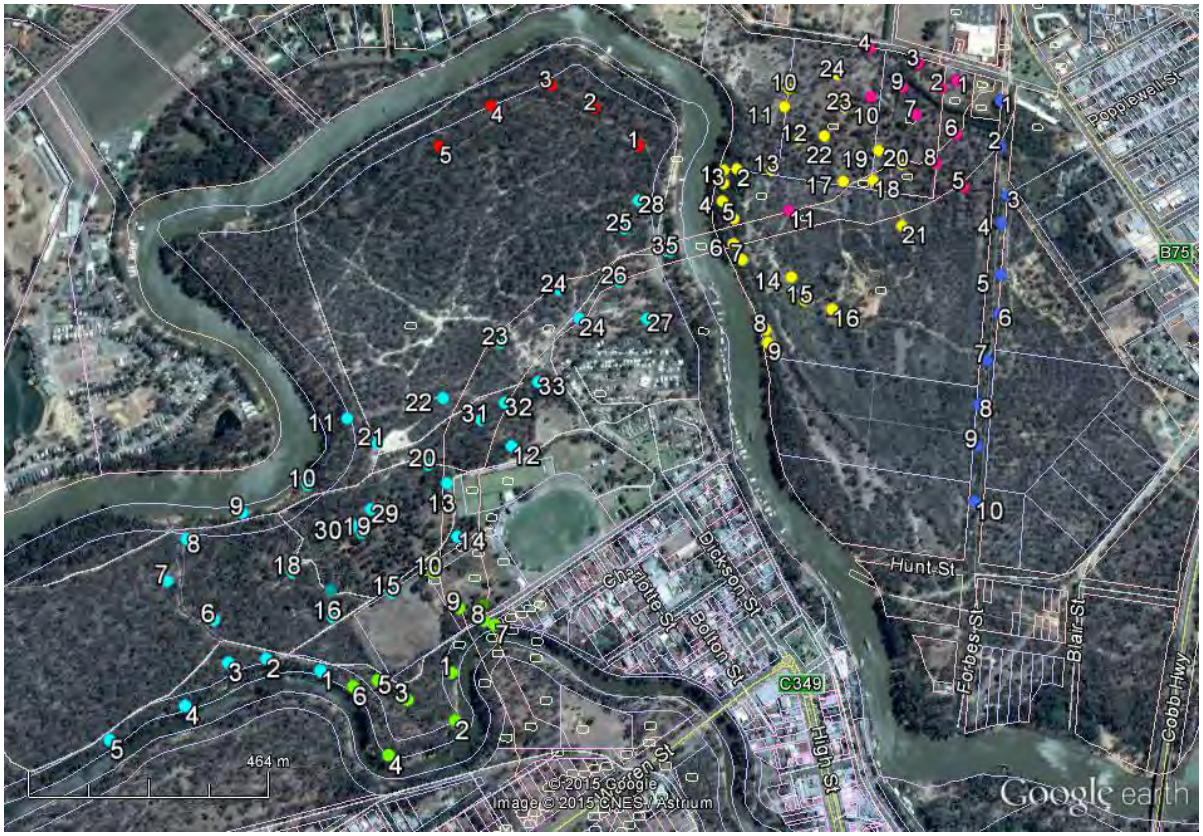

Figure 4. Close up of trapping locations on and immediately adjacent to the mid-west alignment, for the section north of Warren St Echuca and Boundary Rd, Moama. Refer to Table 1 for site names and symbol legend. Source of background image: Google Earth.

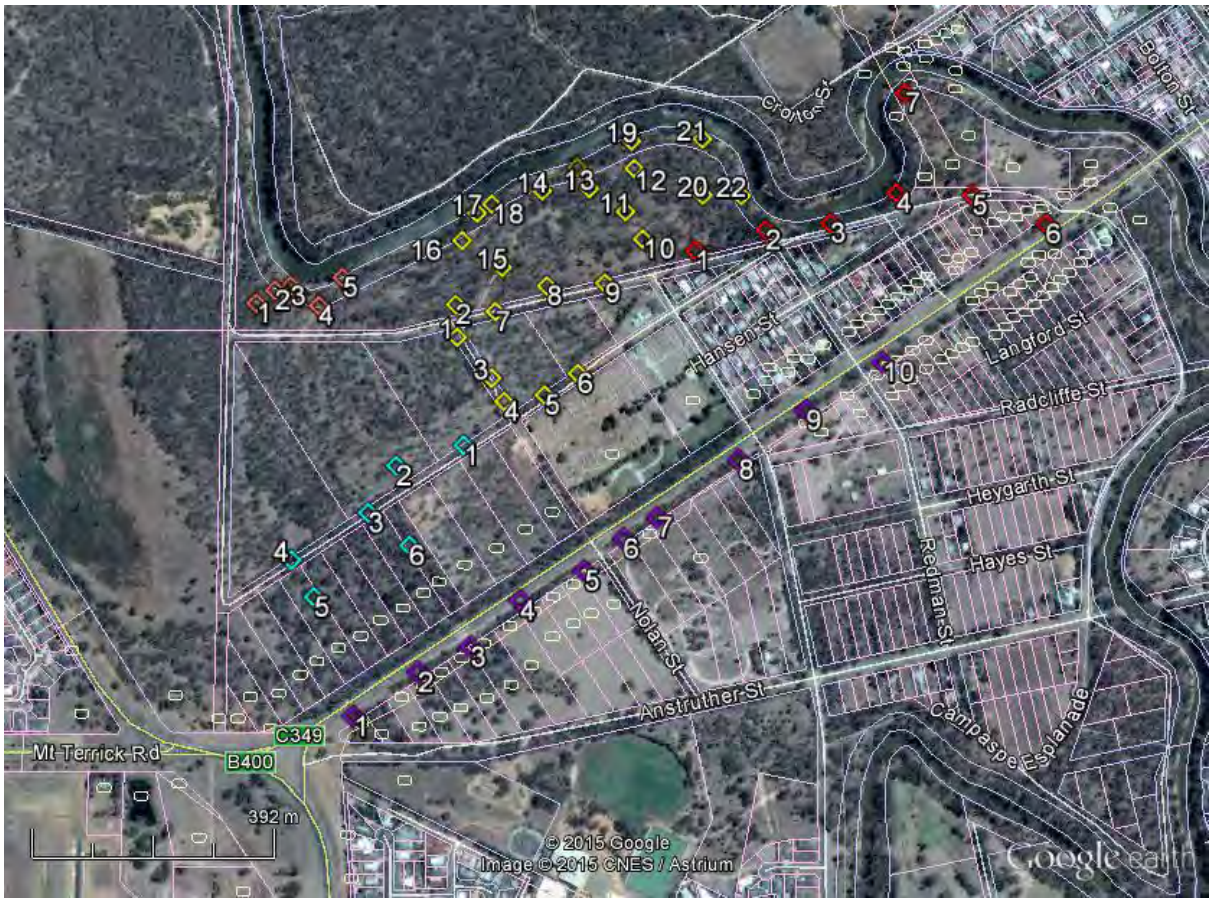

Figure 5. Close up of trapping locations on and immediately adjacent to the mid-west alignment, between the Murray valley Highway (B400) and the Campaspe River. Refer to Table 1 for site names and symbol legend. Source of background image: Google Earth.

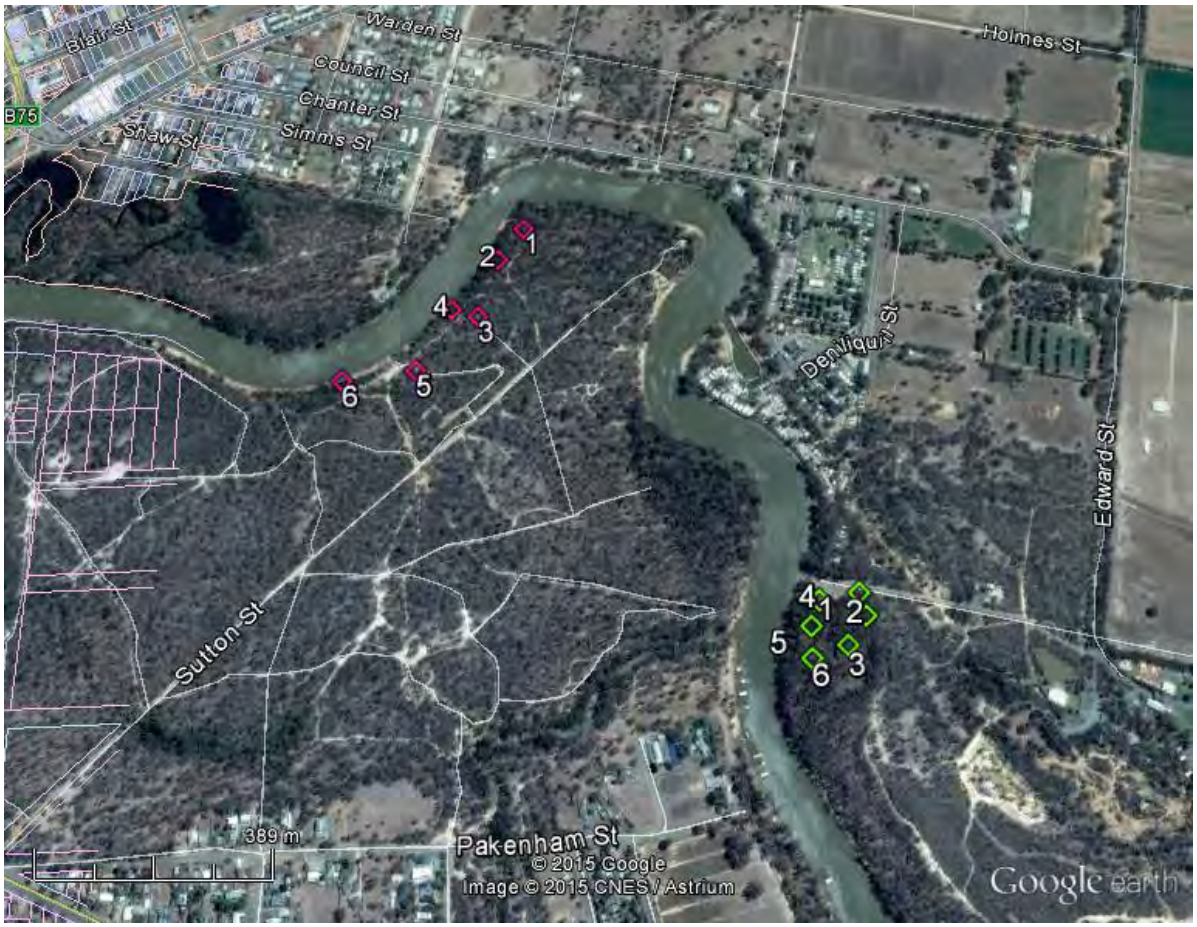

Figure 6. Close up of trapping locations at Horseshoe Lagoon (unfilled lime green diamonds) and Sutton Street (Banyule Park State Forest) (unfilled deep pink diamonds) sites. Source of background image: Google Earth.

RESULTS

Survey effort and Squirrel Glider captures

Seven Squirrel Gliders were captured during 1,068 trap nights (Table 2). Six Squirrel Gliders were trapped within or immediately adjacent to the mid-west alignment (Figure 7), with the seventh glider captured at Sutton Street (Banyule Park State Forest), upstream of Echuca-Moama. Other species captured included two Sugar Gliders (*Petaurus breviceps*), 24 Common Brushtail Possums (*Trichosurus vulpecula*), one Common Ringtail Possum (*Pseudocheirus peregrinus*) and 8 Yellow-footed Antechinus *Antechinus flavipes*.

The Squirrel Gliders captured appeared healthy (body weights ranging from 225 to 305 g), and the age/sex structure of the population was consistent with patterns observed elsewhere (e.g. van der Ree, 2002). Four females and three males were captured, with animals ranging in age from approximately 1-year old to >3-years old. Maximum age of wild Squirrel Gliders is approximately seven to eight years, but accurately aging individuals older than about 3-years is difficult (van der Ree, Harper, & Crane, 2006) The two adult females were either pregnant or carrying pouch young.

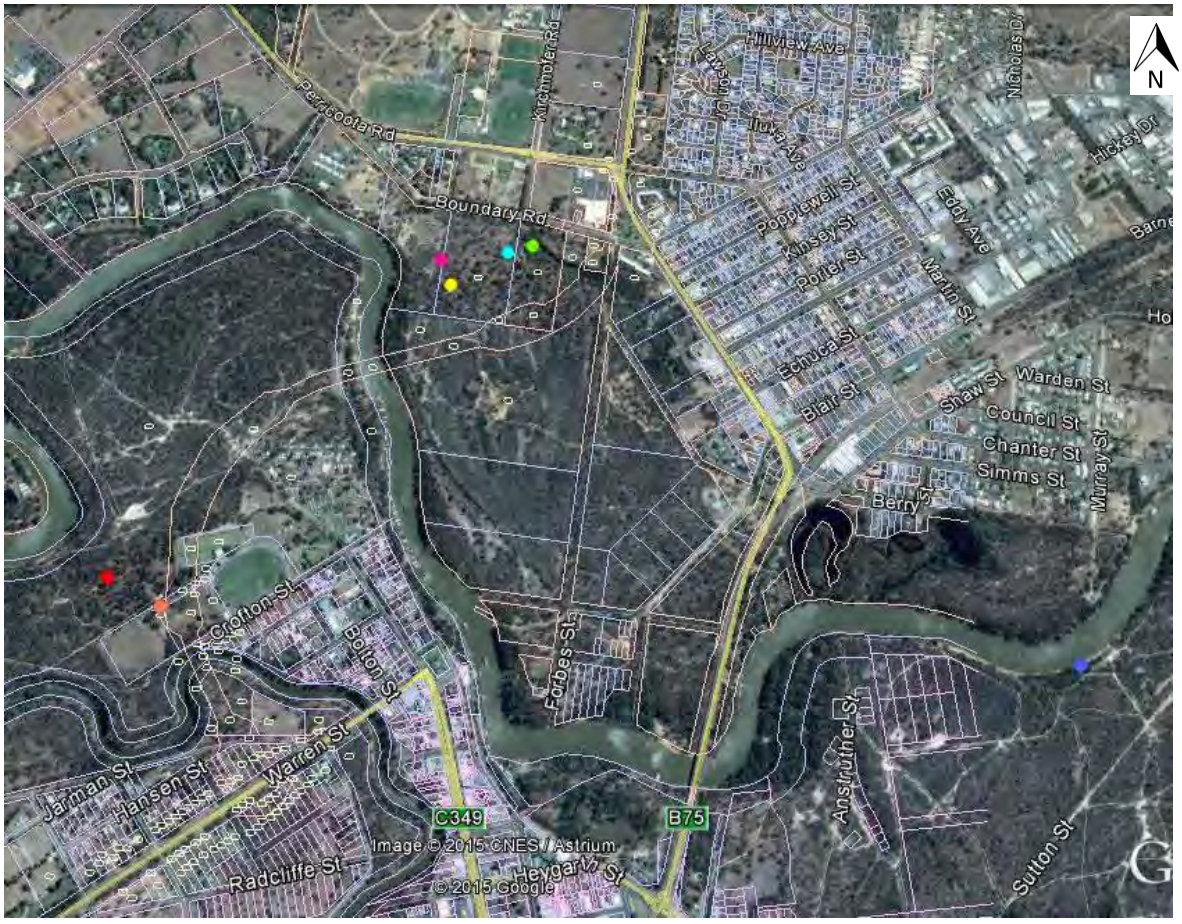

Figure 7. Location of Squirrel Glider capture sites. The yellow dot is F8CDO8, deep pink is the 1st capture of M8FE53, green is F90063, aqua is M90A99 and the second capture of M8FE53, red is M90C77, royal blue is F8BB83 and orange is F8D2DA. Source of background image: Google Earth.

Table 2. Survey effort, including the sex and identity (microchip number) of Squirrel Gliders trapped at each site. Note that one trap each was stolen from Sites 4 and 5 after four nights and were not replaced.

Site no.	Site	**# of traps (# of nights)**	# of trap nights*	Sex (M or F) and microchip code of trapped Squirrel Gliders
1	Boundary Road property	21 (8)	168	F-8CD08, M-8FE53
2	Boundary Road dams	11 (7)	75	M-8FE53, F-90063, M-90A99
3	Forbes Street	10 (7)	70	0
4	Middle (Victoria Park)	35 (7)	228	M-90C77
5	Middle North East	5 (7)	32	0
6	Crofton Street	11 (7)	77	F-82D2A
7	Warren Street	10 (7)	70	0
8	Parks VIC land	6 (7)	42	0
9	Campaspe Esplanade	7 (8)	56	0
10	South	22 (6)	110	0
11	South North West	5 (5)	25	0
12	River Park Drive Reserve	5 (5)	25	0
13	Horseshoe Lagoon	6 (5)	30	0
14	Sutton Street (Banyule Park State Forest)	6 (5)	30	F-8BB83
15	Burnanga Bend	6 (5)	30	0

***** The number of trap nights is the number of traps multiplied by the number of nights set. On some occasions a small number of traps were removed or extra traps added during the trapping session.

DISCUSSION

Abundance and distribution of Squirrel Gliders in study area

The *Eucalyptus* woodland within and around the mid-west alignment on both sides of the Murray River currently supports a resident population of Squirrel Gliders. While most gliders were caught outside the actual alignment (Fig. 7), the entire area is likely used by Squirrel Gliders, either on a nightly-basis as part of their home range or for longer-distance dispersal movements. The home range of Squirrel Gliders can be as large as 10 ha, and may be up to 3 to 5 km in length (van der Ree & Bennett, 2003). Therefore, each of the six gliders caught within the mid-west zone could have home ranges that overlap the actual alignment. The extent of this overlap could be confirmed by radiotracking, as well as determining the rate and location of crossings of the Murray River. A single individual was also captured at Sutton St/Banyule State Park, approximately 2km upstream of the mid-west zone.

The low rate of capture and recapture (i.e. only one individual captured twice) indicates that the size of the Squirrel Glider population within the study area is likely low. While it is almost certain we did not capture the whole population in the area, we consider it unlikely that we failed to detect a large proportion of the population. Therefore, we hypothesise that the population size is small, and that this is because the quality of the woodland habitat is not capable of supporting higher numbers of Squirrel Gliders. Preliminary observations from this field survey revealed that much of the woodland in the study area showed evidence of logging, firewood collection, grazing by stock, weed invasion, and lack of understorey. *Acacia* species are particularly valuable for Squirrel Gliders as a source of energy-rich nectar and sap, and these were absent from a large proportion of the study area. Other areas included young eucalypt regrowth, which typically lack the hollow bearing trees required to support Squirrel Glider populations. Further, the trapping rate observed during this study (0.0066%) is lower than we would expect for relatively extensive areas of woodland, particularly in areas with a high density of large and/or hollow-bearing trees (such as along the banks of the Murray River in NSW). Interestingly, the recapture rate was also unusually low (only one of the seven animals was captured more than once) compared to trapping results around the Hume Freeway in Victoria and southern NSW. This suggests that the population is probably more abundant and widespread than revealed by our trapping surveys. Further surveys would be required to more confidently assess population size.

Based on the findings of this survey, we conclude the following:

1) Squirrel Gliders are resident within the area, including within and immediately adjacent to the mid-west alignment;

2) The population size is probably low, but appears to be functioning as expected (healthy body weights, even ratio of males to females, pregnant females, and adults in all age-classes);

3) The population is probably more widespread and abundant than our trapping data suggests, but still likely quite low and patchy across the area;

4) The quality of the habitat is currently extremely variable, ranging from very low (dense stands of young regrowth with few large and/or hollow-bearing trees) to very high (areas of woodland with high densities of large and/or hollow-bearing trees).

Potential impacts of the proposed road project on Squirrel Gliders and management recommendations

The proposed road and bridge structures will impact upon Squirrel Gliders unless mitigation measures are included in the design and construction of the road. The primary impacts on the species in both NSW and Victoria include: i) loss of habitat due to clearing; ii) loss of large and/or hollow-bearing trees; iii) barriers to movement; iv) increased mortality due collision with vehicles; v) mortality during clearing, (vi) road noise and lighting and (vii) entanglement with barbed wire fencing. Each of these major impacts and potential mitigation measures are described in more detail below.

The likely small size of the resident Squirrel Glider population around the alignment increases its susceptibility to even relatively small impacts of the construction and operation of the road. In other words, the death of a small number of individuals annually due to collision with vehicles may have a disproportionate affect on the viability of the local population, because it may represent the loss of a large proportion of the local population. If the local population was much larger or occurred at higher densities, it may be better able to cope with the loss of a few individuals through mortality or loss of habitat.

Loss of habitat due to clearing

Woodland will be cleared to build the second Murray River crossing and this will result in a loss of habitat for the species and a concomitant reduction in the abundance of gliders. Smaller populations are less resilient to stochastic events, such as disease, wildfire or drought, which further reduce the size of the population. Habitat loss due to construction may have a disproportionate effect on an already small Squirrel Glider population, as even small additional population declines could pass the 'tipping point' beyond which populations cannot recover and local extinctions occur.

Loss of habitat can only be avoided by constructing the road in already-cleared habitat, which is not possible on the mid-west alignment. However, clearing woodland for temporary construction activities (e.g. site offices, car parking, access roads, stock piles) should be avoided, and minor modifications to the alignment to avoid high-quality areas or elements (e.g. tall trees required for connectivity – see below) should be considered. Unavoidable habitat loss should be compensated for by replanting or securing woodland habitat in the nearby area by using strategic revegetation as a form of mitigation. From a Squirrel Glider perspective, this revegetation should benefit the species by restoring connectivity or improving habitat quality within the alignment or more broadly in the region. For example, creating an isolated patch of woodland in the middle of cleared farmland would be of less value to Squirrel Glider conservation than creating a corridor to connect two isolated populations or improving the carrying capacity of an area of degraded woodland. Specifically,

consider undertaking strategic revegetation along the Campaspe River to "fill in the gaps", and to create additional linkages, such as to link the bushland to the north-west and south-east of Warren Street near the intersection with Anstruther street/Murray Valley Highway and then on to the Campaspe River. Additional corridors and linkages around Echuca and Moama should also be considered as part of the strategy to mitigate habitat loss.

Loss of large and/or hollow-bearing trees

Squirrel Gliders, and indeed many other species of arboreal mammal, birds and reptiles rely on hollows in trees for nesting (Gibbons & Lindenmayer, 2002). Hollows in eucalypts typically take 100 to 150 years to form, and in areas where they occur at low densities, they can be a limiting resource. Gliders typically occupy multiple hollows over time, and some individuals may swap hollows every three to five days (van der Ree, unpub. data). The density of hollow-bearing tress along the alignment is variable, ranging from high to absent. For example, Brett Lane and Associates (2014) recorded 35 hollow-bearing trees within the alignment in NSW, approximately half of which occurred within 50 m of the Murray River, and most of the remainder were associated with the Forbes Street reservation (Figure 16 in Brett Lane & Associates Pty. Ltd., 2014). Table 26 in BLA 2013 suggests that 12 of these 35 trees will be removed for the road project, however this will need to be confirmed based on the final alignment and design of the road. The abundance of large and hollow-bearing trees in Victoria is higher than in NSW, and the exact number impacted by the Mid-West alignment does not appear to have been surveyed. Surveys were conducted by Brett Lane and Associates for Alignment Options 2A, 2B, 2C and 2D, but not Mid-West specifically (Brett Lane & Associates Pty. Ltd., 2013). However, alignment 2D appears to most closely match the preferred Mid-West alignment (Fig. 27 in Brett Lane & Associates Pty. Ltd., 2013), and 2D will result in the removal of 374 large old trees, of which approximately 60 were hollow-bearing (pp 94 and 95 in Brett Lane & Associates Pty. Ltd., 2013). The location of large and hollow-bearing trees on the unsurveyed sections of the Mid-West alignment in Victoria need to be surveyed so the project can be aligned to avoid them and minimise the number that need to be cleared.

The loss of hollow-bearing trees will impact glider populations through the loss of potential den locations. Fortunately, Squirrel Gliders will readily use artificial hollows (i.e. nest boxes) if appropriately designed and installed. However, it should be realised that nest boxes are a short-term solution to a potentially long-term problem – the typical lifespan of a nest box is approximately 10 years, or less if poorly built and not maintained. Therefore nest-boxes are a temporary (i.e. ~10 years) solution to a long-term (> 50 years – i.e. assuming some of the existing stand of trees are 50 years old) impact. Nest boxes with a range of sizes and entrance-hole diameters should be installed to cater for a wide range of species, with at least one squirrel-glider-specific nest box for every hollow bearing tree removed. Importantly, these nest boxes should be installed on trees and in areas that do not have any (or many) naturally-occurring hollows, and occur prior to tree clearing. Due to the potentially short lifespan of the boxes, they should be maintained (e.g. occupation by wildlife monitored, box condition and attachment to tree inspected and repaired where necessary, etc), for a minimum of 5 years. At the end of the maintenance period, an additional suite of nest boxes should be installed in the same area but on different trees, to last an additional 10 years. In addition, consider initiating hollow formation in trees by creating incisions that accelerate the formation of hollows. The implementation of accelerated hollow-formation procedures by qualified, experienced

arborists is relatively new in Australia, and some possible experimentation in the field would be required to inform and guide this mitigation. We recommend that this be conducted in an experimental manner in collaboration with scientists to study the effectiveness of this approach. If successful, it could reduce the long-term need for nest boxes to replace the loss of existing natural hollows on other projects.

Barriers to Squirrel Glider movement

Gaps in canopy cover that exceed the gliding capability of squirrel gliders will be a barrier to the movement of individuals. The type of movement animals undertake include home-range movements (such as on a night to night basis to obtain food), dispersal of young from their natal territories and occasional long-distance movements to access new areas. Movement is also important to facilitate the recolonisation of patches that have undergone local extinction, as well as to allow new individuals to supplement declining or small populations, thereby preventing local extinctions from occurring.

Numerous radiotracking studies have shown that wide (e.g. dual-carriageway) roads are a barrier or filter to the movement of Squirrel Gliders (Soanes et al., 2013; van der Ree, 2006; van der Ree, Cesarini, Sunnucks, Moore, & Taylor, 2010). The first stage of the proposed road and bridges at Echuca-Moama (i.e. single-carriageway) is unlikely to be a complete barrier to the movement of gliders because the typical width of the travel lanes, bicycle lanes and verge is approximately 18 m. The overall gap size will be larger where the road is built on fill and is elevated 6 m above the floodplain, and will include the spread of the batters. Furthermore, the ability of gliders to cross such gaps is dependent on tree height – if tall trees are removed during construction or are absent from the specific location, then the road will be a barrier to movement until trees grow to sufficient height. The barrier effect will also be exacerbated where noise walls are installed, effectively increasing the height of the road by a further 1.5 to 3.5 m. In these situations, the trees must be high enough to allow gliders to glide across the road as well as the noise walls.

Importantly, it should be recognised that when the second carriageway is built, and assuming the second carriageway is built close to the first such that trees are unable to grow between them, the road will likely be a substantial barrier to the movement of Squirrel Gliders. Therefore, mitigation should be designed and installed to take into account the eventuality that the second carriageway will also be installed at some point in the future.

Options to mitigate the barrier effect of linear infrastructure on Squirrel Gliders have been extensively studied and can restore at least some connectivity for the species. The most effective techniques are those where the natural tree canopy remains connected above the road or glide distances are short (<10 – 20 m), thereby allowing animals natural movement pathways above the road. Furthermore, the risk of collision with vehicles is greater as glide length increases because the height of the landing point gets lower to the ground, placing them in the path of oncoming vehicles.

Where natural canopy connectivity cannot be maintained or restored, glider poles and rope bridges may be used. Both techniques are readily used by glider to cross roads, however only gliders can use glider poles, while a range of species can use the canopy rope bridges. Furthermore, glider poles may increase the risk of glider collision with vehicles if poles are too short or spaced too widely, as

gliders may need to undertake long glides between poles. Long-term monitoring of Squirrel Glider populations along the Hume Highway Duplication Project in southern NSW has demonstrated that even though gliders use poles and rope bridges, the population has still declined significantly since the highway was duplicated. While the specific cause of the decline is unknown, one potential explanation is that gliders, and potentially young inexperienced individuals, are not successfully using the glider poles on every occasion, thereby increasing their rate of mortality due to collision with vehicles. Other explanations include increased emigration or reduced habitat quality. However, in the context of planning for Echuca-Moama and in the absence of reliable data on the cause of the decline, we should assume some increased mortality due to use of the poles. Therefore, we recommend that rope bridges be the preferred form of connectivity mitigation, second to maintaining natural canopy connectivity. Where natural canopy connectivity and rope bridges are not feasible and glider poles are required, they should be placed closer together, be taller, and also wider at the base than those used along the Hume Freeway Duplication and Bypasses. Every installation of glider poles must be designed to take into account the height of any existing trees, the height of the road and noise walls and the width of the gap to be crossed. This design must be approved by an expert in the ecology of the species to ensure maximum effectiveness.

Rope bridges are an alternative to glider poles and allow gliders and possums to cross above or beneath the carriageway. Because of the potential for increased rates of mortality at glider poles, rope bridges are preferred mitigation options over glider poles. While rope bridges are likely more effective when erected above the roadway, they can also be installed beneath road bridges at locations where there is sufficient clearance. While minimum clearances for Squirrel Gliders are not known, the rope ladder should be a couple of metres below the bridge deck and at least 4 to 6 m above the ground.

Rope bridges and glider poles should always be located in close proximity to large and/or hollow bearing trees in an effort to facilitate movement because these types of trees are preferred habitats for Squirrel Gliders. Radiotracking and surveys of the use of rope bridges with microchip scanners suggest that gliders will attempt to cross the road throughout their home range. In other words, gliders will not travel 1 or 2 km down the road to access a crossing structure. In order to maintain connectivity, crossings should be installed at regular and frequent intervals, such as at every 500 m, along the length of the project. In addition, the structures should be functionally connected to the existing trees to increase rates of use. For example, the first and last pole of rope bridges should be as close as possible to tall and/or hollow-bearing trees, and have at least two or three “feeder” ropes at each end of the bridge that connect it to the trees. Glider poles should be installed to connect with specific tall trees. An effective approach adopted on some sections of the Hume Highway Duplications and Bypasses was to conduct site inspections after the alignment was pegged out but prior to clearing in order to identify strategically important trees that would form part of the connectivity mitigation.

Any area identified as a potentially strategic location for crossing by Squirrel Gliders should be considered as a crossing zone rather than a single crossing point. The crossing zone should be at least 100 – 200 m in length, with animals able to cross the road at multiple points throughout this zone. If the success of a crossing location is reliant on a single tall tree to achieve a glide across the road, and that tree falls over, then that crossing point is non-functional until a new tree reaches

sufficient height. Also, recent evidence from Victoria suggests that single-point crossing structures (rope bridges or poles) can be monopolised by a few individuals which include the structure as part of their territory, thereby potentially limiting access by the rest of the population. Therefore, where possible, crossings should be facilitated along a zone of at least 100 – 200 m, with at least two (and preferably three) options for crossing within the zone. This inbuilt resilience will ensure a more robust and reliable crossing option that will remain functional in the long-term.

Key locations to maintain connectivity in Victoria occurs on the banks of the Murray River and through the caravan park, along the Campaspe River itself and across Warren Street near the intersection with the Murray Valley Highway to join up with the Campaspe River. In NSW, the key locations for maintaining connectivity occur along the entire alignment. In addition, other opportunities to restore connectivity for gliders exists outside the alignment and should be considered to improve viability of the regional population. A connectivity management strategy that identifies the key locations across the alignment and the district should be developed.

The Murray River is likely a barrier at some locations to the movement of Squirrel Gliders, with distances across the river ranging from 86 to 94 m near the boat ramp to > 110 m in other locations. Depending on the height of the trees (typically 20 – 30 m) and the height of the embankment, the gaps of 86 m and 94 m are potentially achievable glides. Because these glides are likely only just achievable, connectivity for gliders across the road must be maintained on both the NSW and Victorian sides of the Murray River. While the Murray River may limit the regular and frequent movement of gliders, it is not a complete barrier, and the animals on both sides of the river are likely functioning as a single population. Dispersal across the river is almost certainly occurring, and daily crossings as part of home range movements are also likely occurring in some places. Therefore, the two "sub-populations" on opposite sides of the river are likely reliant on each other for persistence. If one sub-population declines or goes extinct, the remaining sub-population is therefore smaller and more likely to decline and go extinct due to stochastic events. In order to cross the river, gliders will likely cross in the vicinity of their home range – they are unlikely to travel many kilometres in order to find a suitable crossing location.

Increased mortality of Squirrel Gliders due collision with vehicles

Squirrel Gliders will attempt to glide across the road at any location where they perceive that the distance is within their gliding range. Therefore, gliders may attempt to cross the road along its full length wherever trees occur in close proximity to the road. Due to the low density/abundance of the population in the study area, any increased mortality of gliders due to collision with vehicles will likely have a substantial impact on the viability of the local population and should be avoided. Because there are no fence-designs appropriate to prevent gliders from accessing the roadway, the only viable solution is to provide frequent and regular crossing options, thereby reducing the likelihood of gliders crossing at inappropriate or dangerous locations. The project is unlikely to have a significant impact on Squirrel Glider populations if sufficient crossing structures are installed and if the majority of crossing options are rope bridges or natural canopy connectivity.

While it is not possible to provide a definitive and optimal distance between crossing zones, these should be in the order of approximately every 500 m. The locations should also be optimised to take into account situations where the design of the road facilitates crossings (such as where the road

may transition from cut to fill, or where the batters are less steep and can support tree-growth) or where tall trees occur next to the roadway. A comprehensive survey of the height of the trees adjacent to the roadway should be undertaken during the detailed design stage to identify important trees that must be retained and protected during construction. Importantly, the detailed design should allow for the location of the road to be adjusted slightly to protect key glide trees.

Mortality of Squirrel Gliders during clearing

Wildlife, including Squirrel Gliders, may be injured or killed during the clearing of vegetation. We recommend the adoption of a two-stage clearing process (as detailed in the RMS Biodiversity Guidelines), whereby non-hollow-bearing trees are knocked over on day 1, and hollow-bearing trees on day 2, allowing animals to leave the site on the first night. Alternative denning opportunities (i.e. nest boxes) should be installed in close proximity to the alignment but outside the clearing zone a few months prior to clearing commencing, allowing animals time to locate and use the alternative hollows. Trained and licensed ecologists with experience in fauna handling should be onsite during clearing to check hollows of felled trees and rescue any wildlife.

Road noise and lighting

As discussed earlier, the cause of the decline in the abundance of Squirrel Glider populations along the Hume Freeway in southern NSW is unknown. We have postulated that this may be due to increased mortality, but it may also be because the habitat adjacent to the Hume Freeway is now less suitable for the species because of such things as increased noise and light levels originating from the road and traffic (Blackwell, DeVault, & Seamans, 2015; Parris, 2015). The current plan for the proposed road project at Echuca-Moama includes lighting at intersections only, and low-level strip or LED lighting on the shared user path. This level of lighting is unlikely to have a significant impact on Squirrel Gliders. However, the road is being designed to accommodate lighting in the future if required, and this may have an impact on Squirrel Gliders and other wildlife. All lighting, now and into the future, should be designed to avoid light spill into adjacent habitats through the use of lighting fixtures and light walls.

Entanglement of gliders with barbed-wire fencing

Squirrel Gliders can get entangled with barbed wire fences when gliding, often resulting in death (van der Ree, 1999). This is particularly an issue with new fences (i.e. when barbs are sharp and fence is taught), as gliders are more likely to “bounce-off” a rusty and/or slack barbed wire fence. Most entangled gliders are found in areas that appear to be preferred glide paths, and when the gap between trees is largest (i.e. they land lower down in the tree after a long glide). The use of barbed wire along the alignment is not recommended, and MUST NOT be used within designated crossing zones. The effort and cost involved in providing crossing structures can easily be “undone” if even a small number of gliders get entangled and die.

Additional surveys and monitoring

Comprehensive monitoring of the Squirrel Glider populations along the recently duplicated sections of the Hume Freeway in southern NSW has demonstrated a decline in the population since the construction and operation of the road. Importantly, the decline has not been observed at control sites, strongly suggesting that the impact is due to some aspect of the road duplication or design of mitigation. The cause of the decline is unknown, and we recommend that monitoring of the

population around Echuca be undertaken to assess the effectiveness of mitigation. The two aims of monitoring are to determine if the completed road and bridge has an impact on (1) population size and (2) the level of connectivity and glider movement across the alignment. The impacts of the road and effectiveness of the mitigation on the size (and hence viability) of the population can be determined by establishing a reliable baseline estimate before construction and repeating this approximately five years after construction. Depending on the results at 5-years post construction, additional surveys should be considered for 10-years post-construction if the population shows evidence of a decline. Estimating a reliable population estimate requires more than one trapping episode – we recommend at least three surveys be undertaken prior to construction commencing and another three at 5 years post-construction. Therefore, a further two pre-construction surveys are required, and these should be timed to occur in Spring 2015 and Autumn 2016, if the construction schedule allows. If construction is to commence prior to Autumn 2016, the two surveys should occur sooner. In any case, the timing, effort and methods of the before and after surveys should be similar to ensure they truly represent the status of the population. The most cost-effective approach to understand gene flow is to undertake intensive sampling prior to construction to collect sufficient genetic samples to characterise the population, which is then repeated at five and 10 years after opening to traffic. We recommend that DNA samples be collected simultaneously with the population surveys. The samples should be analysed at the conclusion of the "before" surveys and at the conclusion of the "after" surveys, to prevent degradation of the DNA. This monitoring protocol will allow a comparison of the size of the population before and after construction, but is not sufficient to detect a decline during the intervening 5 years and implement recovery. Surveys should also be conducted at a number of control sites in the region to allow a comparison with trends along the project alignment.

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Appendix 9: Gration (2015)

Appendix 10: BL&A (2015d)