



Draft Conservation Advice for the Wetlands and inner floodplains of the Macquarie Marshes

Under the EPBC Act, the Threatened Species Scientific Committee (TSSC) must invite comments on whether or not a nominated ecological community which has been prioritised for assessment is eligible for listing, and under which threat category. In this case, the TSSC and Department are also seeking comments on this entire *Draft Conservation Advice* for an ecological community prioritised for assessment by 29 November 2024. In addition to potential listing eligibility, the document also provides a draft description of the ecological community, the key threats, and draft key actions to stop decline and support recovery for the ecological community.

The purpose of this consultation document is to elicit updated and additional information to assess the threatened status of the ecological community and help inform future conservation actions within a final Conservation Advice.

This *Draft Conservation Advice*, containing a preliminary listing assessment, should be considered **tentative** at this stage, as it is likely to be updated as a result of responses to this consultation process and the input of further scientific information and analysis.

Historical Notes – 2013 Listing and Conservation Advice

This *Draft Conservation Advice* is based on a previous listing assessment of the same ecological community that was listed as Critically Endangered on 5 August 2013. This listing remained in place for four months before a motion for its disallowance was passed on 11 December 2013 during the next sitting period of Parliament following its approval for listing.

The *2013 Conservation Advice* (with listing assessment) was developed over several years and overseen by the independent Threatened Species Scientific Committee —with input from: over 100 experts; a review of over 350 papers and reports; the outcomes of a technical workshop; and consultation with a range of industry, government, First Nations, and other community stakeholders.

Current Assessment – October 2023 – November 2024

The ecological community was nominated for listing again in 2023 and was deemed a priority by the TSSC and the Minister for the Environment, for the assessment period starting October 2023.

This *Draft Conservation Advice* (i.e. August 2024) has used the 2013 version as a foundation document, with the aim of updating it based on the range of scientific data and other information that has arisen in the intervening decade or so. Updates have been progressing prior to this public consultation period but are not yet fully comprehensive and do not yet take into account upcoming Murray-Darling Basin Plan reports due out soon. Therefore, throughout this Draft document there are text boxes with Questions/ Comments for your consideration as part of the consultation process. These include seeking assistance with identifying further relevant data and information to help the Committee reach a final assessment outcome by November 2024 and the Minister to subsequently agree to an *Approved Conservation Advice* (as required by EPBC Act).

Draft Conservation Advice for the Wetlands and inner floodplains of the Macquarie Marshes

This document forms the *Draft Conservation Advice*, including a preliminary listing assessment, for the Wetlands and inner floodplains of the Macquarie Marshes ecological community (EC). A *Conservation Advice* aims to provide a foundation for conservation action and further planning, including threat abatement.



North Macquarie Marsh Nature Reserve © Nerida Sloane

The Wetlands and inner floodplains of the Macquarie Marshes occurs within Country (the traditional lands) of the Ngiyampaa-Wayilwan peoples of central western NSW and their associated clans. The Ngiyampaa-Wayilwan have traditional connections to the Wongaibon, Kamilaroi/Gomeroi, Ngemba and Wiradjuri. We acknowledge their spiritual and material heritage and culture and continuing link to the ecological community and the Country (including lands and waterways) it inhabits.

Proposed Conservation Status

The Wetlands and inner floodplains of the Macquarie Marshes is proposed to be listed in the Endangered or Critically Endangered category of the threatened ecological communities list under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act).

A preliminary assessment has determined that the ecological community is potentially eligible for listing as 'Endangered' or 'Critically Endangered' under Criterion 4, as 'Endangered' under Criteria 3 and 5, and as 'Vulnerable' under Criteria 1 and 2 of the EPBC Regulations. The draft assessment is at [section 6](#).

At the time of this *Draft Conservation Advice*, there are no comparable ecological communities listed under State or Territory legislation. However, part of the ecological community corresponds with "The aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River" (which includes the Wambuul/Macquarie River below Burrendong Dam) listed in 2003 under the *NSW Fisheries Management Act 1994*. In addition, part of the range for the ecological community overlaps with an internationally recognised (Ramsar) wetland. The ecological community also corresponds with habitat for several threatened species listed under national environment law and also migratory birds listed under international agreements. More information is at [section 5.2](#), [Appendix A](#) and [Appendix B](#).

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About this document

This document has a draft description of the ecological community and where it can be found ([section 1](#)); and outlines draft information to assist in identifying the ecological community and important occurrences of it ([section 2](#)). It also provides a brief, draft description of certain key aspects of the ecological community's cultural significance for First Nations people ([section 3](#)).

In line with the requirements of section 266B of the EPBC Act, it sets out the grounds on which the ecological community may be eligible to be listed as threatened ([section 6](#)); outlines the main factors that may cause it to be eligible for listing ([section 4](#)); and provides draft information about what could appropriately be done to stop its decline and/or support its recovery ([section 5](#)).

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1 Ecological community name and description

1.1 Name

The name of the ecological community is the Wetlands and inner floodplains of the Macquarie Marshes (also referred to as 'Macquarie Marshes', or as the/this ecological community). The name refers to the main ecosystem types and geographic area that correspond with the ecological community. The ecological community was placed on the 2023 Finalised Priority Assessment List under this name.

The nominated ecological community is equivalent to 'The Wetlands and inner floodplains of the Macquarie Marshes' which was listed as critically endangered under the EPBC Act from 13 August 2013 until the Legislative Instrument for inclusion on the list of threatened ecological communities was disallowed on 11 December 2013.

1.2 Description of the ecological community and the area it inhabits

The EPBC Act defines an ecological community as an assemblage of native species that inhabit a particular area in nature. This section describes the species assemblage and area in nature that comprises the ecological community.

The ecological community described in this draft Conservation Advice is the assemblage of native plants, animals and other organisms occurring within a complex of inland freshwater (palustrine) wetlands associated with parts of a lowland river system (the Macquarie or Wambuul River). The ecological community is found in the semi-arid and temperate northern Murray-Darling Basin of New South Wales (NSW). Depending on hydrological flows from the Wambuul/Macquarie River and its tributaries and anabranches, the Macquarie Marshes ecological community occurs across interconnected habitats (or ecotypes), including permanent/intermittent lowland streams, ephemeral freshwater lakes, seasonal floodplain marshes and subtropical/temperate forested wetlands, typically dominated by *Eucalyptus camaldulensis* (river red gum).

This section primarily describes the assemblage of flora and fauna species and the areas of habitat that represent the typical range of natural states of the ecological community. More information to assist in identifying areas of the ecological community is provided in [section 2](#). Because of past loss or degradation, not all extant areas of the ecological community are in a completely natural state. [Section 2.3](#) provides information to identify which areas retain sufficient conservation values to be considered a matter of national environmental significance.

1.2.1 Area in nature inhabited by the ecological community

1.2.1.1 GEOGRAPHIC LOCATION

The geographic location information is current as at August 2024.

The Macquarie Marshes occurs within the Murray-Darling Basin, and entirely within the Darling Riverine Plains IBRA (IBRA - Interim Biogeographic Regionalisation for Australia version 7 (DoE 2012)) bioregion. The ecological community occurs within the Macquarie-Castlereagh region in central-west New South Wales as recognised in the Murray-Darling Basin Plan (MDBA 2012a).

The distribution area for the ecological community extends from: south-east of Brewarrina and includes occurrences near the Ginghet/Marra Creek confluence and Castlereagh/Macquarie River confluence; west of Merri Merri Creek near Quambone; and north of Warren and includes occurrences upstream of the Marebone Weir near the Junction Creek and Wambuul/Macquarie River confluence. The ecological community corresponds with the location and extent of the Macquarie Marshes hydrologic indicator site (A13) as defined in the Murray-Darling Basin Plan process (MDBA 2012) and is equivalent to the area within the boundary specified by the *Directory of Important Wetlands in Australia* (DCCEEW 2019).

The ecological community occurs where water regularly overflows (breaks out of) the main Wambuul/Macquarie River channel, including Bulgeraga Creek, Gum Cowal Creek, Monkeygar Creek and Terrigal Creek, and develops as a network of smaller channels and braided swamps. The Wambuul/Macquarie River extends through the ecological community and, depending on flows, eventually links downstream with the Barwon River. The ecological community also occurs in areas further upstream and downstream from the floodplain that have similar biophysical characteristics, for instance the Ginghet Creek and Marthaguy Creek.

The Macquarie Marshes occurs within the Central West and Far West Local Land Services regions of NSW and national Natural Resources Management (NRM) regions.

Local Government areas in NSW known to contain the ecological community at this time include:

- Bogan Shire Council, Brewarrina Shire Council, Coonamble Shire Council, Walgett Shire Council and Warren Shire Council

Occurrences of the ecological community are located in conservation reserves, such as Ginghet Nature Reserve, the Macquarie Marshes Northern Nature Reserve and Macquarie Marshes Southern Nature Reserve. The Macquarie Marshes Ramsar site overlaps with the distribution area for the ecological community that corresponds with conservation reserves ([section 5.2](#)).

1.2.1.2 ENVIRONMENTAL CHARACTERISTICS OF THE AREA INHABITED IN NATURE

The Macquarie Marshes occur on a dryland alluvial floodplain where wetlands form along and between the main watercourses including the Wambuul/Macquarie River and its anabranches and tributaries (Ralph & Hesse 2010; Thomas et al. 2011; OEH 2012a).

The Macquarie Marshes now occur south (upstream) of the Marebone Weir (near Warren). As the Macquarie River reaches the flat alluvial plain, the floodplain transforms into a maze of interconnected streams, lagoons, distributary creeks and anabranching channels (Paijmans 1981), and extends to the north where all the channels unite to form a single channel near Carinda (OEH 2012a).

The flooding regime (frequency, extent, magnitude and duration) is the key ecosystem driver of the Macquarie Marshes. Most of the wetlands are semi-permanent or ephemeral, depending on the distance from the main streams and channels. Flooding may occur in any season and the extent of inundation varies considerably from year to year. Flooding regimes, together with soil and channel morphology strongly influence the diversity and structure of vegetation across the area of the ecological community and provide for a range of faunal habitats, particularly for woodland birds, waterbirds, frogs, fish and other aquatic and amphibious vertebrates and invertebrates (OEH 2012a; Holmes et al. 2009).

Soil

The ecological community occurs in areas with heavy-textured, black silts and clays, characteristic of low-energy alluvial systems. The mostly uniform textured soils, when dry, can develop deep cracks that allow water and organic material to enter the soil. Cracking typically occurs in areas of the floodplain away from the main channels, where inundation is most variable (Holmes et al. 2009). This leads to gilgai topography: natural low mounds and shallow depressions formed by shrinking and swelling of clay-rich soils. These soil cracks and holes provide important habitat for invertebrates and other small native animals, such as frogs, mammals and reptiles. When floodwaters enter soil cracks, they lead to deep soil recharge (OEH 2012a).

Hydrology - flow and inundation

The structure and function of the wetland components of the ecological community are determined by the Wambuul/Macquarie River flow regime (Schweizer et al 2022). The Wambuul/Macquarie River forms west of the Great Dividing Range near Bathurst and flows north onto the Darling Riverine floodplain where the Macquarie Marshes occur (Kingsford & Thomas 1995; Brock 1998; Kingsford & Johnson 1998; Kingsford & Auld 2005; Ralph & Hesse 2010). On the floodplain, the Macquarie River splits into numerous distributary channels (Ralph & Hesse 2010).

The Macquarie Marshes are comprised of a series of semi-permanent marshes, streams and lagoons and include ephemeral wetlands that are inundated only during large floods (Kingsford & Auld 2005; Ralph & Hesse 2010; Ralph et al. 2011; OEH 2012a). Each wetland has a characteristic natural flow regime (Poff et al. 2010) and each flow-dependent species has specific environmental water requirements due to their adaptations to the flow regime (Roberts & Marston 2011; Rogers & Ralph 2011).

The Wambuul/Macquarie River flow is seasonally variable with runoff and discharge primarily sourced from the upper catchment during July to September. The river drains an area of about 26,000 km² upstream of Narromine but receives few tributary inputs along its lower reaches after it disperses onto the lowland-dryland alluvial floodplain where the ecological community occurs (Ralph & Kobayashi 2018). Despite being perennial, flows along the lower Wambuul/Macquarie River are highly irregular. For example, Mason et al. (2022) found that during the period 2014-2019, the Macquarie Marshes experienced a range of flow conditions. These ranged from no flow from upstream, to small managed inundating environmental flow events and a large natural overbank event in 2016-17 due to dam spill and tributary flows.

Channel change and ecological succession are a natural part of the system but have been exacerbated by alterations to river flow and floodplain fragmentation in the wetlands (Ralph et al. 2016). Some of the largest flows from the Wambuul/Macquarie River may join the Barwon-Darling River system. This is most likely during a period of high rainfall, high stream flows and when the Burrendong Dam exceeds capacity. Such a combination resulted in flows across 220,000 ha of the area including the ecological community in Spring 2022 (CEWO 2023).

The relationship between hydrology and geomorphology and between groundwater and salinity are also covered in the Key ecological processes at [section 1.2.4](#).

Climate

The Macquarie Marshes is influenced by the climatic gradient that exists between the upstream and downstream areas of the catchment, with highland regions receiving higher rainfall and lower evaporative demand relative to lowland areas. The ecological community is more

dependent on rainfall and subsequent flows across the Macquarie River catchment than localised rainfall (Kingsford & Thomas 1995; OEH 2012a).

The Macquarie Marshes rely on the high rainfall in the upper Wambuul/Macquarie catchment to maintain the extensive wetlands in the semi-arid lowland reaches where the ecological community occurs. The Macquarie Marshes typically experiences summer-dominant rainfall averaging about 400 mm per year and evaporation of about 2000 mm per year. By comparison, the upper Macquarie catchment typically has winter-dominant rainfall of between 600-1000 mm per year and evaporation of about 1300 mm per year (MDBA 2012b; BOM 2024).

Annual rainfall in the Wambuul/Macquarie River catchment is highly variable. Inundation of the ecological community is predominantly by winter–spring flooding from the Wambuul/Macquarie River and its tributaries and anabranches, including Monkeygar Creek, Buckiinguy Creek, Bulgeraga Creek, Gum Cowal and Terrigal Creek. Localised rainfall patterns across the Macquarie Marshes are also highly variable, with local rainfall generally being higher in the eastern extent than the western extent of the ecological community. The long-term annual average ($\pm 1SD$) rainfall for Quambone Station (51042) in the east is 469 mm (± 125 mm) (Mason et al. 2022). For the period 2004-2023, annual rainfall varied from 160 to 880 mm (BOM 2024).

Consultation Questions on the area inhabited.

- Do you agree with the proposed name for the ecological community? Please provide an appropriate First Nations name that could be used in addition to, or instead of Macquarie Marshes (noting Wambuul is accepted as one of the First Nations names for the river, but we have not proposed it as part of the ecological community name as it is not likely to be the right First Nations word to use for the Marshes themselves).
- Please indicate if you have any changes to better describe the location, physical environment and environmental characteristics for the area in nature inhabited by the ecological community?

1.2.2 Description of the assemblage of native species

1.2.2.1 ECOSYSTEM TYPE AND VEGETATION STRUCTURE

The ecological community is part of a wetland complex typically found on the inner and most frequently flooded parts of the lower Wambuul/Macquarie River floodplain. The associated vegetation types across the range of the ecological community are determined by abiotic factors such as the position in the landscape, inundation regime of a site (e.g. the frequency, extent, magnitude and duration of flow) ([figure 1](#)), climate and soil. The areas where the ecological community are found can be characterised into four broad water dependent vegetation types: aquatic vegetation, seasonal or intermittent wetland, shrubland wetland and forest/woodland (primarily river red gum) ([Table 1](#)). Due to variable hydrological regimes and inundation patterns between years, some habitat types vary from wet to dry as hydrological flows and quality are disrupted, and the vegetation cover ranges from dense to sparse. Wet-phase wetland vegetation grows and senesces in response to stream and surface flow and seasonality. The expression of dry-phase vegetation is moderated by flow recession and drought conditions. Dry and drought wetland phases are natural components of semi-arid floodplain hydrology (Wen et al. 2023).

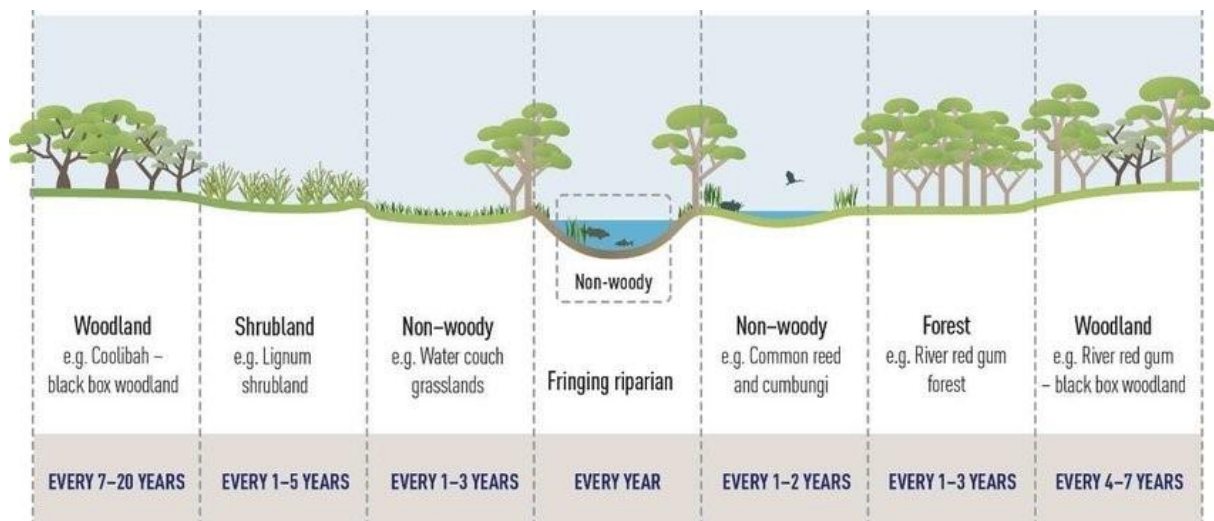


Figure 1: Conceptual model of the hydrological regime and position on the Macquarie floodplain that influence the main freshwater ecosystems. Source: MDBA 2014.

Under the IUCN Global Ecosystem Typology 2.1 (Keith et al. 2022b), the Macquarie Marshes include the Ecosystem Functional Groups:

- TF1 Palustrine wetlands biome:
 - TF 1.2 Subtropical/temperate forested wetlands
 - TF 1.3 Permanent marshes
 - TF 1.4 Seasonal floodplain marshes
 - TF 1.5 Episodic arid floodplains
- F1 Rivers and stream biome
 - F1.2 Permanent lowland rivers
 - F1.5 Seasonal lowland rivers
 - F1.6 Episodic arid rivers
- F2 Lakes biome
 - F2.3 Seasonal freshwater lakes

Flows from the Wambuil/Macquarie River, the Marthaguy Creek and distributary streams create temporal patterns of wetting and drying that structure the floodplain vegetation (Thomas & Ocock 2018; DPIE 2020d; Wen et al. 2023). *Phragmites australis* (common reed) and *Typha domingensis* (cumbungi) wetland, *Paspalum distichum* (water couch) grassland and sedgeland communities require frequent inundation with persistent surface water for much of the year (Roberts & Marston 2011). Woody vegetation communities such as river red gum (*Eucalyptus camaldulensis*) forest and woodland and lignum (*Duma florulenta*) shrubland require less frequent and consistent inundation. However, riparian and floodplain forests and floodplain woodlands depend on river floods for water to maintain mature trees, promote regrowth, and to recharge and refresh soil water and groundwater. *E. largiflorens* (black box) and *E. coolabah* (coolibah) woodland occur higher on the floodplain and occupy the drier end of the hydrological gradient, which is outside the boundary for the ecological community (Figure 1) (Roberts & Marston 2011; Mason et al. 2022).

Connections between the wide range of freshwater ecosystems in the Wambuil/Macquarie River catchment and more broadly in the NSW Murray–Darling Basin, to each other and their floodplains is a vital component of the lifecycle of many plants and animals inhabiting these systems. Connectivity supports productivity by moving nutrients throughout the wetland and

riverine systems (MBDA 2014). In some areas, the ecological community may co-occur, or intergrade, with canopy species that are more commonly associated with drier habitats on the slightly higher ground bordering the marshes. However, if *Acacia pendula* (weeping myall), *Casuarina cristata* (belah), *Eucalyptus coolabah* (coolabah), *E. largiflorens* (black box) or *E. populnea* (poplar box) reach a sufficient (dominant) canopy cover threshold, the area is no longer considered the ecological community (see [section 2.1 Key diagnostic characteristics](#)).

1.2.2.2 FLORA

Vegetation type across the ecological community is determined by the landscape position coupled with the water regime of a site, particularly the frequency, extent, magnitude and duration of inundation. Flows from the Macquarie River and its distributary streams create temporal patterns of wetting and drying that structure the floodplain vegetation (Thomas & Ocock 2018; Mason et al. 2022). Vegetation habitats range from open water, vegetated marshland, to shrub/tree-dominated swamps and seasonally flooded forests, woodlands and shrublands. The dominant trees and shrubs commonly present require flooding at some stage for regeneration, as do many of the characteristic herbaceous species. They can tolerate prolonged flooding for varied durations and can survive dry periods lasting from months to years (Roberts & Marston 2011). During dry phases, such as drought, plants may not be visible above ground and aquatic and amphibious species may persist as desiccated shoots, underground rootstocks or propagules (for example, seeds, spores etc). The Macquarie Marshes can rapidly revert to its wet form upon inundation if the hydrological and biological characteristics of the wetland are relatively intact, but restoration of diversity, abundance and function will take much longer following declines in integrity, and particularly following loss of functionally-significant species.

The wetland vegetation complex that occurs in the Macquarie Marshes is summarised in [Table 1](#). Four broad water dependant vegetation types and several sub-communities are identified that belong to the most flood-dependent ecosystem or habitat types in the landscape. These sub-communities correspond with various vegetation types described in the NSW Plant Community Types (PCT) database (DPE 2022). A list of plant species recorded in the ecological community is at [Appendix A, Table A1](#) and details about equivalent NSW PCT classifications are at [Appendix D](#).

Table 1: Main vegetation types found in the Macquarie Marshes. Source: Adapted from Paijmans 1981; Bowen & Simpson 2010; DECCW 2010; OEH 2012a

Broad vegetation type	Vegetation communities and dominant/common species
River red gum forest and woodland: <ul style="list-style-type: none"> occurs on the floodplain, often with a high species diversity. 	<i>Eucalyptus camaldulensis</i> (river red gum) open forest usually with a wetland understorey of reeds, rushes, sedges and other aquatic herbs: <ul style="list-style-type: none"> occurs mostly in the channel country of the North Marsh. River red gum grass-chenopod open woodland on floodplain clays usually with an understorey of grasses, forbs and/or chenopods: <ul style="list-style-type: none"> occurs between the main channels in less frequently flooded areas generally has a less dense canopy understorey varies with inundation - typically a mixed marsh when wet; typically with grasses and chenopods in the dry phase.
Shrubland wetland: <ul style="list-style-type: none"> generally occurs on the lower parts of the floodplain where areas are seasonally or periodically subject to flood waters 	<i>Acacia stenophylla</i> (river cooba) swamp on the floodplains. <i>Duma florulenta</i> (lignum) shrubland on regularly flooded alluvial clay depressions.

Broad vegetation type	Vegetation communities and dominant/common species
Seasonal or intermittent wetland (marshland or other areas that are typically shallow when inundated): <ul style="list-style-type: none"> occurs on the lower parts of the floodplain where flood waters persist and temporary wetlands are more likely to form. can develop into chenopod shrubland in the dry phase (e.g. with <i>Sclerolaena muricata</i> (black roly-poly) or <i>Salsola australis</i> (buckbush)). 	<i>Paspalum distichum</i> (water couch) marsh grassland of frequently flooded inland watercourses/water couch: <ul style="list-style-type: none"> covers extensive areas in the Macquarie Marshes. <i>Phragmites australis</i> (common reed) amphibious tall grassland of inland river systems: <ul style="list-style-type: none"> Extensive over hundreds of hectares, sometimes in mosaic with aquatic herbland. Sedge-forb (mixed marsh) shallow freshwater wetland in depressions on floodplains on inland alluvial plains and floodplains: <ul style="list-style-type: none"> Often with <i>Bolboschoenus fluviatilis</i> (marsh club-rush) and <i>Eleocharis</i> spp. (spikerushes). <i>Typha domingensis</i> (cumbungi) rushland of shallow seasonal or intermittent water bodies of the inland river systems.
Fully aquatic vegetation: <ul style="list-style-type: none"> occurs in open waters 	<i>Vallisneria australis</i> (river ribbons) and <i>Azolla</i> spp. (floating ferns) and other species.

1.2.2.2.1 Tree and tall shrub species

The forest/woodland wetland component of the Macquarie Marshes typically features a canopy and/or sub-canopy dominated by *Eucalyptus camaldulensis* (river red gum) which is regarded as a keystone species for the Macquarie Marshes. A keystone species is one that has a disproportionately large effect on its environment relative to its abundance or biomass. There are two hallmarks of keystone species: their presence is crucial in maintaining the organisation and diversity of their ecological communities, and these species are 'exceptional', relative to the rest of the community, in their importance (Mills et al. 1993). River red gum contributes structural complexity and provision of habitats and resources, for example, through tree hollows, fallen logs, roosting sites (Roberts & Marston 2011). Other tree species present within the ecological community include *Acacia salicina* (black sally wattle, cooba), *Alectryon oleifolius* (boonaree, western rosewood), *Atalaya hemiglauc* (cattle bush), *Capparis mitchellii* (wild orange), *Casuarina cristata* (belah) and *Geijera parviflora* (dogwood, wilga).

Other eucalypts, which are tolerant of some inundation, include: *E. coolabah* (coolabah/coolibah), *E. largiflorens* (black box) or *E. populnea* (poplar box). However, these species do not dominate and typically occur outside of the core areas for the ecological community in areas that are higher on the floodplain and less frequently flooded.

Partially parasitic species such as the twining *Amyema lucasii* (yellow-flowered mistletoe) and *A. miquelii* (box mistletoe) may also be present on tree or tall shrub species in this community.

A more comprehensive list of tall canopy species that occur, or are likely to occur in the ecological community, are in [Appendix A - Table A1](#).

1.2.2.2.2 Shrub and/or ground and/or open water layer species

The understorey or shrub layer and/or ground layer varies from dense after rain and/or inundation to very sparse during dry periods such as drought. Species composition varies depending mostly on soil, light availability, inundation regime and disturbance.

Common medium shrub species include *Aeschynomene indica* (budda pea), *Eremophila bignoniiflora* (emu bush), *Geijera parviflora* (dogwood) and *Duma florulenta* (lignum). Lignum can form a dominant shrubland in parts of the Macquarie Marshes during a wet phase. The species can also occur as a subcanopy species, often in association with *Acacia stenophylla* (river cooba) or river red gum (DECCW 2010; Roberts & Marston 2011). Low chenopods (saltbushes)

such as *Atriplex leptocarpa* (creeping saltbush), *A. semibaccata* (Australian saltbush), *A. vesicaria* (bladder saltbush), *Enchylaena tomentosa* (barrier saltbush), *Sclerolaena birchii* (blue burr) *S. muricata* (black roly-poly) and *S. tricuspis* (giant red burr) may be representative of the ecological community in a drier state due to prolonged absence of inundation and/or brackish conditions.

Plants with a climbing or prostrate habit may occasionally be present, for example: *Glycine clandestina* (twining glycine), *Capparis lasiantha* (nepine), *Convolvulus angustissimus* (Australian dodder or bindweed) and *Einadia nutans* (climbing saltbush).

Rush species include *Juncus aridicola* (tussock rush) and *J. subsecundus* (finger rush). Sedge species include *Carex appressa* (tall sedge), *Cyperus exaltatus* (sedge), *C. concinnus* (trim flat-sedge), *C. gymnocaulos* (spring flat-sedge), *C. victoriensis* (flat sedge), *Eleocharis pallens* (pale spike-rush) and *E. plana* (flat spike-rush).

A range of forbs occur within the ecological community, including *Alternanthera denticulata* (lesser joyweed), *Boerhavia dominii* (tarvine), *Centipeda cunninghamii* (common sneezeweed), *Goodenia fascicularis* (mallee goodenia), *Haloragis glauca* (grey raspweed), *Lobelia concolor* (poison pratia), *Rumex brownii* (brown dock) and *Swainsona galegifolia* (cranky pea, smooth Darling pea). Forbs that prefer wetter soils include *Persicaria decipiens* (slender knotweed), *P. prostrata* (creeping knotweed), *Lobelia concolor* (poison pratia) and *Ranunculus undosus* (swamp buttercup).

Grass species include *Austrostipa ramosissima* (stout bamboo grass), *A. verticillata* (slender bamboo grass), *Cynodon dactylon* (couch), *Diplachne fusca* (brown beetle grass), *Echinochloa inundata* (channel millet), *Lachnagrostis filiformis* (perehia, Pacific bent grass), *Leptochloa digitata* (umbrella cane grass), *Panicum decompositum* (native millet), *Paspalidium jubiflorum* (Warrego summer grass), *Paspalum distichum* (water couch), *Phragmites australis* (cane grass, common reed), *Pseudoraphis spinescens* (spiny mud grass) and *Rytidosperma caespitosum* (common wallaby grass).

Hydrophytic plants or macrophytes that may be present include *Cyanogeton procerum* (water ribbons), *Lemna disperma* (duckweed), *Myriophyllum* spp. (milfoils), *Nymphoides crenata* (wavy marshwort), *Ottelia ovalifolia* (swamp lily), *Potamogeton crispus* (curly pondweed), *P. tricarinatus* (floating pondweed) and *Vallisneria gigantea* (river ribbons). Tall aquatic perennial herbaceous species include *Bolboschoenus fluviatilis* (marsh club-rush), *Typha domingensis* (cumbungi). Aquatic ferns that may be present in open waters include *Azolla rubra* (red azolla), *Marsilea drummondii* (clover fern, nardoo) and *M. costulifera* (narrow-leaf nardoo).

A more comprehensive list of shrub and/or ground layer species that are likely to occur in the ecological community is in [Appendix A - Species lists](#).

1.2.2.3 FAUNA

The range of vegetation and aquatic, semi-aquatic and terrestrial environments across the Macquarie Marshes provides a wide range of habitats for aquatic and terrestrial fauna. The ecological community provides food, shelter, breeding, nesting and other resources for part or whole of their life cycle. In turn, fauna species play important roles in the ecological community.

Many fauna species that are part of the ecological community may also occur in other types of wetland, or extend into adjoining non-wetland areas. A summary of the main faunal groups follows, and a list of faunal species recorded in the ecological community is at [Appendix A](#).

1.2.2.3.1 Mammals

Dasyurid marsupials include *Sminthopsis crassicaudata* (fat-tailed dunnart), *S. macroura* (stripe-faced Dunnart) and the nocturnal *Planigale tenuirostris* (narrow-nosed planigale) (Moss & Croft 1988) which shelters and hunts in cracking clay soils. Larger mammals include *Macropus fuliginosus* (western grey kangaroo), *M. giganteus* (eastern grey kangaroo), *Osphranter rufus* (red kangaroo) and *Osphranter robustus* (wallaroo). *Wallabia bicolor* (swamp wallaby) may also occur in woodland and forest areas, particularly with a dense ground layer. Hollow-dependent arboreal mammals such as *Petaurus breviceps* (sugar glider), *P. norfolcensis* (squirrel glider), *Pseudocheirus peregrinus* (common ring tail possum) and *Trichosurus vulpecula* (common brushtail possum) have also been recorded in the ecological community.

There are at least 13 bat species present throughout the Macquarie Marshes including the tree hollow roosting microchiroptera (micro-bat) *Australopus australis* (white-striped freetail-bat), *Ozimops planiceps* (south-eastern free-tailed bat), *Nyctophilus geoffroyi* (lesser long-eared), *N. gouldi* (Gould's long-eared bat), *Saccolaimus flaviventris* (yellow-bellied sheath-tail bat), *Scotorepens balstoni* (inland broad-nosed bat) and *Vespadelus vulturnus* (little forest bat). The trees of the ecological community also provide habitat for megabat pollinators such as the nationally vulnerable *Pteropus poliocephalus* (grey-headed flying-fox) (nectarivore and frugivore) and *P. scapulatus* (little red flying-fox) (nectarivore).

The semi-aquatic and terrestrial native mammal *Hydromys chrysogaster* (rakali), is predominantly carnivorous, feeding on a variety of aquatic invertebrates and vertebrates including fish, crustaceans, shellfish, small birds, eggs, mammals, frogs, and reptiles.

A list of mammal species recorded in the ecological community is at [Appendix A, Table A2](#).

1.2.2.3.2 Birds

The Wetlands and inner floodplains of the Macquarie Marshes ecological community includes diverse populations of waterbirds and woodland birds with records of up to 244 species (OEH, 2012a). Species such as nesting waterbirds may use more than just the permanent and temporary wetlands areas; they make use of fringing or riparian woodlands associated with the floodplains of the ecological community for both habitat and nesting sites.

The ecological community is recognised as a refuge for waterbirds during dry times and for supporting some of Australia's largest recorded waterbird breeding aggregations (Kingsford & Auld 2005; DECCW 2010; Kingsford et al. 2017). About 10,000 to 300,000 adult waterbirds rely on the Macquarie Marshes in some seasons for their breeding, feeding and habitat requirements (Kingsford & Thomas 1995; OEH 2012a). At least 42 waterbird species have been recorded breeding in the ecological community (MDBA 2012c). Prominent among these are 16 wetland breeding bird species (Kingsford & Auld (2003) in DECCW 2010) with *Ardea alba modesta* (great egret), *A. intermedia* (intermediate egret), *Egretta garzetta* (little egret), *Nycticorax caledonicus* (rufous/nankeen night heron), *Plegadis falcinellus* (glossy ibis), *Threskiornis moluccus* (Australian white ibis), *T. spinicollis* (straw-necked ibis), *Phalacrocorax melanoleucos* (little pied cormorant) and *P. sulcirostris* (little black cormorant) occurring in the largest numbers (Kingsford & Johnson 1998; Kingsford & Auld 2005). The Macquarie Marshes also has the only NSW breeding record for *Egretta picata* (pied heron) (DECCW 2010).

The Macquarie Marshes provides important habitat for at least 17 species of birds listed as migratory under the EPBC Act. Migratory bird species occurring in the ecological community are also covered under the Convention on the Conservation of Migratory Species of Wild Animals (CMS or Bonn Convention) and/or international bilateral agreements for the protection of

migratory birds and their habitats ([Appendix A](#)). Species include *Apus pacificus* (fork-tailed swift), *Ardea alba modesta* (great egret), *Bubulcus ibis* (cattle egret), *Calidris acuminata* (sharp-tailed sandpiper), *Gallinago hardwickii* (Latham's snipe), *Haliaeetus leucogaster* (white-bellied sea eagle), *Hirundapus caudacutus* (whitethroated needletail), *Hydroprogne caspia* (Caspian tern), *Limosa limosa* (black-tailed godwit), *Merops ornatus* (rainbow bee-eater), *Plegadis falcinellus* (glossy ibis) and *Rostratula australis* (painted snipe).

Habitat and food for a diverse suite of woodland birds is provided by plants in the woodland and forest components of the ecological community, especially river red gums (Di Stefano 2002; Blackwood et al. 2010; Roberts & Marston 2011). Reid (1999) listed 20 woodland bird species whose numbers have declined significantly since the 1980's in the New South Wales Sheep-Wheat Belt, some of which are listed as threatened in NSW. Eighteen of these species are found commonly in the ecological community including *Climacteris picumnus* (brown treecreeper), *Pomatostomus temporalis* (grey-crowned babbler) and *Stagonopleura guttata* (diamond firetail). The ecological community also includes the nationally Endangered *Lophochroa leadbeateri* (pink cockatoo), nationally Endangered *Melanodryas cucullata* (hooded robin), the nationally Vulnerable *Calyptorhynchus lathami lathami* (south-eastern glossy black cockatoo) and nationally Vulnerable *Polytelis swainsonii* (superb parrot), all of which depend on large trees with hollows for breeding.

A list of waterbird and woodland bird species recorded in the ecological community is at [Appendix A, Table A3 and Table A4](#) respectively.

1.2.2.3.3 Reptiles

The Macquarie Marshes are important habitat for highly diverse turtle, dragon, legless lizard, skink, goanna, gecko and snake species due to varied structural layers, habitats and availability of food. Sixty species from these reptile groups have been recorded in, or adjacent to, the ecological community.

Some characteristic reptiles of the ecological community include three turtle species, *Chelodina expansa* (broad-shelled turtle), *C. longicollis* (eastern long-necked turtle) and *Emydura macquarii* (Macquarie River turtle); eight dragons including *Amphibolurus burnsi* (Burns' dragon), *Diporiphora nobbi* (nobbi dragon), *Intellagama lesueurii lesueurii* (eastern water dragon), *Pogona barbata* (bearded dragon) and at least 17 skinks such as *Ctenotus robustus* (robust ctenotus), *Eulamprus quoyii* (eastern water-skink) and *Tiliqua rugosa* (shingleback lizard).

The Macquarie Marshes provides various habitats for at least 16 snake species including *Brachyuophis australis* (coral snake), *Denisonia devisi* (De Vis's banded snake, mud adder), the threatened *Hemiapsis damelii* (grey snake), *Pseudechis porphyriacus* (red-bellied black snake), *Pseudechis australis* (king brown snake), *P. guttatus* (spotted black snake), *Pseudonaja textilis* (eastern brown snake), *Suta spectabilis* (mallee black-headed snake) and *Vermicella annulata* (bandy bandy). These species are top predators that feed on frogs, lizards, small and juvenile birds and other animals and their eggs within the ecological community and also play an important role by transferring nutrients between aquatic and terrestrial environments (Michael et al. 2020).

A list of reptile species recorded in the ecological community is at [Appendix A, Table A2](#).

1.2.2.3.4 Amphibians

The Macquarie Marshes provides important breeding and foraging habitat for up to 18 frog species, many of which are characteristic components of the ecological community (OEH 2012a;

Ocock et al. 2016). Of these, seven are burrowing frogs e.g. *Cyclorana platycephala* (water-holding frog), *Neobatrachus sudellae* (Sudell's burrowing frog) and *Notaden bennettii* (crucifix frog); five are marsh or ground frogs, e.g. *Limnodynastes tasmaniensis* (spotted grass frog), *Limnodynastes fletcheri* (barking marsh frog); and three are tree frogs such as *Litoria caerulea* (green tree frog) (Capon 2018). Frogs are also key indicators of the overall health of the ecological community and associated ecosystems.

Frogs occur in different types of wetland habitat that correspond with the ecological community and depend on both water and land for different life stages, including common reed beds, water couch meadows, flooded woodland and rain-fed ephemeral ponds. Some frogs are known to have specific habitat preferences. For instance, *Crinia parinsignifera* (eastern sign-bearing froglet) prefers wetlands with water couch that have the creeping or trailing stems and good water availability, while *L. fletcheri* (long-thumbed frog) prefers beds of *Eleocharis sphacelata* (tall spike rush) (Healey et al. 1997; OEH 2012a).

The activity of burrowing frogs is triggered by more water in the environment (Ocock et al. 2016; Ocock et al. 2023), whereas others, like *Litoria peronii* (Peron's tree frog) are seasonal and respond to increasing temperatures (Padilla et al. 2019), and marsh frogs use recently inundated wetland areas for breeding (Babbitt & Turner 2000; Anstis 2013; Indermaur et al. 2010; Ocock & Spencer 2016; Ocock et al. 2023).

Frogs form a crucial link in the food chain of the ecological community as both predators of insects and prey for various predators such as fish, birds, mammals and reptiles. For example, frogs are a main food source for a large population of red-bellied black snakes in the Macquarie Marshes, and the snake population declined significantly in the 1990s and 2000s together with frog declines (Johnson 2005 in DECCW 2010). Frog eggs are also an important food source for fish, and tadpoles are an important food source for turtles and waterbirds. Frogs are highly sensitive to environmental changes, especially in their aquatic and terrestrial habitats (Wood et al. 2023; Coleman et al. 2024).

A list of frog species recorded in the ecological community is at [Appendix A, Table A2](#).

1.2.2.3.5 Fish

The Macquarie Marshes provides longitudinal and lateral connectivity for fish populations across river systems (OEH 2013). The ecological community supports about one-third of the native fish species found in the Murray–Darling Basin and is important for breeding. All native fish species in the Macquarie Marshes and lower Wambuul/Macquarie River usually recruit during spring and early summer, where appropriate flows induce spawning, protect eggs and promote larval and juvenile fish survival. Warmer temperatures during this period are important for most species. Appropriate seasonal flows are critical during fish larval rearing stages to prevent larvae and their food from being washed out from nursery habitats (Humphries et al. 2002).

Short to moderate-lived generalist native fish species include: *Hypseleotris* sp. (carp gudgeon), *Melanotaenia fluviatilis* (Murray River rainbowfish), *Nematalosa erebi* (bony herring), *Philypnodon grandiceps* (flathead gudgeon) and *Retropinna semoni* (Australian smelt). Moderate to long-lived flow pulse specialist native fish species include: *Bidyanus bidyanus* (silver perch), *Leiopotherapon unicolor* (spangled perch) and *Macquaria ambigua* (golden perch).

Craterocephalus stercusmuscarum (flyspecked hardyhead) is an omnivore that forms shoals in open pools in the slow to moderate flowing freshwater streams and lakes, often near beds of

aquatic plants. *Tandanus tandanus* (freshwater catfish) is a mostly nocturnal eel-tailed catfish that can grow up to 90 cm. The species builds large nests up to a metre in diameter with small stones and gravel, within which the eggs are laid. One parent, sometimes both, guard the eggs until they hatch. The larvae and juveniles of *Bidyanus bidyanus* (silver perch) use floodplain habitats during floods, with juveniles feeding on small aquatic insects, molluscs, earthworms and green algae, while larvae feed on zooplankton (OEH 2012a).

The Macquarie Marshes provides habitat for the Vulnerable *Maccullochella peelii peelii* (Murray cod), a large long-lived (up to at least 48 years) apex predatory fish that consumes fish, crustaceans, waterbirds such as ducks, freshwater turtles, water dragons, snakes, small mammals and frogs. The Murray cod's complex life history and the different requirements of eggs, larvae, juveniles and adults necessitate integration of the habitats that correspond with the ecological community, as well as good water quantity and quality.

1.2.2.3.6 Invertebrates

The Macquarie Marshes provides important habitat to many terrestrial invertebrates that are part of the ecological community, particularly centipedes, scorpions, slaters, land snails, wolf spiders, crickets and ground dwelling beetles. It also provides permanent and ephemeral habitat for aquatic macroinvertebrates following inundation or where large water bodies or gilgai are present.

Characteristic aquatic-dependent invertebrate groups that are part of the ecological community include: nematodes and other worms; crustaceans (fairy shrimps, clam shrimps, seed shrimps, shield shrimps); molluscs (e.g. Planorbidae); water bugs and beetles; water spiders; flying insects such as butterflies, dragonflies and damselflies; and aquatic insects.

Microinvertebrates feed on algae, bacteria, fungi and protozoans, while macroinvertebrates feed on organic matter, algae and microinvertebrates (Boon & Shiel 1990; Boulton 1999; Bunn & Davies 1999). They indirectly affect nutrient cycles and the movement and interactions of carbon and energy in floodplain wetlands (Baldwin & Mitchell 2000). The abundance of microinvertebrates varies with inundation patterns (OEH 2012a). At least 100 macroinvertebrate taxa have been recorded in the Macquarie Marshes (Jenkins et al. 2007) with the highest diversity and abundance found in floodplain habitats and temporary creeks (OEH 2012a).

Habitats close to the wetland bottom substrate in temporary floodplains and creeks contain a rich array of microinvertebrates available as potential prey to macroinvertebrates and fish (OEH 2012a). These include rotifers and smaller crustaceans such as water fleas, ostracods and copepods.

A more comprehensive list of fauna species that occur, or are likely to occur in the ecological community, including threatened fauna, are in [Appendix A – Species lists](#).

Consultation Questions on the species assemblage

- Do you agree with the vegetation description, including for each of the four main vegetation types associated with the ecological community? Please provide details of how they can be clarified.
- Please indicate if any fauna or flora species are incorrectly recorded and provide details.
- Please provide additional information on common and/or characteristic flora or fauna you would like to see included, particularly commonly encountered or characteristic invertebrates, and any species with important ecological functions in the ecological community. Please suggest further reference information/ sources, particularly those from recent surveys and studies and those covering key interactions between species and with habitat.

1.2.3 Functionally important species of the ecological community

Functionally important flora species in the Macquarie Marshes include river red gum (*Eucalyptus camaldulensis*), lignum (*Duma florulenta*), common reed (*Phragmites australis*) which form large reed beds, and water couch (*Paspalum distichum*), a mat-grass that forms open meadows in areas with regular periods of inundation. This section does not comprehensively cover all functionally important species, rather four of the key habitat-defining flora.

Eucalyptus camaldulensis (river red gum)

Once mature, river red gum potentially reach ages that range from 100-950 years (Jacobs 1955; Ogden 1978; Roberts & Marston 2011). Large hollows form at around 120–180 years of age, creating habitat for many wildlife species, including bats, possums and gliders, carpet pythons and many bird species. Pollination is by bats, birds and insects.

River red gums contribute to the provision and cycling of nutrients and energy for other species, including new foliage, pollen and nectar, and fallen branches and litter, contributing substantial amounts of carbon to terrestrial and aquatic food webs (Baldwin 1999). This is especially important to the ecology in areas of low nutrients.

The tree's preferred habitat of floodplains and watercourses also gives it the role of flood mitigator, which slows silt runoff. River red gum seeds germinate readily after floods and require regular spring floods throughout their life to survive.

River red gums can tolerate immersion in flood waters typically for 3-4 months. Although longer inundation can be tolerated, mortality increases with prolonged flooding and permanent inundation is lethal (Roberts & Marston 2011). They do this by having extensive root systems, some of which contain a spongy, air-filled tissue called aerenchyma that allows for the accumulation and transport of oxygen in waterlogged soils. The extensive root systems of these trees help bind the soil together, preventing erosion along riverbanks and floodplains. This not only protects the trees themselves but also contributes to the overall health of the surrounding ecosystem by reducing erosion and tying together the soil profile.

River red gum is very fire sensitive and even low severity fires may affect growing tissues under bark (cambial injury) (Dexter 1978). Fire kills regenerating seedling/saplings and mature trees are also susceptible if the fire is severe enough since river red gum lacks a lignotuber and therefore has no capacity to resprout. Fire will cause damage to the butt predisposing the tree to fungal and insect attack (Dalton 1990).

Duma florulenta (lignum)

Lignum forms a shrubland in parts of the ecological community but also occurs throughout the Macquarie Marshes as an understorey plant, often in association with *Acacia stenophylla* (river cooba) or river red gum (DECCW 2010). Lignum is a deep rooted (penetrating approximately 3 m in depth), drought-tolerant woody perennial shrub with numerous intertwining branches which occurs in swamps, river-flats, gilgais and other flood-prone areas. The species can reproduce sexually through seedset and asexually through branch layering, rhizomes, and rooting of stem fragments that are broken off and distributed by floodwaters. Reproduction is more opportunistic than seasonal with flowering occurring in response to rainfall and flooding (Jensen et al. 2008; Murray et al. 2019). This process is rapid and the time from anthesis to the production of viable seed can be as little as 14 days (Chong & Walker 2005). Lignum is considered one of the most ecologically significant floodplain shrubs of Australia, influencing understorey vegetation cover and diversity and providing primary habitat for birds, reptiles and mammals, invertebrates and aquatic species (Freestone et al. 2017; Roberts & Marston 2011; Rogers & Ralph 2011). Dense stands of lignum can also protect eucalypt seedlings from grazing animals (Jensen 2011b).

Under favourable conditions, such as flooding, the canopy of an individual lignum can grow up to 3 m in diameter and height and multiple plants may form dense thickets (Sainty & Jacobs 1981). Lignum shrubs also contribute to understorey vegetation diversity by facilitating the establishment of different species than those dominating open habitats (James et al. 2015). The dense canopy structure offers important breeding habitat for many nesting waterbirds keeping them close to food and away from predators. (Maher & Braithwaite 1992; Roberts & Marston 2000; Capon et al. 2009). Notably, lignum has this functional role for *Plegadis falcinellus* (glossy ibis), *Threskiornis spinicollis* (straw-necked ibis), *Threskiornis molucca* (Australian white ibis) and *Stictonetta naevosa* (freckled duck) (Lowe 1983; Jensen 1983; Briggs & Maher 1985; Boulton & Lloyd 1991). Lignum also provides foraging and protection for many other animals such as small woodland birds, e.g. fairy wrens (*Malurus* spp.), mammals and reptiles (Jensen et al. 2008; Cunningham et al. 1981). In wetter periods, the dense submerged roots and foliage also provide shelter and food for aquatic invertebrates, fish such as *Maccullochella peelii peelii* (Murray cod), *Macquaria ambigua* (golden perch) and the juvenile stages of many other fish species (Young 2001; Jensen et al. 2008; Roberts & Marston 2011) and turtles (Francis et al. 2024).

During dry periods, which can extend for multiple-years, lignum can remain viable as underground rootstock (up to 2-3 m deep), retaining its shrub structure and stabilising soils from erosion. Herbs may persist longer in the understorey beneath lignum shrubs during periods of stress such as drought and grazing (James et al. 2015). As lignum is highly responsive to water flows it can quickly produce new stems, leaf growth, flowers and seedset in response to flooding and/or very heavy rainfall (Craig et al. 1991; Capon et al. 2009; Murray et al. 2019). Lignum shrublands require intermediate inundation frequency and duration (Wen et al. 2023).

Phragmites australis (common reed)

Common reed is a robust perennial grass that can persist in conditions of both prolonged inundation and relative drought (Higginson et al. 2022). The species forms a dominant component of wetland vegetation within the ecological community, particularly in the North Marsh (Hogendyk 2007). Common reed provides important ecosystem functions and services for wetlands, which includes important habitat for frogs, fish turtles, waterbirds, passerine birds

and invertebrates (Brandis et al. 2023). It requires frequent (annual to near annual) inundation over several months (Wen et al. 2023).

Common reed maintains and improves water quality and nutrient control (bioremediation filter), regulates water speed, erosion control and flood abatement, regulates carbon and provides substrate stability and biomass accumulation for successional development for other species/sub-communities (Packer et al. 2017; CEWO 2021; Higginson et al. 2022). During dry phases, common reed can reduce above-ground vegetative components such as leaves to reduce transpiration, retaining energy reserves in rhizomes and root systems (Higginson et al. 2022; Wen et al. 2023). Common reed sites that are more frequently flooded have taller reeds with greater biomass compared to sites which are flooded less frequently (Higginson et al. 2022).

Paspalum distichum (water couch)

Water couch provides habitat, notably important feeding areas, for a diversity of fauna within the ecological community. This ranges from invertebrates such as dragonfly larvae and mosquito larvae, herbivorous waterbirds (Hawking & New 2002; Middleton 1992; Middleton 1999), as nocturnal foraging habitat for *Gallinago hardwickii* (Latham's snipe); and some fish species (Roberts & Marston 2011). Its prolific seeding, although typically short-lived (about two years) and low in germination potential (Brock 2011; White et al. 2001) provides major food sources for waterbirds and can sustain extremely large aggregation breeding events.

Water couch provides important functions such as slowing water flow through channels, encouraging overbank flooding and silt deposition, preventing erosion and reducing evaporation in the Marshes through its dense coverage (Hogendyk 2007; Cunningham et al. 1981; Paijmans 1981; Rankine & Hill 1979). During a wet phase, carbon fixed by the growth of submerged and amphibious vegetation such as water couch becomes an important source of bioavailable carbon that supports ecosystem processes during a dry phase (Mason et al. 2022; Baldwin et al. 2013).

Water couch is a creeping perennial semi-aquatic grass that typically favours shallow water and moist soils. It provides dense cover in the understorey of wetland woodlands and can also form extensive mono-specific grassland meadows that are grazed by mammal and bird species. It requires frequent (annual to near annual) inundation over several months (Wen et al. 2023). Water Couch occurs near still or flowing water and tolerates conditions that range from fresh to slightly saline and can persist in a flooded state for up to eight months, providing critical habitat for many aquatic and amphibious species when flooded. It can outcompete other species in deeper water (20 to 60 cm) including the invasive lippia species. Water couch stems can float in water and the species typically spreads laterally by rhizome and stolons, rooting at the nodes in moist soil. Rootstock can persist in heavy clay soils for up to five to seven years and are able to re-establish from dry conditions between seasonally flooding events, preferably in warmer months such as spring-summer-autumn, when many fauna species are breeding.

Table 2: Functionally important flora species within the Macquarie Marshes.

Species name	Functional Role within the ecological community	Ecological Characteristics/Requirements	References
<i>Eucalyptus camaldulensis</i> (river red gum)	<ul style="list-style-type: none"> perennial, single stemmed, large-boled, medium to tall tree up to 45 m provides feeding & shelter habitat for a wide variety of fauna, e.g. mammals, birds, reptiles, insects 	<ul style="list-style-type: none"> relatively long lived - up to 950 years prefers close proximity to permanent fresh water high water users (limited stomatal control if soil deficit; survival dependent on water availability opportunistic) 	White et al. 2000; George et al. 2005; Jensen et al. 2007; Jensen 2008; Newall et al. 2009; Rogers & Ralph 2011

Species name	Functional Role within the ecological community	Ecological Characteristics/Requirements	References
	<ul style="list-style-type: none"> contributes to instream production and habitat structure (e.g. snags, leaf litter, biofilms) contributes to nutrient cycling contributes to soil-water balance on floodplain 	<ul style="list-style-type: none"> resources, e.g. have extensive roots and can depend on groundwater if < 40 dSm-1) flooding 1 in 3 y, < 24 months no flooding or health declines seed production, germination and recruitment promoted by flooding (e.g. summer watering reinforces bud set, flowering & germination during peak seed rain from aerial seed banks) flood duration needed 4–7 months 	(and references therein); Wen et al. 2023
<i>Duma florulenta</i> (lignum)	<ul style="list-style-type: none"> habitat for water birds. shelter & refuge for Murray cod & other large bodied fish shelter & refuge for juvenile fish and turtles when flooded habitat for invertebrates shelter for terrestrial fauna (birds, mammals, reptiles) protects eucalypt seedlings from grazers critical role in soil water (evaporation) balance role in salt-water balance on floodplain (i.e. helps keep saline groundwater levels down) 	<ul style="list-style-type: none"> long-lived, perennial shrub, 1-3 m height & persistent rootstock 2-3 m deep tangled woody stems remain bare until wetted when shoots, leaves & flowers rapidly form prefers higher flood frequency zones than low reliant on flooding to reproduce vegetatively and sexually from seed (i.e. a prerequisite)* seed germination cued by flooding, soil moisture & fluctuating temperature (seeds buoyant for 5-28* days); seeds can ripen & disperse in 12 days; no persistent seed bank flowers in spring (from winter rains) or a few weeks after flooding spring growing season; clone emergence coincides with high moisture soil through autumn & winter* on the floodplain where flooding to < 60 cm depth occurs for 45-115 days per year relatively salt and drought tolerant 	Craig et al. 1991; Capon 2005; Chong & Walker 2005; Jensen et al. 2006; and references therein; Jensen, 2008; Rogers & Ralph 2011; Jensen et al. 2011; Bino et al. 2015; James et al. 2015; Freestone et al. 2017; Wen et al. 2023
<i>Phragmites australis</i> (common reed)	<ul style="list-style-type: none"> Provides wildlife habitat (particularly birds) Maintains and improves water quality (nutrient control) Erosion control and flood abatement Carbon regulation Successional development for other species/sub-communities 	<ul style="list-style-type: none"> Perennial reed that grows from elongated rhizomes or stolons, 1-6 m tall Occurs in low-lying areas with shallow, still water (e.g. the edges of waterbodies, marshes and fens) Intolerant of strong or irregular water movement 	Blanch et al. 1999; Hogendyk 2007; Rogers & Ralph 2011; Roberts & Marston 2011; DECCW 2010; Parker et al. 2017; Brandis et al. 2023; Wen et al. 2023
<i>Paspalum distichum</i> (water couch)	<ul style="list-style-type: none"> Slows water flow through channels Encourages overbank flooding and silt deposition Prevents erosion Reduces evaporation in the Marshes 	<ul style="list-style-type: none"> Summer growing creeping perennial grass to 50cm tall with extensive many-noded, branching, stolons often forming loose mats Prolific seeder Grows in and near freshwater Can extend to form extensive meadows for grazing animals Overgrazing causes water couch to decline 	Rankine & Hill 1979; Cunningham et al. 1981; Pajmans 1981; Hogendyk 2007; Roberts & Marston 2011; Berney et al. 2014; Wen et al. 2023

Consultation Questions on the functionally important flora species.

- How can the information provided on river red gum, lignum, phragmites (common reed) and/or water couch be improved?
- Please provide information on other functionally important flora and fauna that should be highlighted here and include reference information/sources. Examples might include birds, frogs and fish such as silver perch, golden perch or a group of small-bodied fish.

1.2.4 Key ecological processes

Although not comprehensive, some key ecological processes that are critical to the biodiversity, integrity and resilience (viability) of the ecological community are outlined:

1.2.4.1 THE RELATIONSHIP BETWEEN HYDROLOGY AND GEOMORPHOLOGY

The hydrology and geomorphology of the Macquarie Marshes are closely related and together create a dynamic environment (Ralph & Hesse 2010). Greater sediment deposition occurs in the lower reaches of the Wambuul/Macquarie River catchment because of the decline in stream power compared to the steeper upstream reaches of the river. This results in more overbank flows during floods and creates connectivity between the main river channel and substantial floodplains. Over time this has contributed to branches flowing off from the main river channel to create the distinctive multi-channelled system of the ecological community (Rogers & Ralph 2011; Ralph et al. 2016).

Throughout the Macquarie Marshes, there are many fine scale geomorphologic features including small channels, low levees, flood basins, depressions, shallow scour-lines and gilgai. These features affect the distribution of floodwaters across the floodplain, particularly small to moderate magnitude floods, and in turn affect channel and floodplain sedimentation and erosion (Ralph 2008). Floodwaters may reconverge through small channels at the downstream limits of wetlands, or the channels may repeatedly branch and break down into reed beds.

The South Marsh is characterised by distributary channels and marsh channels, extensive unchannelised plains and a few small areas of active reed beds. In contrast, the North Marsh is characterised by larger reed beds that receive water from a few main streams with many interconnected floodplain-surface channels (Ralph 2008).

The ecological community and associated ecosystems can appear very different spatially and temporally, depending on its moisture status, that is, in a dry phase or a wet phase. This is due to rainfall patterns as well as flow and flooding regimes. The ecological community includes the flora, fauna and micro-organisms present in either or both the natural wet and dry phases. During drought or intervening dry phases some plants may not be visible above ground and some fauna will migrate elsewhere. However, aquatic and amphibious species may persist as desiccated shoots, underground rootstocks or propagules (for example, seeds, spores and eggs) in the ground. The ecological community can rapidly revert to its wet form upon significant inundation if the natural hydrological and biological characteristics of the wetland are relatively intact.

1.2.4.2 FLOW

Most of the river flow comes from rainfall in the catchments upstream of Narromine, NSW. The Wambuul/Macquarie River has a long-term average annual flow at Dubbo, upstream of the ecological community, of 1175 GL (1915-2010) (NOW 2011). However, annual flows in the Wambuul/Macquarie River are extremely variable (NSW DWR 1991; MDBA 2012b).

The Wambuul/Macquarie River is a regulated system for much of its length and supports a moderately high level of water use upstream of the ecological community. Water resource development since the construction of the Burrendong Dam in 1967 has increased the average period between important inundation events for the Macquarie Marshes by more than double in 40 years (CSIRO 2008). Median annual flows at Warren, just upstream of the Macquarie Marshes were reduced by about 57% of natural levels over this period to only about 42-45% of natural flow for the Oxley gauge on the Wambuul/Macquarie River (Ren et al. 2010; Ren & Kingsford 2011). This has reduced median extent of flooding by over 40% (Ren et al. 2010). Subsequently less than half of the entire floodplain mapped during the pre-regulation floods of 1955 was flooded in the period 1979-2006 (Steinfeld & Kingsford 2011). High frequency flooded areas contracted, equivalent to losing three or more spring floods from successive nine year periods (1979-1987, 1988-1996, 1997-2006) (Thomas et al. 2011; Bowen 2019). During the dry 2013-2020 period, overbank flows and inundation extent remained low when compared to the long-term median, except for 2016-2017 when widespread flooding increased inundation across the Macquarie Marshes. During the dry period, areas of inundation were concentrated in some areas of the wetland (Mason et al. 2022; Wen et al. 2023; Wentworth Group 2020; CEWH 2024a, b, c).

Natural inflows provided by the Bell and Talbragar Rivers and other tributaries, as well as moderate to large flood events, including spills and flood mitigation zone releases from Burrendong Dam, are critical in sustaining the Macquarie Marshes (OEH 2012b). For example, in September 2016, the Burrendong Dam reached capacity following above average rainfall in the catchment. Flow releases from the dam together with tributary flow in the upper catchment, and local rainfall, resulted in widespread flooding including 154,000 ha (NSW OEH) of the Macquarie Marshes (Brandis 2017). Similar high flows occurred in 2022 inundating 220,000-232,000 ha (DCCEE 2023; Porter et al. 2023). While floods in recent years help with recovery of biological and ecological processes, they are unlikely to reverse the much longer-term decline in ecological function and of many plants and animals within the ecological community that relied on more frequent inundation.

1.2.4.3 GROUNDWATER AND SALINITY

Salinity is another important driver influencing aquatic ecology. The watertable in the Macquarie Marshes rises and falls with floods and droughts (Brereton 1993; OEH 2012a). As the ecological community is in a low-lying part of the landscape, salt has accumulated at depth. Large amounts of salt are bound in saline clays and dissolved in saline groundwater in the Quaternary aquifers and in the underlying regolith beneath the Macquarie Marshes. Over-lying this very large salt store throughout the Marshes is a thin resistive layer, a few metres thick, above which is the fresh pore water store (water between sediment particles) on which the ecology of the ecological community depends for vegetation health (BRS 2009).

Research and monitoring of bores indicate that naturally occurring vertical groundwater leakage is not occurring in the immediate vicinity of the Macquarie Marshes between the deeper Great Artesian Basin and the shallower local water-table (Quaternary Macquarie Marshes sediments) (BRS 2009). However, Palamara et al. (2010) noted that highly saline stores of water occur under the Macquarie Marshes and could present a significant threat to vegetation should groundwater rise or if saline groundwater is extracted and used to supplement surface flows or for irrigation.

Levels of salinity in riverine, floodplain, other wetland, and groundwater environments of the ecological community are largely influenced by flow. The retention of salt in floodplain soils may have been increased through the hydraulic effects of the weirs. If the river level drops suddenly

after an overbank flood, higher levels of salt may be entrained (Walker 2006). Nielson et al. (2008) found that as natural wetlands increase in salinity very few freshwater species will survive to dominate once salinities reach 5 g/L. In the long term such salinized wetlands would need to be recolonised by salt-tolerant taxa for a functional wetland to persist.

A review of salt sensitivity of Australian freshwater biota (including microbes, plants, and a range of invertebrate and vertebrate taxa) found that biological effects are likely to occur in river, stream, and wetland ecosystems if salinity (total soluble salts) is increased to around 1 g/L (Hart et al. 1991). This review also found that:

- freshwater macrophytes are not generally adapted to survive major fluctuations of salinity and water level, and many species of riparian plants are salt sensitive with adverse effects often apparent at salinities above 2 g/L (Hart et al. 1991)

Osmoregulatory mechanisms of most freshwater invertebrates fail when animals are exposed to solutions containing salts in excess of 9 g/L—however most also experience significant deleterious effects on physiology, biochemistry, and behaviour at far lower salt concentrations (Hart et al. 1991; Nielson et al. 2008). Therefore, in general, most freshwater organisms within the ecological community will live at salinities < 1 g/L. Some species will not survive above this level, and there is a further loss of biodiversity at about 2-3 g/L and again at about 9 g/L (Hart et al. 1991). In general, the juvenile stages of both animals and plants are less tolerant of high salinity than the corresponding adults.

1.2.4.4 NUTRIENT CYCLING

Organic matter, nutrients and aquatic biofilms comprised of algae, bacteria and fungi underpin the secondary production of microinvertebrates, macroinvertebrates, and vertebrates such as fish and waterbirds in arid zone floodplain food webs. Organic matter and nutrients build up in floodplain sediments and depositional patches in river and creek channels as leaf litter is deposited and via the senescence and decomposition of terrestrial and aquatic plants and animals.

During dry phases organic material is broken down and retained within the soil. Flooding events inundate these soils releasing nutrients to the water. Despite large floods in recent years, reductions in flooding events in the Macquarie Marshes over time has diminished the reservoir of organic matter and dormant biota in floodplain sediments. For example, research by Jenkins and Wolfenden (2006) showed that soils not flooded since 1990 (14 years) had lost significant amounts of organic matter and micro invertebrate diversity and density compared to those soils flooded in 2000 (four years) and 2003 (one year). Rana et al. (2017) found that the use of carbon compounds by soil microbes tends to be higher in areas where inundation frequency is lower which may lead to a large spike in planktonic respiration, at least for a short period of time. This can lead to anoxic water events following inundation, impacting aquatic species (King et al. 2012; Moran et al. 2014).

Consultation Questions on the key ecological processes

- How can the preceding summaries on key ecological processes be improved using latest data and published studies?
- Please provide any other relevant functional biology and ecology processes or other elements you think are important to highlight in this section. Please explain your reasons and provide supporting evidence and/or references.

2 Identifying areas of the ecological community

Section 1.2 (and Appendix A – Species lists) describes the species assemblage comprising the ecological community and the particular area in nature that it inhabits (as well as some key ecological processes). This section provides additional information to assist with the identification of the ecological community and important areas of it.

2.1 Key diagnostic characteristics

The key diagnostic characteristics are designed to help identify areas of the ecological community. They define the features that distinguish it from other ecological communities. This wetland ecological community is most clearly defined by its area in nature and associated hydrology, with a diversity of mostly aquatic or semi-aquatic species organised around several vegetation sub-communities, as described in section 1.2. Assemblages of species and areas that do not meet the key diagnostics are not part of the nationally listed ecological community; unless they are natural areas that are temporarily absent and/or recovering (e.g. due to drought or fire) within the overall geographic extent. Particular exclusions and inclusions are described further in this section.

The ecological community is defined as the assemblage of native species inhabiting a particular area in nature as described in section 1.2 and referenced information therein, that meets the key diagnostic characteristics:

Location

- The ecological community occurs within the Murray-Darling Basin, and entirely within New South Wales in the Darling Riverine Plains IBRA Bioregion (Interim Biogeographic Regionalisation of Australia version 7 (CoA 2012)).
- It occurs where water breaks out of the main Wambuul/Macquarie River channel and develops as a network of smaller channels, extending from: south-east of Brewarrina and includes occurrences near the Ginghet/Marra Creek confluence and Castlereagh/Macquarie River confluence; west of Merri Merri Creek near Quambone; and north of Warren and includes occurrences upstream of the Marebone Weir near the Junction Creek and Wambuul/Macquarie River confluence. The boundary of the ecological community relates to the area identified by the Murray-Darling Basin Authority as the hydrologic indicator site for the Macquarie Marshes in the Basin Plan process (MDBA 2012) and relates to the boundary specified within the *Directory of Important Wetlands in Australia* (DCCEEW 2019).

Hydrology and habitat/vegetation types

- It corresponds with a number of constituent wetlands that may be identified as discrete but linked eco-hydrological units. One or multiple components can be inundated on a permanent, semi-permanent, seasonal or intermittent basis. These correspond with four broad aquatic or semi-aquatic vegetation types or sub-communities associated with:
 - bodies of open water e.g. lakes, billabongs or lagoons;
 - marshes/swamps;
 - riverine channels, tributaries, distributaries (anastomosing/anabranching); and
 - floodplains.

- The main water sources for the ecological community are rainfall and inflows from the Wambuul/Macquarie River catchment. The Macquarie Marshes form where the Wambuul/Macquarie River breaks into a series of creeks and channels. There may be groundwater interactions within the floodplains.

Soil

- It typically is associated with:
 - low-energy alluvial soils that are typically grey/black clays,
 - cracking clay Gilgai soils,
 - low-energy alluvial soils that are typically grey/black silt and self-mulching clays that are periodically waterlogged.

Biological assemblages

- It contains many species dependent on the prolonged presence of bodies of water and/or flooding at some stage to complete their life cycle. The assemblages of species present may vary with inundation regime and between wet and dry periods.
- Key water-dependent non-woody vegetation (marshland) sub-communities include: semi-permanent wetland vegetation - reed marshes (dominated by *Phragmites australis*); *Paspalum distichum* (water couch) marshes; mixed marshes e.g. with *Typha domingensis* (cumbungi); sedgeland/rushlands characterised by *Bolboschoenus fluviatilis* (marsh club-rush) and genuses such as *Juncus*, *Carex*, *Cyperus* and *Eleocharis*; and other seasonal or intermittent marshland wetlands characterised by *Aeschynomene indica* (budda pea) and *Marsilea drummondii* (clover fern, nardoo).
- Key water-dependent woody vegetation sub-communities associated with lower floodplains, swamps and riparian zones are: river red gum forest and woodland wetlands; *Acacia stenophylla* (river cooba), *A. ligulata* (bakka, cooba) and/or lignum swamp shrubland wetlands. All of these sub-communities have herbaceous ground layers of grasses, forbs and/or low shrubs which vary depending on environmental conditions and some species may not be visible above ground during prolonged drought.
- Floating aquatic vegetation in more permanent waters include *Azolla* spp. (floating ferns) and *Vallisneria australis* (river ribbons).
- Terrestrial vegetation such as dryland grasses and chenopods e.g. *Sclerolaena muricata* (black roly-poly) and *Salsola australis* (buckbush), may encroach into wetland sites and be part of the ecological community at times, particularly during dry periods (refer also to Exclusions).
- There is an abundant and diverse fauna within the ecological community—including diverse terrestrial and wetland assemblages of native birds (notably colonial nesting water birds), fish, reptiles, frogs, mammals, and invertebrates.
- Characteristic and frequently occurring plants of the ecological community are at [Table A1](#) and animals at [Table A2](#) of [Appendix A](#).
- During extended dry periods, such as drought, native species dependent on prolonged presence of water bodies and/or flooding may not be evident, even in core marsh areas.

Under these circumstances, landscape position and/or known site history may be used to inform the presence of the ecological community at a site. Positive indicators include: if the site is likely to be in a position conducive to formation of a natural wetland meeting the description of the area in nature for this ecological community; relevant seedbanks found in the soil; if the site is surrounded by natural or largely unmodified vegetation; and/or if the site has been classified and/or mapped as a relevant type of native vegetation or habitat in the past decade (see Bowen & Simpson 2010).

Exclusions

The ecological community excludes certain types of native vegetation that are less dependent on the regular presence of water and sites that have been substantially modified from their natural state (see also condition thresholds at [section 2.3](#)). In particular:

- Areas that support woodlands and forests dominated by *Acacia pendula* (weeping myall), *Casuarina cristata* (belah) or *Eucalyptus populnea* (poplar box); areas dominated by chenopod shrublands and dryland grasslands (except where they encroach into the ecological community e.g. during dry periods (MDBA 2012b). These typically occur on higher ground or outside the floodplain proper and support many species that do not require as much inundation with water for their life cycle. The Poplar Box Grassy Woodlands on Alluvial Plains is listed nationally as a threatened ecological community.
- Woodlands dominated by coolibah and/or black box. As these occur on the outer (or higher) floodplain they are inundated less frequently than the ecological community. However, there are areas that intergrade and these are not excluded where coolabah and/or black box trees are not dominant. The Coolibah – Black Box Woodlands of the Darling Riverine Plains and Brigalow Belt South Bioregions is listed nationally as a threatened ecological community.
- Human-made water bodies, e.g. dams, are not natural in origin and differ in their hydrological and floristic characteristics, so species within these areas are excluded from the ecological community. Despite this, they may provide some habitat value for waterbirds or other fauna and their maintenance for such is encouraged. The *Directory of Important Wetlands of Australia* (DCCEEW 2019) identifies a range of artificial wetland types that fall outside of the definition of the ecological community including:
 - water storage areas such as reservoirs, barrages, hydro-electric dams, impoundments;
 - artificial ponds, including farm ponds, stock ponds, small tanks;
 - aquaculture ponds: fish ponds, shrimp ponds;
 - salt exploitation areas: salt pans, salinas;
 - excavations: gravel pits, borrows pits, mining pools, tailing dams;
 - wastewater treatment: sewage farms, settling ponds, oxidation basins; and
 - irrigated land (crops or areas dominated continuously by non-native pasture) and irrigation channels: rice fields, canals, ditches.

Other inclusions

Canalised sections of natural streams (that have been straightened, deepened or artificially forced to flow along a particular course) are only included if they retain sufficient natural values to meet the description and condition thresholds for the ecological community. In this case they can still provide for natural connectivity and functionality of the ecological community. Areas

altered by more minor structures, such as bridges, gauging weirs and fords are not explicitly excluded. Although these structures may contribute to degradation, they do not necessarily or always modify a site into a wholly unnatural state. Similarly, natural wetlands that have been enhanced or modified by human intervention and still retain sufficient biodiversity and function are not excluded from the ecological community (if they meet the key diagnostic characteristics and the condition thresholds at [section 2.3](#)).

Areas of the Macquarie Marshes that previously met the key diagnostic characteristics of the species assemblage may be temporarily altered by recent disturbances or extreme events (e.g. drought or fire may damage or remove above-ground cover and stems) and cause a shift to a dormant or regenerative state. Under these circumstances the loss is likely to be a temporary phenomenon if key ecological processes and natural regeneration are not disrupted.

Recovering/regenerating or restored areas are still included in the nationally protected ecological community if they meet key diagnostic characteristics. See also [section 2.2.2](#) Survey requirements for more guidance.

Consultation Questions on the key diagnostic characteristics

- In your opinion, please indicate if these key diagnostic characteristics are sufficient to identify the relevant species and areas in nature that should be included in the nationally protected ecological community – and to exclude any vegetation types (/areas) that should be excluded. If not, please show how the key diagnostic characteristics should be amended to ensure appropriate inclusion / exclusion.

2.2 Additional information to assist in identifying occurrences of the ecological community

Additional information should also be taken into consideration when applying the key diagnostic characteristics to assess if the ecological community is present at a site.

2.2.1 *Identifying an occurrence*

A patch or occurrence is a discrete and mostly continuous area of the ecological community, as defined by the key diagnostic characteristics, but can include small-scale variations, gaps and disturbances within this area. Where a larger area has been mapped or classified as a different plant community, habitat or ecosystem type, e.g., dry forest, other type or woodland (e.g. dominated by *Eucalyptus* trees other than river red gum), dry shrubland or grassland, localised occurrences of the Macquarie Marshes ecological community may be present within this larger area (typically in lower parts of the landscape).

2.2.1.1 REVEGETATION AND REGROWTH

Restored (including revegetated or replanted) sites or areas of regrowth are not excluded from the listed ecological community as long as the patch or occurrence meets the key diagnostic characteristics.

2.2.2 *Survey requirements*

Occurrences of the ecological community can vary markedly in their shape, size, condition, and features, particularly following hydrological changes such as floods or drought. Thorough and representative on-ground surveys are essential to accurately assess the extent and condition of a

patch or occurrence. The NSW Native Vegetation Type Standard (Sivertsen 2009) and the Australian Soil and Land Survey Field Handbook (Isbell 2009) may provide guidance.

Survey protocols are suggested as a guide to determine the presence and condition of the ecological community at a particular site.

- For wetland areas requiring a degree of inundation:
 - Undertake an overall inspection of the wetland and its surrounding landscape.
 - Select areas that are representative of variability in inundation patterns and vegetation type across the wetland area.
 - Sample vegetation within each representative area.

Further general advice on how to sample wetland vegetation and to monitor changes in wetland condition is provided in Brock (1997); Brock & Casanova (2000); Brock et al. (2000).

For woodland or forest sites containing river red gum trees:

- Sampling of areas to determine proportion (dominance) of canopy cover should be based upon an accepted methodology and appropriate plot/transect/quadrat size.

Ideally, surveys should be conducted in more than one season to maximise the chance of detecting all species present. In years of low rainfall and/or flow, assessors should recognise that many species may not be detected. In these situations, it is preferable that surveys are carried out over more than one year and historical survey records and maps utilised.

2.2.3 Mapping and vegetation classifications

Different mapping and vegetation classification schemes are used within NSW. Although none directly map areas of the ecological community according to the key diagnostic characteristics, they can provide useful information on the likely occurrence of the ecological community.

Appendix B - Relationship to other vegetation classification and mapping systems outlines the map units or classifications from several common mapping and classification systems that best relate to the ecological community.

2.2.4 Other relevant listed ecological communities

Other nationally listed ecological communities that may intergrade with this threatened ecological community, include:

- Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions (listed as Endangered in 2011)
- Poplar Box Grassy Woodland on Alluvial Plains (listed as Endangered in 2019).

2.2.4.1 RELATIONSHIPS TO STATE-LISTED ECOLOGICAL COMMUNITIES

The Macquarie Marshes is not currently listed as a threatened ecological community under the NSW *Biodiversity Conservation Act 2016*. However, NSW State-listed threatened ecological communities that occur within or near to the national *ecological community* include:

- Coolibah – Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions. Listed as Endangered under the NSW *Biodiversity Conservation Act 2016* (NSW Scientific Committee 2004, 2009).

- Marsh Club-rush sedgeland in the Darling Riverine Plains Bioregion. Listed as Critically Endangered under the NSW *Biodiversity Conservation Act 2016*;
- The aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River (which includes the Wambuul/Macquarie River below Burrendong Dam) was listed in 2003 under the *NSW Fisheries Management Act 1994* and includes the native fish and aquatic invertebrates within the natural rivers, creeks, lagoons, billabongs, wetlands, lakes, tributaries and anabranches.

Consultation Questions on additional identification information

- Please indicate if the survey/sampling requirements appropriate.
- Are all the relevant intergrading ecological communities that are listed at state or national level correctly mentioned?
- Please explain how we can improve on the information provided to assist with identifying the ecological community, particularly differences to other ecological communities/map/vegetation units (refer also to Appendix B).

2.3 Condition classes, categories and thresholds

Land use, disturbance history and other factors that may cause degradation or loss of its features will influence the current state and condition of individual patches or occurrences of the ecological community. National listing focuses legal protection on occurrences of the ecological community that are the most natural and functional, and in comparatively good condition. These occurrences, or parts of them can be identified through *minimum condition thresholds*.

Condition classes are also sometimes used to distinguish between areas of an ecological community of different qualities, to aid environmental management and recovery decisions. For this ecological community, there are only two classes for areas with native vegetation: (1) those that are in relatively good condition because they meet the minimum condition thresholds, and (2) those that are in poor condition because they do not meet minimum thresholds.

In order to be protected as a matter of national environmental significance, areas of the ecological community must meet both:

- the key diagnostic characteristics ([section 2.1](#)) AND
- at least the minimum condition thresholds (where relevant).

The minimum condition thresholds are designed to identify those areas that retain sufficient conservation value to be considered a matter of national environmental significance, to which the referral, assessment, approval and compliance provisions of national environment law (currently the EPBC Act) apply.

Areas that do not meet the minimum condition thresholds are excluded from protection under national environment law (currently the EPBC Act). In many cases, the loss or degradation is irreversible because natural features have been permanently altered or removed. However, although not protected by national law, many of these areas may retain important natural values and may be protected through state and local laws or planning schemes.

In addition, areas that can be restored should not be excluded from recovery and other management actions (see [section 5](#)) as these actions may improve condition, such that it subsequently can be included as part of the ecological community fully protected under national environment law. Management actions should be designed to restore occurrences to higher condition where practical.

When assessing the condition of an occurrence of the ecological community it is important to first refer to the key diagnostic characteristics ([section 2.1](#)) and the information on defining an occurrence ([section 2.2](#)) to determine the area to assess for condition.

The broadest area that meets the key diagnostic characteristics of the ecological community should be used in determining condition. Where condition is variable and the condition of the total area falls below the minimum thresholds, the largest area or areas within the overall area that meet the minimum condition thresholds should be identified. This may result in multiple protected occurrences of the ecological community being identified within the overall area first considered.

The Macquarie Marshes was originally a broad natural landscape with interconnected wetland components. It likely comprised a single wetland system with several hydrological and

vegetative components. Within this single system, there are now elements that have been lost, degraded and disconnected. The condition thresholds are intended to identify which parts of some of the key native vegetation elements are now in poor condition and less likely to recover and which parts are in relatively good condition, hence part of the ecological community. There are no water quality or other hydrological condition thresholds specified, although the condition thresholds for native vegetation are indicative of some aspects of hydrological condition.

Condition thresholds:

For areas that meet the key diagnostic characteristics (other than areas of open water), a patch of terrestrial vegetation is the nationally listed ecological community if:

- a tree or shrub canopy is present with 50% or more of the crown cover from native species **And/Or** at least 50% of the perennial understorey or ground vegetation cover is comprised of native species (including small or immature trees, shrubs, and herbaceous plants with a life-cycle of more than two growing seasons).

OR

- if a canopy of mature (i.e. with hollows and/or more than 40 cm diameter at breast height) trees is present (typically river red gum) at a density of five or more per hectare (including stags with hollows), then the perennial vegetation understory or ground cover needs to have a minimum of 25% as native species.

Note 1: Crown cover is the percentage plant cover of an area within the vertical projection of the periphery of crowns. In this case, crowns are treated as opaque (Walker & Hopkins 1990).

Consultation Questions on condition classes, categories and thresholds

- Are the condition thresholds appropriate for this ecological community? If not, please suggest and justify alternatives.
- Please indicate if higher condition classes can also be specified for the national ecological community to guide restoration and monitoring. If so, what are the best indicators of higher condition classes, for each form (seasonal / intermittent wetland, shrubland wetland, woodland/forest) of the ecological community? Could fauna measures such as frog or waterbird diversity or abundance/density also be used as indicators of higher condition classes (e.g. for monitoring and restoration purposes)?

2.4 Habitat critical to the survival of the ecological community

For areas other than open water bodies, the habitat or areas most critical to the survival of the ecological community are those patches or occurrences that are in the best condition, thereby at least meeting the minimum condition thresholds specified in [section 2.3](#). These represent those parts of the ecological community with native vegetation that are most likely to retain the highest natural diversity of flora and fauna and most intact structure and ecological function and therefore have the highest chance of persisting in the long-term (viability and resilience). Open water bodies that meet the key diagnostic characteristics of the ecological community are also critical to its survival, particularly those with high cover of aquatic macrophytes. Also critical are any areas containing aggregations of nesting waterbirds or a high abundance and diversity of other characteristic species.

Areas that show evidence of recruitment of key native plant species, or that have a range of age cohorts (including through successful assisted regeneration, or management of sites) are also important.

For natural resource management activities, or actions that may have 'significant impacts' and hence require approval under national environment law, it is also important to consider the entire landscape context, the key ecological processes (particularly flow and other hydrological factors) and the environment surrounding patches of the ecological community. Surrounding vegetation, the health of upstream water and catchments, and other landscape considerations influence the health and survival of the ecological community as a whole.

Additional areas such as adjoining and large nearby areas of native vegetation or wetland habitat and areas that meet the description of the ecological community but not the condition thresholds are also considered important to the survival of the ecological community because they could retain some biodiversity, habitat or functional values. For example, adjacent and nearby ecological communities are likely to play a significant complementary role in the provision of food, refuge and other habitat resources for mobile species and thereby contribute to connectivity, and maintaining biodiversity and key ecological processes. These adjoining and large nearby areas of native vegetation habitat are also critical to the survival of the ecological community when they act as buffer zones to help protect the ecological community from key threats (see [section 5](#) for more advice on buffer zones).

Also, of critical importance to the function and survival of the ecological community is an ongoing connection with the Wambuul/Macquarie River and associated inland rivers and creeks (particularly upstream).

In terms of natural and managed environmental water flows, as outlined in the *Assessment of environmental water requirements for the Macquarie Marshes* (MDBA 2012b), a critical flow regime is one which:

- supports the habitat requirements of waterbirds and is conducive to successful breeding of nesting waterbirds;
- ensures the current extent of native vegetation of the riparian, floodplain and wetland communities is sustained in a healthy, dynamic and resilient condition (including various ages classes from regrowth to mature growth);
- supports recruitment opportunities for a range of native aquatic species (for example, fish, frogs, turtles and invertebrates); and

- supports key ecosystem functions (including those summarised in [section 1.2.4](#)), particularly those related to hydrological connectivity between the river and the floodplain.

No Critical Habitat as defined under section 207A of the EPBC Act has been identified for inclusion in the Register of Critical Habitat at this time. That is because no areas of this ecological community are known to occur on Commonwealth land at this time.

Consultation Questions on habitat critical to the survival

- Is the description of areas critical to survival of the ecological community appropriate for this ecological community? If not, please suggest and justify alternatives.

3 Cultural significance

The Wetlands and inner floodplains of the Macquarie Marshes occurs within Country (the traditional lands) of the Ngiyampaa-Wayilwan peoples (and their associated clans Ngemba and Wangaaypuwan) of central western NSW. The Ngiyampaa-Wayilwan community has traditional trading and other social connections to the west, the Wongaibon (with whom the Wayilwan shared the Ngiyampaa language) and northern groups such as Kamilaroi/Gomeroi, Ngemba and Wiradjuri (Hogendyk 2007; Peckham & Molsher 2005). We acknowledge their spiritual and material heritage and culture and continuing link to the ecological community, the Country it inhabits and the waters that support it.

First Nations peoples value Country and water for a range of cultural, social, and economic reasons. These include heritage, identity, and connection. Recognition, access, management, stewardship, ownership, and other rights to Country and water are components of their ongoing relationship with the ecological community. The ecological community provides a direct link with spiritual and material culture and the Macquarie Marshes hold significant cultural significance for its Traditional Custodians (Flakelar & O’Gorman 2023).

Listing an ecological community as threatened under national environmental law does not change land tenure. Nor does it affect Native Title rights, nor traditional access and use of Country; for example, collecting bushfood and medicine. Current lawful use (including under Native Title) is supported through protection and recovery of the Macquarie Marshes.

The significance of the ecological community, particular species, spiritual and other cultural values are diverse and varied for the First Nations that live in the vicinity and care for Country (DECCW 2010). In some cases, knowledge of this significance may be only held by First Nations groups and individuals who are its custodians and have the rights to decide how it is shared and used.

3.1 First Nations values and uses of the ecological community

The Macquarie Marshes have been recognised as being of high importance to the natural and cultural heritage of Australia. The plants, including canopy species such as river red gum and river cooba, and animals within the ecological community not only provide food and other resources but also have cultural and spiritual qualities for First Nations people and are intrinsically linked through their relationship with the Marshes. Maintaining the health and integrity of the ecological community supports the conservation of a wide range of native flora and fauna including many that have traditional cultural importance for First Nations.

The plants and animals within the ecological community not only provide food and other resources but also have cultural and spiritual qualities for Aboriginal people and are intrinsically linked through their relationship with the Marshes. In addition, water flows within the Marshes not only provide for conservation of aquatic species of ecological significance but are also valued for cultural purposes (NSW DECCW 2010; Berney & Hosking 2016).

At the time of this advice, the Ngiyampaa-Wayilwan continue to have co-management responsibilities for much of the Country where the ecological community is found. For example, in the North Marsh Nature Reserve, the reed beds have particular cultural significance to women. These reed beds have been targeted for cultural and environmental water flow delivery

so as to protect the values, facilitated by the NSW and Commonwealth Governments since 2011/12.

First Nations culture at Macquarie Marshes extends to stories and songs of creation, ritual and ceremonial dances, painting and the use of natural materials including feathers, bone, wood, bark, ochres, pigments, leather, clay, stone and water, to express community events and important issues and to preserve indigenous knowledge (Teresa Crowley 2003; Marshall 2015).

Large numbers of extant First Nation implements, such as seed grinders and hammers, and hearths/heat retaining ovens particularly around watercourses demonstrate how the Macquarie Marshes were a rich resource in an otherwise dry region. These implements also indicate the importance of grasses and seeds that occur throughout the Marshes. Important canopy species such as river red gum, river cooba, as well as cumbungi and nardoo have important cultural values. The wetlands are a refuge for many other species found within the ecological community, such as waterfowl, emu, kangaroo and fish (which explorer Charles Sturt observed being caught with complex fish-traps) as well as bush tucker and medicine plants (Flakelar & O’Gorman 2023).

After the arrival of Europeans (and other) settlers in the 1800s, the Ngiympaa-Wayilwan have remained connected to places within the complex marsh system, such as Bora Creek, the Macquarie Marshes Nature Reserve; Monkey Creek, River Quandong Paddock and Old Oxley Station (NSW DECCW 2010). Therefore, many cultural values continue to exist within the ecological community and conservation management actions should be undertaken in consultation with Traditional Knowledge Holders (Moggridge 2005, 2020).

Consultation Questions on cultural significance

- Can you provide information to support or clarify information, including anything that you don’t agree with, in the draft?
- Are you able to share extra information about the cultural significance of the ecological community or surrounding landscape? If so, please provide information and advice on appropriate use, including what consent has been obtained or should be sought. Please also direct us to other appropriate people and organisations in the area who may have information.

4 Threats

The Macquarie Marshes has been primarily impacted by hydrological changes, land clearance, sedimentation and climate change. Other threats include invasive species, diseases and pathogens, overgrazing and changed fire regimes. Most threats are ongoing and impacts increasing.

4.1 Threat table

Table 1 outlines the key threats facing the ecological community, which represent the *main factors that cause it to be eligible for listing* as required by section 266B (2) (a) (ii) of the EPBC Act. This information supports the assessment against the criteria at section 6. Although presented as a list, in reality these threats often interact, rather than act independently.

Table 1: Summary of threats facing the ecological community

Threat factor	Threat Status*	Threat impacts
Hydrological changes (anthropogenic)	<p><i>Timing:</i> ongoing</p> <p><i>Trend:</i> impacts increasing</p> <p><i>Severity: and consequences:</i> extreme</p> <p><i>Scope/extent:</i> whole</p>	<p><i>Inappropriate flow regime</i></p> <p>The primary threat to the ecological community is changed water flow due to regulation of the Wambuul/Macquarie River, particularly water management structures and increased diversions upstream.</p> <p>The construction of dams, weirs, off-river storages, by-pass channels and levee banks, culverts, erosion control structures and causeways has changed the landscape and affected natural river and floodplain flows for the Macquarie Marshes ecological community (DPI 2002; Steinfeld & Kingsford 2008). Building of structures has changed the frequency, amplitude, and duration of floods and increased the frequency of short-term water level fluctuations, disrupting connections between the river and the floodplain. In addition, water has been diverted for crop and pasture irrigation and to fill farm dams.</p> <p>The effects and impacts of the changed hydrology come about principally because river and wetland biota are adapted to the pre-regulation flow regime. For example, the primary cause of die-back in mature <i>Eucalyptus camaldulensis</i> (river red gum) trees is reduced water availability (Jensen 2015). In a study undertaken by Jensen (2015), reduced flows were shown to impact riparian forests by allowing annual regeneration of reedbeds to occur earlier, creating competition with red gum seedlings when seeds land in watercourses, with only a few seedlings surviving to sapling stage. Reductions in flows have also likely caused reductions in frequency and size of breeding events of waterbirds in the Macquarie Marshes (Kingsford & Johnson 1998; Brandis et al. 2022). Impacts such as this on the ecological community from anthropogenic hydrological changes are exacerbated during natural extremes of drought and flood, let alone under climate change scenarios (see also the climate change threat analysis later).</p> <p>Wetlands that occur in semi-arid regions, such as the Macquarie Marshes, alternate between dry and wet phases of varying frequency, regularity and duration. Ecosystem resilience is dependent on the capacity of the wetland biota of the ecological community to survive prolonged dry phases, grow and reproduce during wet phases and then return to dry phase survival strategies following flood recession (Colloff & Baldwin 2010). As dry periods become more frequent and prolonged under a drying climate trend for the region, wetlands, or at least those parts of wetland complexes where changes in flow regimes are most pronounced, may transition to dryland ecosystems, commencing with declines in cover of flow-dependent vegetation and increased extent of terrestrial species which don't depend on inundation and bare ground (Mason et al. 2022).</p> <p>The Macquarie Marshes and their catchment are highly regulated, with more than 15 small weirs and two large dams built on the Wambuul/Macquarie River and its tributaries. The largest water storage, Burrendong Dam, is located approximately 350 km upstream of the Macquarie Marshes, on the Wambuul/Macquarie River. The northern By-Pass-Channel was constructed around the eastern margin of the marshes, along with many private channels and levees built by farmers (Yu et al. 2015). All these modifications have altered the natural flooding regime in the bioregion (Kingsford & Auld 2005; Ralph et al. 2011; Rayner et al. 2015; Mason et al. 2022; DPIE 2024; Muller & Whiterod 2024).</p>

Hydrological changes (anthropogenic) - continued	<p><i>Timing:</i> ongoing</p> <p><i>Trend:</i> impacts increasing</p> <p><i>Severity: and consequences:</i> extreme</p> <p><i>Scope/extent:</i> whole</p>	<p>At the southern, upstream end of the Macquarie Marshes is an extensive area of irrigated cotton production where irrigation diversions and floodplain water harvesting (diversion and storage of overbank and overland flows in on-farm dams) has reduced inflows to the Wambuil/Macquarie River (Brown et al. 2022; Schweizer et al. 2022).</p> <p>Alterations to the natural flow regime of the Wambuil/Macquarie River have resulted in significant reductions in the frequency and duration of wetland and floodplain inundation across high, medium and low flow events. The site is considered to have been in decline since 1944 when the first alterations to the flow regime for farming in the catchment were undertaken. Extended dry periods such as the Millennium Drought (2000–10) has increased the rate of decline of some long-lived vegetation components of the Macquarie Marshes Ramsar site as large areas of wetland were not flooded for several years (van Dijk et al. 2013; OEH 2015). In addition, short but intense dry periods such as during 2018- 2019, also have bigger impacts when river flows and overbank inundation are reduced, impacting vegetation condition (CEWO 2020). Despite increased flows from floods in recent years, some vegetation components such as mature red gum forests and woodlands could take decades to centuries to recover, and in some areas may be replaced by dense thickets of regrowth that substantially alter community integrity (Bowen et al. 2019; Mason et al. 2022; Schweizer et al. 2022).</p> <p>The installation and operation of instream structures and other mechanisms that alter natural flow regimes of rivers and streams have several ecosystem impacts including (Kingsford 2000; DPI 2002; Rayner et al. 2015; Capon et al. 2018; Coleman et al. 2024; Muller & Whiterod 2024):</p> <ul style="list-style-type: none"> • Extraction of water at all scales, ranging from diversion into irrigation canals to pumping, reduces the total availability of water for riverine ecosystems. • Cold water releases from low level outlets in large dams impair spawning, growth, recruitment, feeding and other life cycle processes in native fish and frog species. • Instream structures present barriers to migration for native fish species. Weir pool environments provide ideal conditions for harmful algal blooms and the proliferation of non-native species such as carp and water hyacinth. • Changes to natural seasonality and variability of flow regimes (duration, extent and rate), as a result of water regulation for flood mitigation and irrigation, impact on native species by disrupting natural environmental cues necessary for reproductive cycles (including migration, spawning, growth and recruitment). • Reduction of habitat due to changes in the area, frequency and duration of inundation of floodplains and terminal wetlands limits distributions and reduces spawning successes. These areas are used by some fish, frogs and invertebrates during flood periods for the purposes of breeding and dispersal. • Generally, altered flow regimes, particularly reduced inundation impact many fauna such as amphibian sub-communities (Wassens & Maher 2011; Eskew et al. 2012; Coleman et al. 2024), water bird sub-communities (Kingsford & Thomas 1995; Kingsford et al. 2017), and flood-dependent vegetation health and distribution (Stromberg et al. 2012). • The natural processes of sediment deposition, erosion and transport are also affected by instream structures. Altered sedimentary
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		<p>processes have been shown to result in the loss of fish habitat including important breeding and feeding sites, causing declines in native fish numbers.</p> <ul style="list-style-type: none"> Alteration to the natural flow regimes by instream structures and other mechanisms can cause changes in physical, chemical and biological conditions that in turn alter the biota. Species composition can change. For example, due to changes in natural flow regimes, algal biofilms have replaced bacterial biofilms in some rivers and as a result some invertebrates may no longer occur. Disruption of ecological processes may continue long after initial flow alteration, causing continued decline in biological diversity. <p><u>Irrigation pumps</u> divert upstream water flow for irrigation through pipelines or channels. Entrapment of native fish and other biota of the ecological community, through irrigation pumps is another environmental impact of irrigation activities, with significant levels of mortality and/or physical injury (Baumgartner et al. 2009; Stocks et al. 2018; Boys et al. 2021a, 2021b).</p> <p><u>Floodplain harvesting</u> in the Northern Murray Darling Basin via the diversion and storage of overbank and overland flows leads to water losses that would otherwise flow directly or indirectly to watercourses or wetlands, impacting river hydrological and ecological processes and biodiversity (Dula et al. 2024):</p> <ul style="list-style-type: none"> The highest concentrations of water storages in NSW floodplain Management Areas include the Macquarie River between Narromine and Warren. Brown et al. (2022) noted there is a direct correlation between on-farm storage development and decreased inflows and catchment water yield. Neal et al. (2002) found that for every 1 ML of farm dam storage capacity there was a decrease in streamflow of 1–1.3 ML. This would result in an annual average reduction in streamflow in the Macintyre, Gwydir, Namoi, Macquarie and Barwon–Darling rivers of between 1393 – 1811 GL. Brown et al (2022) estimated that 40 GL is harvested from the Wambuil/Macquarie River floodplain management area. The Basin Plan allows for a long-term average take of 46.3 GL/yr from floodplain harvesting in the northern NSW catchments (which includes the Macquarie River) (MDBA 2020b). In most catchments, floodplain harvesting exceeds the legal limits of diversions (DPIE 2021a; Brown et al. 2022) and impacts river flows. Irrigation diversions in the northern Basin were considered a major contributing factor in fish impacts and lead to ‘catastrophic decline of condition through dry periods’ (Brown et al. 2022). <p><u>Degraded water quality</u></p> <p>The ecological community has been impacted by water quality degradation in the Wambuil/Macquarie River because of contamination by nutrients and pesticide residues, increased salinity, turbidity, and sedimentation.</p> <p>The historically relatively deep wetland areas of the Macquarie Marshes became shallower from the 1940s onwards due to land use change and increased sedimentation (Ralph et al. 2016; Yu et al. 2015). Degraded riparian zones also increase bank erosion, turbidity and sedimentation, which fills pools and smothers habitat.</p> <p>High turbidity, nitrogen and phosphorus levels have led to blue-green algal blooms in water storages within the Macquarie catchment and the Wambuil/Macquarie River. There was an intense 300 km algal bloom in</p>
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Threat factor	Threat Status*	Threat impacts
		the Wambuul/Macquarie River downstream of Burrendong Dam in the summer and autumn of 1997/98. Some blue-green algae produce toxins that are poisonous to fauna and can contribute to fish deaths in certain circumstances, as algal blooms use oxygen in water particularly in the night.

<p>Climate change (increasing temperatures, declining rainfall, rainfall timing)</p>	<p><i>Timing:</i> ongoing</p> <p><i>Trend:</i> impacts increasing</p> <p><i>Severity and consequences:</i> extreme</p> <p><i>Scope/extent:</i> whole</p>	<p>There is an ongoing, long-term trend of warming and drying over the region of the ecological community, with increased potential for significant disturbance from extreme events, including wildfire (Rawson 2016; MBDA 2019; Van Oldenborgh et al. 2021; Prosser et al. 2021). This is likely to increasingly case:</p> <p><i>Biodiversity decline or loss</i></p> <ul style="list-style-type: none"> the freshwater biodiversity at the Macquarie Marshes is highly vulnerable due to 'typical' ectothermic physiology and limited habitat; particularly for species occurring close to physiological tolerance limits detrimental impacts on physiology and ecology of biodiversity and related genetic stock phenological impacts – e.g. timing of migrations or breeding or flowering, and desynchronisation of interactions between species, e.g. predator-prey mismatch potential recruitment failure of many plant and animal species in the ecological community, and loss of seed or egg 'banks' e.g. reductions in flows are predicted to cause reductions in frequency and size of breeding events of waterbirds in the Macquarie Marshes (Kingsford & Johnson 1998) may result in 'range' shifts or contractions for some species (i.e. depending on their ability to disperse and re-establish) – and concomitant shifts in genetic composition/expansion of some vegetation types at the expense of others in combination with other threats, may result in 'tipping points' leading to irreversible change for some species or ecosystems <p><i>Impaired ecosystem function</i></p> <ul style="list-style-type: none"> potential impacts to ecosystem function (e.g. disruption of food-web relationships and energy transfer between taxa and habitats) simplification of food-web structure and impaired energetic transfer efficiency (for example, increasing atmospheric CO₂) is projected to alter molar Carbon-Nitrogen-Phosphorus ratios of detrital inputs. <p><i>Promotion of invasive species</i></p> <ul style="list-style-type: none"> invasion of weeds and pest animal species encouraged by changes in climate and/or associated conditions; i.e. promote conditions for invasive species to spread in new areas and prosper (see separate threat analysis for invasive species) increased risk of disease and parasitism leading to biodiversity loss. <p><i>Inability to adapt</i></p> <ul style="list-style-type: none"> adaptation to climate change relies on reducing vulnerability (and therefore other threats) and building resilience; the former may not be practical, the latter may not be possible may depend on availability and accessibility of refuge sites. <p><i>Rising temperature</i></p> <ul style="list-style-type: none"> temperature impacts metabolic rates (also size dependent) which can constrain food-web structure and dynamics temperature impacts many ecosystem processes and key aspects of foraging and breeding behaviour of fauna increased evaporation of water promotes deoxygenation events and potential mass fish deaths and other aquatic species declines (particularly during drought) detrimental impacts on ecological 'triggers' for reproduction or migration, particularly if in combination with unfavourable salinity or oxygen levels heatwaves and heat stress impact native plants and animals and can lead to mortality lower soil moisture which can impact runoff
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Threat factor	Threat Status*	Threat impacts
		<ul style="list-style-type: none"> altered photosynthesis of submerged plants e.g. due to shading from increased algal growth reduced groundwater recharge. <p>Changes to Rainfall and Runoff</p> <ul style="list-style-type: none"> combination of longer dry spells and increases in extreme precipitation magnitude leading to important changes in the character of the precipitation time series along with changes in seasonal patterns of rainfall—resulting in mismatch of hydrological and ecological cycles, which in turn impacts biodiversity changes to ecological ‘triggers’ for reproduction or migration (e.g. via flow or water-column stratification) prolonged drought may induce a post-drought low-runoff state due to increased evapotranspiration per unity of precipitation changed opportunities for dispersal and re-establishment of native species e.g. aquatic species such as fish and frogs. <p>Extreme Events</p> <p>Extreme events (as opposed to trends) related to flow and temperature reduce species richness, impact productivity, and may induce regime shifts in wetland ecosystems</p> <ul style="list-style-type: none"> increased frequency and/or intensity of drought periods resulting in degraded and reduced habitat, and declines and/or mortality in biodiversity increased frequency and intensity of storms. Lightning strikes are a significant ignition source for wildfires increased risk of algal blooms and/or blackwater events leading to deoxygenated waters.
Clearing for rural, development	<p><i>Timing:</i> past / ongoing</p> <p><i>Trend:</i> impacts stable</p> <p><i>Severity and consequences:</i> major</p> <p><i>Scope/extent:</i> minority</p>	<p>Cropping intensity increased notably in the bioregion from 1967, coincident with deployment of heavy farm machinery and development of river regulation infrastructure, which made more water available for irrigation. Outside of the National Reserve System (which contains an estimated 28% of the area of the ecological community), grazing lands in the area of the ecological community could be progressively converted to croplands, such as cotton. Even small-scale losses from clearing and other conversion (e.g. tree thinning) can have large cumulative negative impacts, particularly in combination with other actions and threats. The impacts can be summarised as:</p> <ul style="list-style-type: none"> clearing of riparian vegetation and continued stock access to the riparian zone increases erosion and siltation, and removes critical habitat, including reproductive sites for species in this aquatic ecological community clearing of the floodplain vegetation for agriculture or other purposes also increases sedimentation and reduces carbon inputs to the river, which are important food sources for instream invertebrates clearing and thinning of trees results in decreased recruitment of canopy species. In some areas of the distribution, river red gums are threatened by the lack of regeneration due to these activities, exacerbated when combined with threats caused by hydrological changes vegetation clearing reduces the area of wetland habitat and the filtering effect of riparian and wetland vegetation. Changes to vegetation contribute to raised groundwater levels and increased salinity

Threat factor	Threat Status*	Threat impacts
Overgrazing and trampling by herbivores	<p><i>Timing:</i> ongoing</p> <p><i>Trend:</i> impacts stable</p> <p><i>Severity and consequences:</i> major</p> <p><i>Scope/extent:</i> mostly floodplain</p>	<p>Moderate to heavy, or frequent, grazing by domestic stock along with the activities of feral pests and native herbivores can change the structure, composition and ecological function of the ecological community. The impacts can include:</p> <ul style="list-style-type: none"> grazing by livestock (and pest species) results in loss of riparian vegetation and suppression of regrowth (meaning loss of species diversity and resilience and community structure) increased erosion and collapse of waterway banks via trampling and loss of riparian vegetation increased nutrient loads on floodplain and in water (via waste) increased annual-plant dominance (loss of native perennials) weed invasion and spread (causing impacts as described in the Invasive plants (weeds) section) compromised role of riparian vegetation such as, nutrient and sediment filtering, structural support for riverbanks, and habitat for native biodiversity increased bare ground (with no vegetation or litter) can detrimentally impact waterways decline in water quality native flora species adapted to low nitrogen and phosphorous soils can decline due to direct pasture improvement (which can also further advantage exotic plant species and annuals as mentioned)
Invasive plants (weeds)	<p><i>Timing:</i> ongoing</p> <p><i>Trend:</i> increasing</p> <p><i>Severity and consequences:</i> major</p> <p><i>Scope/extent:</i> majority</p>	<p>Exotic plants often invade and degrade the ecological community. This is particularly the case in disturbed patches such as areas where nutrient levels are increased from runoff from tracks and agricultural land and areas post-fire where competition is reduced. Invasive plant species occurring in the ecological community include but are not limited to:</p> <ul style="list-style-type: none"> <i>Cirsium vulgare</i> (spear thistle) <i>Cuscuta campestris</i> (dodder) <i>Cynodon incompletus</i> (blue couch) <i>Echium plantagineum</i> (Paterson's curse) <i>Eragrostis cilianensis</i> (stinkgrass) <i>Hypochoeris</i> spp. (flatweeds) <i>Lycium ferocissimum</i> (African boxthorn) <i>Lythrum hyssopifolia</i> (hyssop loosestrife) <i>Phyla canescens</i> (lippia) <i>Polygonum aviculare</i> (knotweed) <i>Xanthium occidentale</i> (clotbur) <i>X. spinosum</i> (spiny clotburr). <p>Weeds alter nutrient cycling, vegetation structure, habitat values, other flora and fauna composition, soil chemistry, mycorrhizae, hydrological and fire regimes.</p>

Threat factor	Threat Status*	Threat impacts
Invasive animals	<p><i>Timing:</i> ongoing</p> <p><i>Trend:</i> increasing</p> <p><i>Severity and consequences:</i> major</p> <p><i>Scope/extent:</i> majority</p>	<p>Invasive animals and their impacts (DSEWPac 2011) include:</p> <p><i>Mammals</i></p> <ul style="list-style-type: none"> • <i>Sus scrofa</i> (feral pig) - Common on the lower floodplain and among the reed beds. Wallowing, digging (up to 1 m in depth) and rooting by feral pigs can destroy vegetation and fauna habitat, cause erosion and encourage weed invasion. Although mainly herbivorous, they also prey on invertebrates and vertebrates such as the eggs and young of ground-nesting birds, small mammals, turtles, other reptiles and amphibians. • <i>Felis catus</i> (feral cat), <i>Rattus rattus</i> (black rat) and <i>Vulpes vulpes</i> (red fox) – These species prey on native fauna particularly ground dwelling reptiles, mammals and ground feeding and nesting birds. Foxes and cats have contributed to the absence of many small mammals, as well as loss of reptiles and frogs. Foxes can also spread weed species through seed distribution or soil disturbance. <p>Grazing and trampling pressures from <i>Lepus capensis</i> (brown hare), <i>Oryctolagus cuniculus</i> (rabbits) and feral <i>Capra hircus</i> (goats) can also add to bank erosion, loss of plants (including red gum seedlings) and exacerbate weeds.</p> <p><i>Fish</i></p> <ul style="list-style-type: none"> • <i>Cyprinus carpio</i> (European carp) – there has been a major and irreversible invasion since the 1970s; leading to increased turbidity due to their bottom feeding behaviour, loss of macrophytes, and they often outcompete native species, particularly during early life-history stages, and can prey on native juveniles (Capon et al. 2018; Cruz et al. 2020; NSW DPE 2020; Stocks et al. 2021). <ul style="list-style-type: none"> ○ carp may displace native fish and make aquatic habitat less suitable for native fish breeding and survival ○ carp uproot aquatic plants • <i>Gambusia holbrooki</i> (eastern gambusia) – consumes zooplankton, invertebrates, the larvae of many fish and amphibian species, and plant-associated animals. • <i>Perca fluviatilis</i> (redfin) - voracious predators of other fish and invertebrates, can destroy recreational fisheries in enclosed waters by building up large numbers of stunted fish and eliminating other species. They consume a wide variety of fish and invertebrates, including small native species and the eggs and fry of larger fish such as silver perch, golden perch and Murray cod. Redfin spawn several months earlier than native fishes (late winter to early spring), with large schools of redfin fingerlings preying on hatching native fish larvae severely limiting recruitment success (EPI 2023b).

Threat factor	Threat Status*	Threat impacts
Diseases and pathogens	<p><i>Timing:</i> future</p> <p><i>Trend:</i> unknown</p> <p><i>Severity and consequences:</i> unknown</p> <p><i>Scope/extent:</i> unknown</p>	<p>Epizootic Haematopoietic Necrosis Virus (EHNV) is an alien virus affecting Australian native fish in the wild. The introduced <i>Perca fluviatilis</i> (redfin) has been recognized as a carrier, and possibly <i>Oncorhynchus mykiss</i> (rainbow trout), of EHNV (Kaminskas 2020).</p> <p>EHNV enters fish through the body surface or gastrointestinal tract, multiplies in the blood forming organs such as the spleen and kidney and destroys them in the process. The liver is also affected by the virus.</p> <ul style="list-style-type: none"> Native species within the Macquarie Marshes that have shown susceptibility to EHNV infection include <i>Bidyanus bidyanus</i> (silver perch), <i>Macquaria australasica</i> (Macquarie perch), <i>Melanotaenia fluviatilis</i> (Murray-Darling rainbowfish) and <i>Tandanus tandanus</i> (freshwater catfish) (EPI 2023a). <p>The amphibian disease chytridiomycosis (chytrid), caused by the pathogen <i>Batrachochytrium dendrobatidis</i> has caused dramatic population declines and extinctions. Infection prevalence and mortality rates are typically correlated with cool temperatures and high elevations. Although the ecological community occurs in a low elevation, semi-arid region, Ocock et al (2013) found that seven of the frog species in the Macquarie Marshes have been infected by the pathogen.</p> <p>Waterbird populations and other fauna may be impacted by new strains of Avian Influenza that are not currently present in Australian wildlife but have been spreading worldwide and causing major population declines for some species. The ecological community may be highly susceptible to impacts because of the high densities of waterbird breeding colonies and various birds that migrate into the ecological community each year from overseas.</p>

Threat factor	Threat Status*	Threat impacts
Fire regimes that cause declines in biodiversity	<p><i>Timing:</i> ongoing</p> <p><i>Trend:</i> increasing</p> <p><i>Severity and consequences:</i> unknown</p> <p><i>Scope/extent:</i> majority</p>	<ul style="list-style-type: none"> There are several mechanisms by which the fire regime can threaten this ecological community (DAWE 2022). These include the frequency of fire (high vs low), the season of fire, and the interactions between fire and climate change and other threats (weeds, invasive animal impacts, etc.). 18 major fire events have occurred in the Macquarie Marshes since 1947 (largest fires 1947, 1966, 1994, 1995). In 2019, fire burnt 86% (3000 ha) of reedbeds in the Northern Nature Reserve (DEH 2020; Fire in Wetlands forum 2021). Other fire events that have impacted reed beds and/or river red gum have occurred in 2013-14, 2014-15 and 2015-16 (DEH 2020). Intense fires in reedbeds can damage rhizomes and impact ability to regenerate. Increased frequency or inappropriate timing of fire can reduce genetic diversity and recovery. High intensity fire events can damage river red gum and river cooba, particularly regenerating areas and trees with hollows such as stags. Even with lower intensity fire, intervals of less than 10 years is considered detrimental for red gum and river cooba (DEH 2020). Interval squeeze (Enright et al. 2015), driven by both increasing fire frequency and slower developmental rates, is likely threatening the persistence of some species and their community interactions. Fires also have effects on biotic interactions, such as herbivore-plant interactions (e.g. altering resource availability), predator-prey interactions (e.g. facilitating easier access for feral predators to native fauna) and abiotic interactions, such as combined drought and fire, which may have compounding effects on rates of plant mortality and regenerative capacity (DAWE 2022). Fire impacts are expected to increase in the Macquarie Marshes under climate change as temperatures rise, rainfall variability increases, droughts become more severe and ecosystem dynamics alter — resulting in changed biomass fuel loads and types (Andrade et al. 2019; Nolan et al. 2020, Canadell et al. 2021). Climate-change related changes to fire regimes are likely to increase pressures on biodiversity through expansion of the fire season (e.g. potential for fires earlier and later than normal), changes to the dominant fire type (e.g. a shift from low severity understorey fires toward higher severity fires) and changes to the spatial patterns of fire in the landscape (DAWE 2022; Cunningham et al. 2023). The projected hotter, drier, windier conditions associated with climate change would also extend the period of fuel drying and increase rates of fire spread (Harrison & Kelley 2017).

Threat factor	Threat Status*	Threat impacts
Acid Sulphate Soils (ASS) and Salinity	<p><i>Timing:</i> future</p> <p><i>Trend:</i> stable</p> <p><i>Severity and consequences:</i> unknown</p> <p><i>Scope/extent:</i> unknown</p>	<ul style="list-style-type: none"> • Acid sulphate soils (ASS) when they are exposed to air by changes to hydrology/hydrogeology, can form sulphuric acid, which can lead to ASS induced vegetation changes, including death (Bush et al. 2009; MDBA 2011) • The lower Wambuul/Macquarie River, including areas of the ecological community support potential or actual ASS, which if exposed to air through drainage or disturbance present a threat to the ecological community (Bush et al. 2009). • To date, the observed impacts of salinity to the ecological community is relatively low. • Dryland salinity within the upper Wambuul/Macquarie River catchment affects 3850 ha of land in five main locations (EPA 1995). In the Salinity Audit of the MDB Ministerial Council (MDBMC 1999), river salinities are predicted to rise. • Wetlands with reduced flushing flows, such as the Macquarie Marshes, have increased salt concentrations in the sediment and this can influence in the abundance and diversity of biota such as aquatic plants and benthic animals and on germination rates under certain moisture conditions (Brock et al. 2005; DPIE 2020c). Salt increase may also affect the long-term viability of dormant eggs of macroinvertebrates and seed of aquatic plants. • Salt concentrations typically alter due to seasonal flow and water demand. The highest concentrations were experienced during the period May through to August when flows are low but decrease during summer when base flows are higher coinciding with irrigation demand (Brock et al. 2005). • EPA (2001) noted that high salt concentrations occur during the winter months when irrigation demand is low. This is attributed to the base flows in the river being composed primarily of ground water inputs and tributary flows at this time. Instream biota would have naturally adapted to higher salinities during the summer months and low salinities during the winter months. As the reverse is now occurring this may have implications for the macroinvertebrate populations. Many species reside in the river over the autumn, winter and spring period to emerge during summer. These species are often salt sensitive and may not be able to tolerate elevated salinities during the winter month.
Clearing for mining	<p><i>Timing:</i> future</p> <p><i>Trend:</i> stable</p> <p><i>Severity and consequences:</i> unknown</p> <p><i>Scope/extent:</i> unknown</p>	<p>Mineral exploration and extraction leases exist over some areas containing this ecological community. Even though there have not been any known impacts from mining on Macquarie Marshes to date, there has been recent approval for exploration drilling as demand for minerals such as gold and copper is high. Potential impacts include direct clearing of areas to be mined or for access tracks and other infrastructure, the introduction and spread of weeds, and most importantly for the Macquarie Marshes ecological community, pollution and temporary or long-term changes to surface and groundwater hydrology. In addition, restoration following mining impacts has a high chance of failure in an environment such as the Macquarie Marshes.</p>

***Timing** – the threat occurs in the **past** (and unlikely to return, although impacts may continue), is **ongoing** (present/continuing), is likely to occur/return in the **future**, or timing is **unknown**

Trend – the severity of the threat and its consequences are likely to be **decreasing, increasing, stable/static** or **unknown**.

Severity and consequences – the threat causes or has the potential to cause impacts that are **extreme** (leading to loss or transformation of affected patches/occurrences), **major** (leading to degradation of affected patches/occurrences), **minor** (impacting some components of affected patches/occurrences), **negligible** or **unknown**

Scope/extent – the threat is affecting the **whole** (estimated >90%), a **majority** (estimated >50%), a **minority** (estimated <50%), a **negligible** amount, or **unknown** amount of the ecological community

4.1.1 Key threatening processes

National environment law (currently the EPBC Act) provides for the identification and listing of key threatening processes. A process is defined as a key threatening process if it threatens or may threaten the survival, abundance or evolutionary development of a native species or ecological community.

There are EPBC-listed key threatening processes, current at the date of writing, that may be relevant to the ecological community or specific plants and animals that comprise it:

- Competition and land degradation by rabbits
- Competition and land degradation by unmanaged goats
- Fire regimes that cause declines in biodiversity
- Infection of amphibians with chytrid fungus resulting in chytridiomycosis
- Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases
- Novel biota and their impact on biodiversity
- Predation by European red fox
- Predation by feral cats
- Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs
- Land clearance

Any approved threat abatement plans or advice associated with these items provides information to help landowners manage these threats and reduce their impacts to biodiversity. These can be found at <http://www.environment.gov.au/cgi-bin/sprat/public/publicgetkeythreats.pl>.

Consultation Questions on threats

- Is the order of the threats in the Threats table (**Table 3**) correct (i.e. are they in order of current importance, starting with the greatest current threat)? If not, please indicate the correct order (e.g. by numbering the Threat factors). Have any threats or impacts been missed? If so, what are they?
- Are any of the listed threats more, or less, severe, or of different timing or scope than currently proposed for this ecological community?
- Please supply us with additional details of/ information about threats & impacts to the ecological community which you are aware of; and references (and further sources).

5 Conservation of the ecological community

5.1 Primary conservation objective

To halt the loss of the Macquarie Marshes ecological community, and hence prevent its probable extinction (and/or collapse of its associated ecosystem) in the immediate to near future, and to recover the abundance, diversity, integrity and resilience (or viability) of:

- a) its component species, particularly functionally significant species and,
- b) natural processes that maintain its natural biodiversity and ecosystem function.

This objective will be achieved by:

- protecting the Macquarie Marshes from unacceptable and significant impacts as a matter of national environmental significance under national environmental law (currently the EPBC Act).
- implementing priority conservation management and recovery consistent with the recommended actions and other guidance in this Conservation Advice.

Existing protection and key management plans are set out at [section 5.2](#); principles and standards for conservation are set out at [section 5.3](#); and priority conservation and recovery actions are set out at [section 5.4](#). Not all actions that may benefit the protection and recovery of the Macquarie Marshes ecological community are encompassed. The aim is to provide overall guidance for threat prevention, management and recovery, rather than being site-specific.

5.2 Existing protection and management plans

5.2.1 Existing protections

At the time of this advice, approximately 27,400 ha of the Macquarie Marshes ecological community are within conservation tenure (CAPAD 2020). This comprises two separate sections of wetland: Pillicawarrina Purchase Area which abuts the southern end of the North Marsh Reserve and Gingham Nature Reserve to the northwest of the North Marsh. Many of the threats impact or have the potential to impact, the ecological community in this tenure.

Approximately 19,300 ha of the Macquarie Marshes Wetland of International Importance (Ramsar) site occurs within the ecological community. The Ramsar site includes the South Marsh, Ninia in the east and part of the North Marsh component of the Macquarie Marshes. The Ramsar site also includes two areas on private property, Wilgara Wetlands and U block (DSEWPac 2011).

There are no comparable ecological communities protected under State legislation. However, part of the ecological community overlaps with “The aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River” (which includes the Wambuul/Macquarie River below Burrendong Dam) listed in 2003 under the *NSW Fisheries Management Act 1994*.

5.2.2 Existing management plans

Since 2012, a particularly important national plan relevant to the Macquarie Marshes ecological community is the Basin Plan. Under the national *Water Act 2007*, the Basin Plan aims to return more environmental water to the Murray-Darling Basin. The Plan is being implemented by the

Murray-Darling Basin Authority, in collaboration with the five partner jurisdictions, QLD, NSW, ACT, VIC and SA. The latest version of the Basin Plan (2023) is available at: [Federal Register of Legislation - Basin Plan 2012](#).

Under the Basin Plan, there are legislative responsibilities for monitoring, evaluation, and reporting against a range of objectives and outcomes. The most pertinent of these to the ecological community are in Chapter 5 of the Basin Plan; and they relate to protecting and restoring water-dependent ecosystems, their functioning and their resilience to climate change.

Other key plans at the time this advice are provided in the list of management plans (please refer to the relevant agency's website for any updated versions). This list is not comprehensive, rather it is intended to help identify where some other key information relevant to the management of the ecological community and broader landscape may be found.

Commonwealth Environmental Water Office (2020) Commonwealth Environmental Water Office Water Management Plan 2020-21, Commonwealth of Australia, 2020. Available at: [Water Management Plan 2020-21: Chapter 3.6 - Macquarie River \(dcceew.gov.au\)](#)

DECCW (Department of Environment, Climate Change and Water) (2010) *Macquarie Marshes Adaptive Environmental Management Plan*. NSW Department of Environment, Climate Change and Water. Sydney.

DPE (Department of Planning and Environment) (2023) Regional Water Strategy Macquarie-Castlereagh.

DPI (Department of Primary Industry) (2005) Guidelines for grazing in the Gwydir Wetlands and Macquarie Marshes (Section three). Available at: http://www.dpi.nsw.gov.au/_data/assets/pdf_file/0011/299108/Guidelines-for-grazing-in-the-gwydir-wetlands-and-macquarie-marshes-section-3.pdf

DPIE (Department of Planning, Industry and Environment) (2020a) Macquarie-Castlereagh Long-Term Water Plan Part A: Macquarie-Castlereagh catchment. NSW. Available at: [Macquarie-Castlereagh Long-Term Water Plan Part A: Macquarie-Castlereagh catchment | NSW Environment and Heritage](#)

DPIE (2020b) Macquarie-Castlereagh Long-Term Water Plan Part B: Macquarie-Castlereagh planning units. NSW. Available at: [Macquarie-Castlereagh Long-Term Water Plan Part B: Macquarie-Castlereagh planning units | NSW Environment and Heritage](#)

Department of Water and Energy (2009) *Water sharing in the Macquarie and Cudgegong Regulated Rivers Progress report 2004 to 2008*. NSW Department of Water and Energy. Sydney.

DSEWPac (Department of Sustainability, Environment, Water, Population and Communities) (2011) *Information Sheet on Ramsar Wetlands (RIS) – 2009-2012 version*. Available at: <https://www.environment.gov.au/water/topics/wetlands/database/pubs/28-ris.pdf>

DCCEEW (Department of Climate Change, Energy, the Environment and Water) (2019) Directory of Important Wetlands in Australia – Macquarie Marshes. Available at: <http://www.environment.gov.au/cgi-bin/wetlands/report.pl>

Local Land Services (2021) Central West Local strategic plan 2021-2026. Available at: [Central West Local Strategic Plan 2021-2026 \(nsw.gov.au\)](#)

MDBA (Murray-Darling Basin Authority) (2012a) *Water Act 2007 – Basin Plan 2012*. Available at: www.comlaw.gov.au/.../F2012L02240/3f0f4bcc-7985-4bd4-b5d1-79c6cc9fe145) and its related docs (<http://www.mdba.gov.au/basin-plan>)

MDBA (Murray-Darling Basin Authority) (2012b) *Assessment of environmental water requirements for the proposed Basin Plan: Macquarie Marshes*. Murray–Darling Basin Authority. Canberra.

NOW (Office of Water) (2018) *NSW Floodplain Harvesting Policy: Draft for community consultation*. NSW Office of Water. Sydney.

NOW (Office of Water) (2011). *Water resources and management overview: Macquarie-Bogan catchment*. NSW Office of Water. Sydney.

OEH (Office of Environment and Heritage) (2010) *Macquarie Marshes Adaptive Environmental Management Plan*. Available at: [Macquarie Marshes Adaptive Environmental Management Plan | NSW Environment and Heritage](#)

OEH (Office of Environment and Heritage) (2011a) *Macquarie Marshes Nature Reserve and Macquarie Marshes State Conservation Area Fire Management Strategy 2011-2016*. Available at: <http://www.environment.nsw.gov.au/resources/firemanagement/final/110113MacquarieMarshesNRSCAfm.pdf>

OEH (Office of Environment and Heritage) (2012a) *Macquarie Marshes Ramsar site: Ecological character description Macquarie Marshes Nature Reserve and U-block components*. NSW Department of Premier and Cabinet. Sydney.

Warren Shire Council (2012) *Warren Local Environmental Plan 2012: Exhibition Draft*. Warren. NSW.

Consultation Questions on existing protection and management plans

- Do you agree with the existing protection description? If not, please suggest changes and provide relevant references.
- Are the plans listed above still relevant and correctly referenced?
- Are there any other management plans that you suggest for inclusion? If so, please provide details (including website links).

5.3 Principles and standards for conservation and restoration

To undertake priority actions to meet the conservation objective, the overarching principle is to maintain existing areas and condition of the ecological community. This is particularly important for those areas that are relatively intact and of good condition. This is because they are likely to retain a fuller suite of native plant and animal species, and ecological functions. Certain species, particularly fauna and flora sensitive to changes in the environment, and mature stages of plants, are likely to be difficult or not possible to recover in practice, if lost from a site.

This principle is highlighted in the *National Standards for the Practice of Ecological Restoration in Australia* (Standards Reference Group SERA, 2021):

“Ecological restoration is not a substitute for sustainably managing and protecting ecosystems in the first instance.

The promise of restoration cannot be invoked as a justification for destroying or damaging existing ecosystems because functional natural ecosystems are not transportable or easily rebuilt once damaged and the success of ecological restoration cannot be assured.”

Standards Reference Group SERA (2021) – Appendix 2.

The principle discourages ‘offsets’ where intact remnants are removed with an undertaking to set aside and/or restore other, lower quality, sites. The destruction of intact sites represents a net loss of the functional ecological community because it is unlikely that all the species and ecological functions of the intact site can be replicated elsewhere. It is therefore more cost-effective and less risky to retain an intact area than to allow degradation or loss and then attempt to restore it or establish an occurrence in another area to replace it.

Where restoration is to be undertaken, it should be planned and implemented with reference to the *National Standards for the Practice of Ecological Restoration in Australia*. These Standards guide how ecological restoration actions should be undertaken and are available online from the Standards Reference Group SERA (2021). They outline the principles that convey the main ecological, biological, technical, social and ethical underpinnings of ecological restoration practice.

5.4 Priority conservation and research actions

Priority actions are recommended to abate threats and support recovery of the ecological community. They are designed to provide guidance for:

- planning, management and restoration of the ecological community by landholders, Local Land Services/Natural Resource Management (NRM) and community groups, Traditional Owners/Custodians and other land managers (including local and/or state governments);
- avoiding impacts and setting approval conditions for relevant controlled actions under national environment law (the EPBC Act)
- prioritising activities in applications for Australian Government funding programs.

More detailed advice on actions may be available in specific plans, such as management plans for weeds, fire or certain parks or regions. The most relevant at the time this Conservation Advice was developed are listed in [section 5.2.2](#).

More specific guidance may be developed in the future; restoration ecology develops continually. So, it is important to reflect on the experience of others involved in restoring the ecological community, or other aquatic or floodplain communities — and adapt restoration projects as site level experience accumulates.

To achieve cost-effective investments in conservation management and restoration it is important that you consider the likely interactions between management actions at a site. They

may be synergistic, or antagonistic. There are also likely to be interactions between sites and within the broader catchment. Also, when you allocate management resources, it is important to consider what is the minimum investment required for success, and the follow-up required to secure long term recovery (e.g. how many years should weed management be repeated).

This Conservation Advice identifies priority conservation actions under the key approaches.

- PROTECT the ecological community to prevent further losses.
- RESTORE the ecological community by active abatement of threats, appropriate management, restoration and other conservation initiatives.
- COMMUNICATE, ENGAGE WITH AND SUPPORT people to increase understanding of the value and function of the ecological community and encourage their efforts in its protection and recovery.
- RESEARCH AND MONITORING to improve our understanding of the ecological community and the best methods to aid its management and recovery.

These approaches overlap and are iterative— they include research, planning, action on the ground, monitoring, analysis and review.

5.4.1 *PROTECT the ecological community*

This key approach includes priorities intended to protect the ecological community by preventing further loss of area and condition (abundance, diversity, integrity and resilience).

5.4.1.1 *PLAN FOR PROTECTION*

- Preventing direct and indirect impacts to the ecological community from threats such as vegetation clearance or changed hydrology (e.g. reduced flows or connectivity) needs to be properly considered during the early stages of planning within the broader catchment (before decisions are made).
- All relevant strategic planning documents at national, state, regional and local levels should include appropriate actions to prevent the loss of extent or integrity/condition of the ecological community and adjacent or nearby native habitats.
- Planning and zoning decisions should protect the hydrology/hydrogeology and other key ecological processes and areas in the broader catchment that influence integrity/condition of the ecological community, including the areas that support different successional stages of characteristic species (e.g. river red gum regrowth, frogs, waterbirds).
- Liaise with local councils, State authorities and Local Aboriginal Land Councils and/or Elders groups, to ensure that cumulative impacts to the ecological community, and associated ecosystem functions and cultural values, are minimised as part of broader strategic planning and planning for large projects (e.g. road works, dams, levees, other developments, land and water management plans).
- Implement strong border biosecurity and plan to avoid importing or accidentally introducing invasive species and pathogens that may severely impact this ecological community.
- Plan activities to mitigate future climate change and therefore reduce the impacts of climate stress on this ecological community.

- Develop an invasive species action plan for the Macquarie Marshes region in consultation with local farmers, conservation area managers, fisheries managers, Traditional Custodians and other local authorities, identifying priority prevention and management actions, and including regular monitoring of trends.
- Develop a Climate Extremes Emergency Plan for the ecological community — include appropriate management strategies and actions, including rescue and recovery requirements for threatened and other key native species that are highly susceptible.

5.4.1.2 *MANAGE MORE HIGH PRIORITY AREAS FOR CONSERVATION PURPOSES*

- In consultation with the agriculture sector and First Nations people, protect additional areas of the ecological community identified as the most important (e.g. wildlife refuges and other sites with high biodiversity, ecological and cultural significance) in formal conservation reserves.
- Consider other areas for less formal conservation tenures, preferably ones affording long-term protection. This includes investigating formal conservation arrangements, management agreements and covenants to protect occurrences on private land in-perpetuity. This is particularly important for larger areas that link to other patches of native vegetation or wetlands and areas that are part of wildlife corridors or migration routes or other habitat areas critical to the long-term survival of functionally significant species and key ecological processes (some of which are summarised in [section 1.2.4](#)).
- Aim for connected networks of conservation areas with functioning open water bodies, marshland, floodplain and other habitats serving as refugia or linkages for the wildlife of the ecological community across the broader catchment landscape.
- Consider additional measures to protect the ecological community through carbon offset and nature repair-biodiversity market schemes or working with landholders and First Nations peoples on other conservation programs.

5.4.1.3 *MANAGE ACTIONS TO MINIMISE IMPACT, INCLUDING CUMULATIVE IMPACTS*

- Apply the mitigation hierarchy to avoid, then mitigate potential impacts on the ecological community from development or other actions within the broader catchment. The priority is to avoid vegetation clearance, hydrological changes, and other impacts to integrity and resilience, including loss of biodiversity and abundance (particularly of functional species), loss of connectivity and changes to other key natural processes (particularly hydrology). Plan projects to avoid the need to offset, by avoiding unacceptable and significant impacts to the ecological community and achieving nature positive outcomes.
- Minimise the risk of indirect impacts to the ecological community from actions outside but near to or upstream of the ecological community, such as changes to hydrology or other ecological processes and damage to landscape function within the broader catchment.
 - Avoid building infrastructure within or near the ecological community that will interrupt or divert hydrological flows on the floodplain or cause significant run-off of nutrients. If they proceed, control runoff during nearby construction activities to prevent the spread of weeds, pathogens and nutrients into the ecological community.

- The ecological community is threatened due to the cumulative impacts from multiple land and water changes and degradation, sometimes large and sometimes small or gradual. Therefore:
 - Take into account that approval of even a relatively small loss and/or degradation of one area, characteristic or functional species, or key ecological process, can multiply the negative effects of other past and future actions and threats.
 - When considering how to minimise significant impacts and achieve nature positive outcomes — gather evidence and consider other recent, current and likely near future losses and/or degradation if actions are approved.
- Maintain the extent, condition and existing landscape scale connections between and within the ecological community and its surrounding natural environment.
- Protect other native vegetation and wetlands near the ecological community, particularly where they are important for connectivity and diversity of habitat.
- Avoid hydrological changes that could disrupt natural patterns of inundation, overland flows and water table levels, or that could increase salinity, nutrient loads, algal blooms, sedimentation/turbidity, or pollution.
- Minimise unnecessary soil disturbance that may facilitate weed establishment.
- Protect habitat features for fauna and flora, including for threatened, functional and culturally important species, noting particular vegetation structures or other species requirements. For example, a continuous canopy or sub canopy of *Duma florulenta* (lignum) as a refuge for various species and flooded areas of *Paspalum distichum* (water couch) are important for waterbird aggregation breeding events.
- Where this ecological community is regenerating, protect it to full maturity. For example, provide temporary fencing to minimise risk of damage to native tree and other vegetation regrowth if appropriate, and ensure fire response and management plans are aligned with regeneration needs.
- If approval has been provided to remove native trees or use heavy machinery that may damage the ecological community, ensure comprehensive flora and fauna surveys have identified threatened or locally important species at the site (and in the case of fauna, their potential shelter and nesting sites such as tree hollows, burrows, rocks and crevices, as well as visible nests).
 - Avoid damage to these wherever possible and, if necessary, take care to appropriately relocate flora and fauna; and avoid undertaking the works during important times, such as breeding-nesting and flowering-seeding seasons.

5.4.1.4 OTHER THREAT PREVENTION

- When conducting activities in or around this ecological community, practice good biosecurity hygiene to avoid spreading weeds or pathogens (see DoE 2015). Also implement hygiene management plans and risk assessments to protect vegetation and fauna of the ecological community from disease outbreaks. This may include, but is not limited to, ensuring that:
 - contaminated soil is not introduced into an area as part of restoration, translocation, infrastructure development or revegetation activities, and

- in areas of disease outbreaks — disease free areas are sign posted, and hygiene stations constructed and maintained where feasible.
- Support landholders/managers to prevent introduction of invasive species and pathogens to new areas.
 - Encourage landholders/managers to engage in weed identification and intervention early, including monitoring invasion pathways and implementing prevention measures using current best management practices.
- Prevent dumping waste, particularly garden and soil waste, in or near the ecological community.
- Vehicle tracks and walking trails can spread or amplify diseases. Existing tracks should be reviewed for removal and re-alignment to protect catchments and any proposed future tracks or trails should minimise risks (particularly from impeding natural hydrology and causing runoff and weed and pathogen introduction).
- Prevent death and injury to native fish and other aquatic fauna through installation and maintenance of modern fish-protection water pump screens. Align with relevant existing initiatives through local authorities.
- Avoid grazing in areas with threatened species or highly diverse native ground layers during peak native plant flowering and seeding times for many species (late spring and summer), and when seedlings are establishing.
 - Also minimise grazing when the soil is too wet; or when plants are stressed by other pressures.
 - Fence to exclude stock, feral and native herbivores, until seedlings are at least two metres high; individual seedlings may be protected by herbivore guards.
- Promote guidelines/restrictions, educational material (e.g. signage) and monitoring protocols for recreational activities that adversely impact on the ecological community, including: fishing; 4WD and other recreational vehicle use (e.g. at nature reserves); regulated hunting activity; recreational boating; camping (including lighting of fires).
- Cease/prohibit and monitor wood collection, such as for firewood or fencing, that leads to the loss and damage of riparian or floodplain trees, stags and logs, or disturbs the natural litter layer.
- Prohibit access by domestic pets to sensitive areas (e.g. waterbird nesting areas).

5.4.1.5 *APPLY BUFFER ZONES*

- Protect and apply appropriate buffer zones (particularly adjacent areas of other native vegetation) to minimise impacts arising 'off-site'. A buffer zone is a contiguous area adjacent to areas of the ecological community that is important to protect the integrity of this ecological community but is not a part of the ecological community itself. The risk of indirect damage is usually greater where threatening actions occur nearby. Buffer zones can minimise this risk, by absorbing and reducing impacts. They can also guide land managers to notice that the ecological community is nearby and to be extra careful.
 - For instance, buffer zones help protect outermost plants and other members of this ecological community from spray drift (fertiliser, pesticide or herbicide sprayed in adjacent land), weed invasion, polluted water runoff and other damage.

- The best buffer zones are typically areas of native vegetation. Fire breaks and other built asset protection zones do not typically provide a suitable buffer and should be on the outside of vegetated buffer.
- The recommended minimum buffer zone for the ecological community is at least 200 m from the outer edge. The appropriate size depends on the nature of the threatening action and local context (e.g. groundwater or downstream impacts). Apply larger buffer zones to protect occurrences from broader landscape threats such as hydrological changes.
- Determination of wetland buffer zones can be complex and should be determined on a case-by-case basis, taking site-specific features such as the localised catchment area of the wetland into account. Exercise good judgement, to determine an appropriate buffer distance, depending on circumstances. Guideline for the Determination of Wetland Buffer Requirements (EES 2005) explains a multi-step process and buffer types/size depending on wetland attributes, objectives and threat.

Consultation Questions on the buffer zones

In your opinion, is the advice on buffer zones and recommended minimum buffer distance appropriate? If not, how should the buffer zone advice be amended to ensure appropriate application?

5.4.2 *RESTORE (and MANAGE) the ecological community*

This key approach includes priorities to restore areas of the ecological community by active threat abatement, appropriate management, restoration and other conservation initiatives. Act to increase the extent, condition, and landscape scale connectivity of this ecological community (including connectivity with other surrounding native habitats). The aim should be for recovery of as many key biodiversity and ecosystem attributes as practical for a particular site, so that the ecological community is on a trajectory to recovery and is self-sustaining. This should be based on following the *National Standards for the Practice of Ecological Restoration in Australia* (Standards Reference Group SERA 2021).

5.4.2.1 *GENERAL*

- Implement actions identified in key existing management plans such as the Murray-Darling Basin Plan, and the management plan for the Ramsar site.
- Restore the extent, condition and existing landscape-scale connections between and within the ecological community and the surrounding natural environment.
- Ensure that hydrological restoration and revegetation activities are coordinated and occur in the right chronological order to enable complementary and well targeted outcomes to be achieved.
- Undertake strategic invasive species management in conjunction with other management activities, to facilitate and promote natural regeneration of native vegetation and increased biodiversity.
- Consider the landscape context and other relevant values when planning and undertaking restoration works. For example, ensure threatened species, migratory species, Ramsar site characters and First Nations cultural values are not adversely impacted by restoration activities for the Macquarie Marshes.

- Provide and maintain a network of fishways throughout the ecological community to facilitate native fish passage and breeding migrations (particularly for threatened species). Carefully remove barriers where feasible or mitigate when barrier removal is not possible.
- Maintain or increase diversity of riparian and in-stream habitat (e.g. in-stream pools and low flow refuges, physical structures such as snags, logs and rocks, and leaf litter) for identified priority sites.
- Ensure that connected networks of functioning wetlands and floodplain habitats exist to serve as refugia or linkages for wildlife across the landscape.
- Identify, evaluate, and if practical and feasible, implement measures to address constraints that potentially affect environmental water delivery within the ecological community.
- Maintain and improve current management that maximises threat mitigation measures, including the delivery of environmental flows, protection of core refugia and restoration of free-flowing streams in the Macquarie Marshes catchment through adaptive management.
- Maintain or restore the condition of understorey wetland groundcover and shrub-layer vegetation (including water couch and lignum) in river red gum woodland.
- Maintain or restore the condition of inner semi-permanent wetland vegetation, including reeds, water couch and mixed marsh sub-communities.
- Increase river productivity and improve the abundance and resilience of native fish in the mid-Macquarie/Wambuul River, including freshwater catfish.
- Maintain and restore nesting vegetation structure at key sites for aggregating breeding species e.g., ibis, egrets, herons, cormorants, between breeding seasons, to improve their 'readiness' for future colonial breeding events.
 - Restore other waterbird habitat, including foraging grounds for juvenile waterbirds, to increase their abundance and resilience.
 - Provide environmental water, as needed (e.g. duration extension, increased depth, water quality) during breeding events.
- Restore abundance and habitat for other aquatic or semi-aquatic species, including culturally significant species (e.g. frogs, turtles, rakali, bivalves and gastropods).
- Include this ecological community as a key target in Nature Repair Market schemes and other environment restoration strategies and programs.
- Directly involve, or seek guidance, from experienced restoration experts and Traditional Ecological Knowledge from First Nations groups when planning and carrying out restoration works – from seed collection and propagation, planting, environmental flows to invasive species management, fauna reintroductions and other activities.

5.4.2.2 RESTORE FLOW REGIMES AND OTHER HYDROLOGY

- Consistent with the Murray-Darling Basin Plan's principles to be applied in environmental watering, and to the extent possible within operating constraints, support hydrological connectivity between river channels and floodplain environments.

- Implement appropriate wetting and drying cycles and inundation intervals that do not exceed the tolerance of the ecological community's resilience or known thresholds of irreversible change for functionally significant species (e.g. river red gum, lignum).
- In consultation with First Nations groups and landholders, restore natural hydrological regimes to high priority areas of the ecological community that have been adversely impacted. This may include:
 - Removing or altering weirs, causeways, drains or other artificial structures, where feasible, or installation of levees and control structures that have positive environmental benefits.
 - Targeted environmental (and cultural) watering and other activities that will mitigate and reduce detrimental hydrological impacts and restore flows and water quality. Determine high priority areas in consultation with First Nations groups.
 - Re-instate appropriate flows to facilitate within-channel and overbank flows for the various types of wetland vegetation and aquatic species e.g. for fish and frog spawning and native vegetation recruitment.
 - Ensure environmental watering considers whole of system influences such as: agricultural run-off, climate change, pollution, and potential impacts on culturally important areas.
- In managing flows:
 - Take into consideration that variability of the natural flow regime, including implementing changes to mitigate or avoid seasonal inversions of flows.
 - Determine and implement the environmental water requirements for priority environmental assets and ecosystem functions and to maintain connectivity (as defined by this Conservation Advice, the Murray-Darling Basin Plan and other plans for obtaining positive environmental outcomes).

5.4.2.3 RESPOND TO THE THREAT OF CLIMATE CHANGE

- Develop and implement a Climate Change Adaptation Plan for the ecological community, including determining appropriate adaptation management strategies and actions, and identifying options to enhance habitat and biodiversity resilience (e.g. riparian shading, fish hotels, shaded nesting boxes).
- Undertake activities to mitigate climate change and reduce climate stress impacts, particularly hydrological impacts.
- Enhance the resilience of the ecological community to the impacts of climate change by reducing other pressures.
- Identify important climate refuge areas for key species.

5.4.2.4 RESTORE NATIVE VEGETATION

- Undertake restoration (including facilitating regeneration and revegetation) of lower condition patches, to restore them to a higher condition. Restoration should aspire to the 5 Star Standard of the SERA Standards. Land managers should aim for the highest and best recovery of native vegetation habitat, to maximise biodiversity and ecological function based on appropriate metrics for each site. SERA (2021) gives guidance on

implementing appropriate standards. These aspirations are particularly important for sites that are being restored or reconstructed from highly altered states.

- Identify which areas are best revegetated with either seedlings or seed (e.g. residual chemicals and nutrients in the soil of agricultural areas can suppress native species germination for up to five years).
- Aim to establish species from the full suite of life-history characteristic species; create resilient conditions to promote natural regeneration and recovery from disturbance.
- Support natural regeneration where possible (e.g. through floodplain flows).
- Replant native vegetation to riparian/littoral and floodplain areas that are not naturally regenerating using species known to previously occur locally.
- Work with landholders/managers to restore and reconnect areas of the ecological community, and to increase adjacent or nearby native vegetation (including buffer areas).
- Maintain snags, stags, logs, large rocks and mature and old-growth trees with hollows, because they provide important habitat for fauna. If necessary, supplement (but do not replace) habitat as part of restoration projects – this may be particularly important after severe disturbance.
- Use local native species in restoration projects, and restore structure, abundance and diversity to an appropriate and sustainable level for the site.
 - In general, use locally collected seeds, where available, to revegetate native plant species. However, choosing sources of seed closer to the margins of their range may increase resilience to climate change. Take account of key plant species' growing seasons to successfully achieve seed set.
- Ensure commitment to follow up after planting, such as the care of newly planted vegetation by watering, weeding and use/removal of tree guards if needed.
- Consider the landscape context and other relevant species and communities when planning restoration works. For example, ensure that adjacent ecological communities and threatened and migratory species are not adversely impacted by restoration activities.
- Close and rehabilitate unnecessary roads and tracks and otherwise control access to restored areas; but take account of required access (e.g. by elders of Traditional Owners/Custodians to cultural sites).
- Where appropriate habitat is available, and predators and competitors can be sufficiently controlled, re-introduction of some fauna species, including those supporting important ecological functions, may be possible.
 - Consider the size of the gene pool and interactions with naturally occurring populations when introducing fauna.
 - Where key ecological services, formerly provided by fauna, are limited or missing, consider any opportunities to replicate these.
- Explore the potential for carbon mitigation investment activities to restore wooded areas through reforestation. This should be in line with appropriate reforestation methodologies such as those developed under the Carbon Credits (Carbon Farming

Initiative) Act 2011. As part of any such initiatives, aim to also achieve biodiversity credits.

- Implement effective adaptive management regimes using information from available research and management guidelines. For example, see the National Standards for the Practice of Ecological Restoration in Australia (Standards Reference Group SERA, 2021), relevant research or advice from local authorities.

5.4.2.5 *MANAGE WEEDS, PESTS AND PATHOGENS*

Implement effective integrated control and management techniques for weeds, pests and pathogens (disease causing organisms) affecting the ecological community; and manage sites to prevent the introduction of new, or further spread of existing, invasive species.

5.4.2.5.1 Weed species

- Identify new weed and pathogen incursions early and manage for local eradication, where possible (small infestations are much easier to eradicate).
 - Support landholders/managers in weed identification and to report new invasions to local authorities early, and to implement early intervention measures using current best management practices
- Prioritise weeds and areas for which management is most urgent.
- Develop/enhance management plans for the control of particular major weeds identified for the ecological community (e.g. lippia).
- Weed control programs should be risk-assessed and managed to avoid impacting non-target species or having unintended consequences (e.g. consider habitat requirements of native species and likelihood of erosion, effects on water bodies or increased access before removing weeds).
- Ensure chemicals, or other mechanisms used to manage weeds, do not have significant adverse, off-target impacts on the ecological community e.g. waterbodies or adjacent native vegetation.
- Plan and budget for both initial weed management and for follow up treatment for as long as this is needed.
- Involve Traditional Custodians in detection, eradication and control programs whenever possible.

5.4.2.5.2 Pest fauna species

- Control introduced pest animals through coordinated landscape-scale control programs in consultation with farmers, conservation area managers, fisheries managers, Traditional Custodians and local authorities. Target pests include carp, eastern gambusia, redfish, pigs, goats, rabbits, foxes and feral cats.
- Post-fire management is critical to avoid synergistic impacts from feral animals further damaging burnt occurrences.
- Involve Traditional Custodians in eradication and control programs whenever possible.

5.4.2.5.3 Pathogens

- Implement controls to prevent or reduce infection by pathogens, for example chytridiomycosis (chytrid), Epizootic Haematopoietic Necrosis virus (EHNV) and new highly pathogenic strains of Avian Influenza.

- Maintaining hygiene protocols is critical, including when undertaking fire management and weeding.

5.4.2.6 FIRE MANAGEMENT

- Each wetland vegetation type requires specific fire management due to landscape context and environmental variation (including hydrological inputs). The marked changes in post-regulation hydrology and increase in temperature has likely contributed to drying out the vegetation and substrate, allowing fires to spread more easily. These factors have produced a complex fire-management environment.
- Identify suitable fire regimes (interval, intensity, seasonality, prevailing conditions) at each appropriate site considering information such as the vegetation type, maturity and seed production rates, as well as the seed germination requirements by key plant species, as well as sensitivities of local fauna. Ensure fire frequencies allow sufficient recovery time for adequate regeneration of key plant species, particularly in a drying climate. It is likely that at some sites, active fire suppression will be necessary at times.
 - For areas affected by too low fire frequency, identify opportunities for applying appropriate ecological burns, including with traditional knowledge and practices.
 - For areas affected by too high fire frequency, identify options for reducing the frequency of fires and protecting important features, such as large habitat trees.
 - Fire management strategies at each location should take into account antecedent fire history, life histories of species within the community, forecasts of drought, post-fire management plans for herbivores and predators, patch size, habitat features (e.g. protect hollow-bearing trees and large logs), vegetation structure and the surrounding landscape (including property protection) to sustain biological diversity, maintain refuges for fauna (during and after fire) and increase habitat variability.
- Liaise with local fire management authorities and agencies; and engage their support to manage fire in the ecological community.
- Take into account Traditional knowledge and implement any planned fire in accordance with other ecological scientific advice.
- Manage fires, so that prevailing fire regimes support rather than degrade the ecological community; genetic diversity is maintained; and life cycles of members of the ecological community are not disrupted.
- Where hazard reduction burns, or prescribed fires, are undertaken near the ecological community, ensure that the potential for the fire to escape is appropriately risk assessed and management responses are in place to protect the ecological community.
- Minimise the impacts of out-of-season fires, fire-drought impacts; and to reduce the risk of interval squeeze for flora and fauna.
- Use available ecological information to avoid detrimental fire impacts on key and susceptible species in the ecological community. For instance, do not burn areas in or adjacent to the ecological community when key, threatened or functionally important flora and fauna (that may be adversely impacted) are flowering, nesting or otherwise reproducing.

- Consider weather conditions. Do not burn in, or adjacent to, the ecological community when soil moisture is low, or dry conditions are predicted for the coming season. Otherwise, already stressed flora and fauna will struggle to recover and erosion may occur, or weeds may become established while vegetation cover is reduced. Take into account that isolated fauna populations and threatened plants are particularly vulnerable to local extinction following intense fires, combined with other threats.
- Manage the fire-weed cycle by controlling invasive weed species before and after any fire events. However, care must be taken whenever using herbicide to control weeds after a fire as it can be detrimental to wetland biodiversity. It not only kills weeds, it can also kill or damage native flora, invertebrates and other fauna.
- Avoid physical damage to the ecological community during and after fire operations. Containment lines should be rehabilitated as soon as possible as part of the suppression operations.
- Avoid using fire-retardant chemicals such as use of foam, wetting agents and retardants in or near the ecological community unless necessary in emergencies.
- Monitor fire outcomes and the consequences of other threats. Manage these threats in an appropriate timescale (e.g. immediately put in place erosion control measures; limit access by feral predators and grazers; and control weeds as they first appear, with follow up treatments as necessary, until native vegetation has regenerated). Ensure monitoring results are considered when planning and implementing future fire regimes.

5.4.2.7 *MANAGE TRAMPLING, BROWSING AND GRAZING*

- Manage total grazing pressure and trampling in the ecological community.
- Work with other agencies (cross-tenure) and pest management groups/individuals to raise awareness and develop management strategies for feral goats and rabbits, in addition to native fauna such as kangaroos if they become over-abundant.

5.4.2.8 *MANAGE FISHING PRESSURE*

- Undertake surveys and analysis of recreational catches of native species that are part of the ecological community to track and report on trends within the Macquarie River.
- Instigate an education and awareness program to promote 'catch and release' of native species, particularly Murray cod and other threatened or declining species.
- Ensure adequate regard to environmental considerations and genetic implications of any proposed fish stocking scheme in the ecological community (see Gillanders & Ye 2011 for Murray cod).

5.4.2.9 *SOIL MANAGEMENT*

- Develop techniques to ameliorate the potential effects of acid sulphate soils (ASS) and salinisation within the ecological community.
- To prevent resources being misdirected to inappropriate locations, future habitat restoration should consider the potential interactions between salinisation and changed hydrological patterns resulting from vegetation decline, fire, reduced flows, and rainfall patterns.
- Support appropriate programs for desalinisation of water and soils associated with the ecological community (e.g. salt interception schemes and irrigation improvements) while ensuring there are no adverse impacts.

5.4.3 *COMMUNICATE, ENGAGE WITH AND SUPPORT*

This key approach includes priorities to promote awareness of the ecological community and to encourage people and groups to contribute to its protection and recovery. Gain support from (and in turn, support and encourage) key stakeholders. Increase their understanding of its value and function, as well as of its key threats, the importance of its protection and restoration, and appropriate management actions based on Traditional Ecological Knowledge and other ecological science. Key groups include local restoration and NRM groups, government agencies, landholders, land managers, land use planners, researchers, First Nations communities and other community members and groups.

- In particular consult, build capacity and partner with farmers and Traditional Owners/Custodians to assist with appropriate restoration and management actions.

5.4.3.1 *RAISE AWARENESS AND ENCOURAGE PARTNERSHIPS TO PROTECT AND RESTORE*

- Communicate with landholders/managers, relevant agencies and the public to emphasise the value of the ecological community, its natural and cultural heritage significance, the key threats (such as flow disruption, invasive species, diseases and pathogens, and fire) and appropriate management.
- Raise public awareness about the value of the ecological community, its natural and cultural significance, its key threats (such as flow disruption, vegetation clearance, invasive species and diseases) and appropriate management and recovery priorities using a range of media/methods. For example, fact sheets, information brochures, and interpretive signs at strategic locations (e.g., in nature reserves and nearby towns) — in conjunction with industry or community interest groups.
- Promote responsibilities under state and local regulations, and under the EPBC Act.
- Promote latest science on threat mitigation and restoration techniques.
- Promote First Nations Traditional ecological knowledge and involvement in conservation management and recovery throughout the range of the ecological community.
 - Identify and support culturally appropriate mechanisms to share this knowledge, to protect and restore the ecological community.
 - With permission, include culturally appropriate information and values in education and awareness programs, publications and signage.
- Support landholders/managers to build on existing relationships and establish new ones amongst their peers and with Local Land Services/NRM organisations, First Nations Elders groups and knowledgeable community groups, to protect and restore areas of the ecological community.
 - In particular, build capacity and partnerships between First Nations and landholders to manage threats (e.g. invasive species) and foster stewardship of areas of wetland and their associated biodiversity within the ecological community and the broader catchment.
- Seek support from local restoration groups, state-based and national conservation organisations and the business sector.

- Undertake effective community engagement and education to highlight the importance of minimising disturbance (for example, during recreational activities) and of minimising pollution, littering and fire impacts.
- Liaise with planning authorities to promote the inclusion of the ecological community in their plans/responses to climate change.
- Inform landholders/managers, including First Nations groups, about incentives to support them to manage threats and look after the ecological community on private land, such as conservation agreements, stewardship projects, nature repair market initiatives and other initiatives, some of which may be available through government agencies such as Local Land Services, that.
- Support graziers to reduce any residual impacts of grazing in the ecological community, particularly for the most sensitive areas or species.
 - Also inform land managers of appropriate forms of landuse/grazing to assist with management of remnants. For example, grazing regimes that may help to reduce weedy grasses or shrubs.
- Promote awareness and protection of the ecological community with relevant agencies and industries. For example, with the following.
 - State and local government planning authorities — to ensure that planning protects remnants, with due regard to principles for long-term conservation.
 - Landowners and mining and energy sectors — to minimise threats associated with land conversion and development within the broader catchment.
 - Local councils and state authorities — to ensure that infrastructure or development works (particularly those involving substrate or vegetation disturbance) do not adversely impact the ecological community. This includes avoiding the introduction or spread of invasive species and hydrology impacts.

5.4.4 RESEARCH and MONITORING

This key approach includes priorities for research into the ecological community, and monitoring, to improve understanding of the ecological community and the best methods to aid its recovery through restoration and protection. Relevant and well-targeted research and other information gathering activities are important in informing the protection and management of the ecological community.

5.4.4.1 RESEARCH PRIORITIES

- Improve understanding of how hydrological regimes affect life history processes and population dynamics of component flora and fauna, including indirect effects through interactions with threats posed by periodic and intense droughts, invasive species and other pressures.
 - Determine optimal water regimes for floodplain wetlands in the ecological community, taking into account likely climate change scenarios.
- Conduct research to develop effective landscape-scale restoration techniques for the ecological community.
- Develop greater understanding of strategies to minimise the negative ecological impacts of 'blackwater' and other deoxygenation events.

- Improve understanding of responses to alternative grazing regimes taking into account grazing timing and duration (i.e. when to spell) and management options.
- Support more research into the biology and ecology of aquatic invertebrates within the ecological community.
- Improve understanding of habitat requirements and connectivity needs for breeding birds and other key fauna e.g. frogs.
- Support ongoing research on the biology, ecology (and genetics) and integrated management to assist eliminating alien animals and plants, including common carp and lippia.
- Integrate Traditional Ecological Knowledge and other ecological scientific advice, using appropriate free prior and informed consent procedures and data use agreements.

5.4.4.2 *MAPPING*

- Improve the accuracy and resolution of mapping and field validation for this ecological community and identify gaps in knowledge.
 - Support targeted field surveys and interpretation of other data, such as aerial photographs (e.g. including using drones) and satellite images. Update current extent, condition, threats, function, and the presence of, and use by, regionally significant or threatened species. Ground-truth to fill data and knowledge gaps, including knowledge of the ecological community's different forms and recovery from different disturbances.
- Monitor and report on changes in the extent and condition of each wetland or vegetation type across the ecological community's range.
- Investigate and monitor the resilience and responses of the ecological community to climatic variations, including prolonged drought.

5.4.4.3 *MONITORING*

- Implement regular and long-term monitoring for the ecological community.
- Plan and integrate monitoring with management strategies, to ensure that monitoring design and data address research priorities and answer management questions. Monitoring must also be adequately resourced for management activities, especially for those using a novel approach, and applied before, during and following management action.
 - Monitor changes in the condition, composition, structure and function of the ecological community at targeted sites, including response to various management actions. Use this information to better understand the ecological community and inform future management recommendations.
 - Monitor for new weeds, pest animal and pathogen incursions. Continual reappraisal is needed for the evolving potential arrival pathways, and measures for prevention and early detection.
 - Regularly evaluate monitoring programs associated with the Macquarie Marshes, including analysis of their outcomes and providing recommendations for continuous improvement.

- Monitor river flows, water levels and water regimes to help determine how hydrology may change in concert with changing climate and the effectiveness of environmental watering.
- Implement long-term monitoring of native and non-native fish abundance and distribution (adults and juveniles of key species) at key locations within the ecological community. Ensure consistency of data with similar strategies (e.g. Native Fish Strategy).
- Monitor fishways throughout the ecological community to facilitate improved native fish passage and breeding migrations.
- Monitor and assist the progress of recovery of vegetation via: improved mapping, estimates of extent and condition assessments of the ecological community, and effective adaptive management actions.
- Ensure long-term monitoring of invasive plant and animal species throughout the ecological community and develop associated risk management plans (e.g. for weeds, pest mammals, pathogens etc).
 - Ensure long-term monitoring of common carp at all life-history stages throughout the ecological community.
- Monitor algal blooms and blackwater events that occur within the ecological community and document their occurrence, conditions, impacts and longevity. Develop an associated analytical database.
- Monitor and manage impacts on biodiversity from irrigation pumping infrastructure and practices.
- Monitor and regularly report on activities related to floodplain harvesting within the catchment of the ecological community.

Consultation Questions on priority actions

- Please suggest any changes to the draft conservation and recovery actions, including any missing actions, for the ecological community based on your knowledge and expertise (along with references to the source documentation).
- This includes further actions that encourage appropriate use of Traditional Ecological Knowledge of First Nations and encourage more involvement of Traditional Owners and Custodians in conservation management, recovery and research.

6 Listing assessment

This draft assessment outlines *grounds on which the community may be eligible to be listed* to be included in a conservation advice according to section 266B (2) (a) (i) of the EPBC Act.

It is provided for consultation in accordance with section 194M of the EPBC Act.

6.1 Assessment process

6.1.1 Reason for assessment

This draft listing assessment follows prioritisation of a nomination from the public which is on the 2023 Finalised Priority Assessment List (FPAL) under the EPBC Act.

Note: Assessment for the 2024 Conservation Advice is still in progress, with a statutory deadline of 29 November 2024.

This Draft of the *Conservation Advice*, currently released to meet the legislative requirement for public consultation under the EPBC Act, should be considered as having an 'indicative conservation status for the ecological community'.

In updating the comprehensive assessment previously completed in 2013, contemporary data and analysis from the new nomination and various other sources has been incorporated but it is acknowledged that additional data and analyses will become available in the next couple of months. This information was unavailable prior to this public consultation period due to Basin Plan processes being run by the Commonwealth and State governments which have differing timelines (e.g. Schedule 12 Matter 7 & 8 reporting, and upcoming Murray-Darling Water and Environment Research Program publications).

When these additional information resources become available, they are expected to be incorporated into the Criterion assessments and the *Conservation Advice*. At this juncture, it is considered unlikely that this extra information will alter the indicative conservation status overall, but individual criteria analysis could change.

6.2 Eligibility for listing

An ecological community is eligible for listing under section 182 of the EPBC Act if it meets the prescribed criteria outlined in the [EPBC Regulations](#). This assessment uses the criteria set out in section 7.02 the [EPBC Regulations](#) and the [Guidelines for nominating and assessing the eligibility for listing of ecological communities as threatened under national environment law](#) (TSSC 2016), as in force at the time of the assessment.

6.2.1 Criterion 1 – decline in geographic distribution

Nominated under Criterion 1 as Vulnerable. Draft information suggests may not be eligible under Criterion 1.

Category	Critically Endangered	Endangered	Vulnerable
Its decline in geographic distribution is:	very severe	severe	substantial
decline relative to the longer-term/1750 timeframe	≥90%	≥70%	≥50%
decline relative to the past 50 years	≥80%	≥50%	≥30%

Source: TSSC 2016

Evidence:

The Macquarie Marshes are estimated to cover an area of 200,000 to 233,000 ha but this varies according to the area of the floodplain inundated during major flooding events (Brereton 1994; Kingsford & Thomas 1995; DLWC 2004; MMC 2006; NPWS 1996; OEH 2012a; Wen et al. 2013; Capon et al. 2018; Bowen et al. 2019; DCCEEW 2019). The region had its largest pre-regulation flood in 1955, covering 374,400 ha (Steinfeld & Kingsford 2011). The 1996 Macquarie Marshes Water Management Plan adopted the maximum area inundated by the 1990 flood event as the boundary for the Macquarie Marshes (DLWC 1996). This is an area of about 228,200 ha that includes ‘islands’ of higher ground within this boundary that are not inundated regularly.

The vegetation types and species on higher ground and on the outer floodplain are not part of the ecological community. The excluded vegetation accounts for about 120,000-149,000 ha. In 2008, entire native vegetation cover within the Macquarie Marshes contracted, to about 140,000 ha (Table E1). If the higher ground and outer floodplain vegetation is excluded, the 1990s benchmark extent for the ecological community covers about 92,000 ha. Following the Millenium Drought, the 2008 extent of the ecological community was estimated to be 54,000 ha (Table E1). This equates with a decline of about 41% in geographic distribution compared to the 1990s benchmark (as adopted for the Macquarie Marshes Water Management Plan).

The Macquarie Valley experienced relatively wet conditions in 2016 and again between mid-2022 and early February 2023 due to high rainfall and river flows (when the Burrendong Dam remained above 100% of capacity). The combination of water from Burrendong Dam, rainfall and stream flows into the Macquarie River inundated about 232,000 ha of the Macquarie Marshes in Spring 2022 (NSW DPE 2022; Brandis et al. 2023). This included outer floodplain areas that did not receive water from large floods in 1990, 2016 or 2021 (CEWO 2023).

A preliminary comparison of the extent of vegetation functional groups within the Macquarie Marshes between 2013 and 2023 found that non-woody wetland increased from 19,000 ha to 36,000 ha (53% increase) (Table E1). However, between 2013 and autumn 2022 and 2023, amphibious plants in the groundcover began to decline and terrestrial species increased. Therefore, despite some large floods that lead to an increase in vegetation cover over the past decade, overall there has been a loss of cover for characteristic amphibious plants due to less water retained in the landscape overall.

The available data indicates a **substantial** decline in geographic distribution between 1990 and 2008. However, by 2024, draft information suggests that the ecological community has not met the relevant elements of Criterion 1 to make it eligible for listing as Vulnerable. The assessment of this criterion will be finalised when additional important data, information, and analyses,

becomes available later in 2024, such as the Basin Plan Matter 7 (Commonwealth – MDBA/CEWO) and Matter 8 (States) reports.

Consultation Questions on criterion 1. More recent data and analysis on trends will be available and will be incorporated when Murray-Darling Basin Plan reports are released soon. In addition to that:

- Please provide any feedback on the preliminary assessment under Criterion 1 or further data or information that would support or update the assessment?
- If you can provide any additional information, please also provide any relevant references.

6.2.2 Criterion 2 – limited geographic distribution coupled with demonstrable threat

Nominated under Criterion 2 as Vulnerable. May be eligible under Criterion 2 for listing as **Vulnerable or Endangered**

Its geographic distribution is:		very restricted	restricted	limited
Extent of occurrence (EOO)		< 100 km ² = <10,000 ha	<1,000 km ² = <100,000 ha	<10,000 km ² = <1,000,000 ha
Area of occupancy (AOO)		< 10 km ² = <1,000 ha	<100 km ² = <10,000 ha	<1,000 km ² = <100,000 ha
Average patch size		< 0.1 km ² = <10 ha	< 1 km ² = <100 ha	-
AND the nature of its distribution makes it likely that the action of a threatening process could cause it to be lost in:				
the immediate future	10 years or 3 generations (up to a maximum of 60 years)	Critically endangered	Endangered	Vulnerable
the near future	20 years or 5 generations (up to a maximum of 100 years)	Endangered	Endangered	Vulnerable
the medium term future	50 years or 10 generations (up to a maximum of 100 years)	Vulnerable	Vulnerable	Vulnerable

Source: TSSC 2016

Evidence:

This criterion identifies ecological communities that are geographically restricted or limited. Three relevant measures apply: 1) extent of occurrence (i.e. the total geographic range of the ecological community); 2) area of occupancy (i.e. the area actually occupied by the ecological community within its natural geographic range); and 3) patch/occurrence size distribution (an indicator of the degree of fragmentation).

An ecological community with a geographic distribution that is limited, either naturally or through modification faces a higher risk of extinction if it continues to be subject to threats that may cause it to be further degraded, fragmented and potentially lost in the future.

Extent of occurrence (EOO)

The extent of occurrence of the ecological community ranges within the Darling Riverine Plains bioregion of western New South Wales. The estimated EOO is 20,000-97,000 ha (Kingsford & Thomas 1995; Bowen & Simpson 2010; DPI 2013) and would be considered restricted under Criterion 2.

Area of occupancy (AOO)

The estimated area of occupancy for the period 1991-2013 range from about 54,000-92,000 ha (DPI 2013; Bowen et al. 2024) (Table E1). Based on these estimates, the area of occupancy is most likely to be considered limited under Criterion 2.

Average patch size

Concepts of patch size are difficult to apply to a dynamic wetland complex that is connected by channels and multiple overbank flows. Prior to any vegetation clearing or water regulation the system effectively operated as a single connected unit. This is still the case despite clearing, regulation and other threats causing some discontinuities in the natural vegetation of the floodplain and wetlands.

Demonstrable and ongoing threats to the ecological community that could cause it to be lost in the future are outlined in section 4. The cumulative impacts of these threats are having a severe impact on the integrity of the ecological community, and its ability to recover in the future without significant additional intervention, as analysed further under Criteria 3 and 4.

Conclusion

The ecological community has a **restricted** geographic distribution, and the nature of this distribution makes it likely that the action of a threatening process could cause it to be lost in the **near to medium term future**. After preliminary assessment the ecological community may have met the relevant elements of Criterion 2 to make it eligible for listing as **Vulnerable or Endangered**. The assessment of this criterion will be finalised when additional important data, information, and analyses becomes available later in 2024, such as the Basin Plan Matter 7 (Commonwealth – MDBA/CEWO) and Matter 8 (States) reports.

Consultation Questions on criterion 2. More recent data and analysis on trends will be available and will be incorporated when Murray-Darling Basin Plan reports are released soon. In addition to that:

- Please provide any feedback on the preliminary assessment under Criterion 2 or further data or information that would support or update the assessment?
- If you can provide any additional information on the nature of the geographic distribution for the ecological community, please also provide any relevant references.

6.2.3 Criterion 3 – decline of functionally important species

Nominated under Criterion 3 as Critically Endangered. May be eligible under Criterion 3 for listing as **Endangered to Critically Endangered**

Category	Critically Endangered	Endangered	Vulnerable
For a population of a native species that is likely to play a major role in the community, there is a:	very severe decline	severe decline	substantial decline
<i>Estimated decline over the last 10 years or three generations (up to a maximum of 60 years), whichever is longer</i>	<i>80%</i>	<i>50%</i>	<i>20%</i>
to the extent that restoration of the community is not likely to be possible in:	the immediate future	the near future	the medium-term future
<i>timeframe</i>	<i>10 years or 3 generations (up to a maximum of 60 years)</i>	<i>20 years or 5 generations (up to a maximum of 100 years)</i>	<i>50 years or 10 generations (up to a maximum of 100 years)</i>

Source: TSSC 2016

Evidence:

The assessment against this criterion focuses on the vegetative component of the ecological community because changes in vegetative condition and cover have been monitored and offer visible indicators of decline in functionally important species. Two key species and two wetland vegetation sub-assemblages are identified to be most relevant to this criterion, together with their association with aggregating nesting birds.

Arid and semi-arid wetlands such as the Macquarie Marshes alternate between dry and wet phases of varying frequency, regularity and duration and ecosystem resilience is dependent on the capacity of wetland species to survive dry phases, recover and reproduce during wet phases and then return to dry phase survival strategies following flood recession (Colloff & Baldwin 2010). If dry periods become more frequent and prolonged, wetlands, or at least those parts of wetland complexes where changes in flow regimes are most pronounced, may contract or transition to dryland ecosystems over time. This process commences with declines in cover of flow-dependent vegetation and results in increased extent of predominantly terrestrial species and bare ground (Mason et al. 2022; Schweizer et al. 2022). In addition, the critical mature stage of functionally significant trees and their associated fauna, may disappear or become rare, and take a long time to recover.

Eucalyptus camaldulensis (river red gum) – a keystone canopy species

River red gum occurs as a narrow riparian fringe lining the main channel of the Wambuul/Macquarie River, Terrigal Creek and other tributaries, and can also form extensive stands associated with swamps and other low-lying parts of the Macquarie Marshes floodplain.

The biological requirements of river red gum trees in terms of being a long-lived species and inundation periods required for growth and recruitment are outlined in [section 1.2.3](#). River red gums perform a keystone role, including as ecosystem engineers in the ecological community. As the predominant tree canopy species, river red gums, and particularly mature specimens, contribute to habitat complexity and variability, local hydrology, and provide important food, shelter and nesting resources for a wide range of organisms (Wallace 2009). River red gum forest and woodlands are by far the largest vegetation component on the floodplain of the

Wetlands and inner floodplains of the Macquarie Marshes. Floodplain corridors are critically important as refuges in times of drought, particularly for birds. Any long-term decline in the health of river red gums along such corridors has severe consequences for native fauna species across broader areas (MDBC 2003).

Studies and data indicate that there has been a serious loss or decline in condition of river red gum forest and woodland within the area of the ecological community.

- The extent of river red gum forest and woodland in 1991 was estimated to be about 40,139 ha ([Table E1](#)). The extent of river red gums stands in intermediate condition (i.e. exhibiting <40% canopy dieback) was 13,401 ha in 2008 and 19,232 ha in 2013 ([Table E2b](#)). The extent in good condition (i.e. exhibiting <10% canopy dieback) was estimated to be 36,300 ha in 1991, 2180 ha in 2008 and 12,840 ha in 2013. This indicates a severe to very severe decline in condition from the 1991 benchmarks to about 66-94% by 2008 and 52-68% by 2013 (Bowen & Simpson 2010; Capon et al. 2018; Bowen et al. 2019).
- There is also evidence of decline prior to the benchmark year of 1991. The area of Macquarie Marshes on which river red gums grow declined by 50% between 1934 and 1981 (Brander 1987; Kingsford & Thomas 1995). This indicates that the original extent of river red gums in the Macquarie Marshes was substantial, and that the variation in extent and condition of river red gums is a long-term phenomenon.
- A survey of fifty stands of river red gums in the Macquarie Marshes in 2008 found only two stands (4% of the total surveyed) were considered as healthy (Nairn 2008; Nairn et al. 2009). This reduction in health was not due to disease or insect attack. However, there was a marked difference in tree health between sites that were flooded in 2003 and those that have not been flooded since 2000. The major symptom was loss of leaves leading to significantly lower canopy density, and tree death (Bacon 2004; Nairn 2008; Blackwood et al. 2010).
- Steinfeld & Kingsford (2008) observed that 33% of the river red gum sites in the northern area of the Macquarie Marshes contained only dead river red gums following the prolonged Millennium Drought.

The overall conclusion from published studies is that river red gum forest and woodland has undergone a substantial to severe decline in condition within the ecological community for the period up to 2008 (Catelotti et al. 2015; Bowen 2019; Bowen et al. 2019; Mason et al. 2022). Major flooding events since 2008, augmented by environmental water flows, have enabled substantial inundation of most wetland areas in the ecological community with regeneration of the wetland forms of river red gum woodland and forest. However, quality in some areas has lagged and the ecological community will take a very long time to recover from the previous severe to very severe decline (particularly loss of mature river red gums). For example, in the northern Macquarie Marshes, river red gum forest (PCT36) was in intermediate community condition during 2016-2017 and declined to intermediate/poor condition in 2022-2023. River red gum forest (PCT454) was in poor community condition in 2016-2017 and in intermediate community condition in 2022-2023 (NSW DCCEEW in draft a).

Duma florulenta (lignum) – a keystone wetland shrub

Duma florulenta (lignum, tangled lignum) is a key shrub species associated with wetlands and the inland floodplains of the Murray-Darling Basin playing a key functional role for the ecological community, as detailed in [section 1.2.3](#). Its dense stands are particularly important nesting habitat for breeding waterbirds, for instance the straw-necked ibis.

Duma florulenta (lignum) in the Macquarie Marshes can occur as a dominant shrubland and as scattered plants, often in the understorey beneath river red gum stands. There is information that lignum has undergone a severe decline in the ecological community.

- *Duma florulenta* -dominated shrublands have declined in extent from 4395 ha in 1991 to 1507 ha in 2008 (a decline of 66%) and 1442 ha in 2013 (a decline of 67%) (Capon et al. 2018; Bowen et al. 2019) (Table E1).
- There is evidence of long-term degradation of lignum shrublands in the northern Macquarie Marshes Nature Reserve (Bowen & Simpson 2010). A 7 ha occurrence of *D. florulenta* shrublands in 1991 was entirely transitioned to chenopod shrubland in 2008. A 10 ha occurrence was in intermediate condition, i.e. had 10–50% cover of weeds or chenopods. These changes reflect patterns of a changed inundation regime that favours establishment of terrestrial species over flood dependant species.
- *D. florulenta* as scattered understorey plants have also declined. For example, where it occurs with river red gums, reduced inundation regimes result in lignum understorey transitioning to dry land species such as chenopod shrubs.

A preliminary comparison of vegetation extent within the Macquarie Marshes Ramsar sites for 2013-2022 indicated that lignum and river cooba shrublands decreased from 21,000 ha to 12,000 ha. Lignum shrubland (PCT247) was in good condition in 2016-2017 but declined to intermediate condition in 2018-2019 (NSW DCCEEW in draft a). The overall conclusion from these observations is that lignum shrublands, and likely lignum generally, has undergone a substantial to severe decline in extent and condition. Deline of lignum in combination with low water levels, increased predatory impacts and reduced feeding habitat can impact aggregation waterbird breeding events. Wen et al. (2023) found that lignum shrubland required high flow before condition improvement was observed.

Seasonal or intermittent wetland – a key wetland assemblage

Intermittent wetland forms the next largest category of vegetation/wetland type within the Macquarie Marshes. Seasonal or intermittent wetlands are generally characterised by their temporary inundation pattern and dominance by wetland grasses, notably water couch, and tall marsh species, such as reeds and cumbungi. Seasonal or intermittent wetlands are important and functionally significant for the Macquarie Marshes. They provide habitats and refuges for many aquatic fauna and flora. Freshwater algae and numerous aquatic invertebrates such as water fleas, copepods and water insects are adapted to temporary inundation and populations of these groups provide a food source for the many waterbirds in the ecological community. Seasonal or intermittent wetlands also contribute to ecological productivity via detritus and biofilms. The wetlands provide nesting platforms for large breeding aggregations of birds including *Threskiornis molucca* (Australian white ibis) and *Platylea regia* (royal spoonbills), and also for breeding of the threatened *Botaurus poiciloptilus* (Australasian bittern). The large stems and dense thickets of reeds and cumbungi, especially provide protected sites for many birds. Water couch provides food for many waterbird species, especially magpie geese which feed on its prolific seeds.

Availability of wetland habitat is a major driver of waterbird abundance, breeding and diversity. Reductions in habitat area and persistence due to climate change, river regulation and water extraction have resulted in ongoing long-term declines particularly in the Murray Darling basin, which includes the Macquarie Marshes. Purchases and timed releases of environmental water to support breeding or habitat retention have offset some the ongoing impacts of regulation.

However, three major indices for waterbirds (total abundance, number of species breeding and wetland area index) continue to show significant declines over time (Porter et al. 2023).

Seasonal or intermittent wetlands have reduced in extent and/or are declining within the ecological community and the decline is likely to result in a loss of the functional roles associated with this wetland assemblage.

Semi-permanent wetland typically occur near to watercourses and their condition is particularly responsive to the previous six-months of river flow (Bino et al. 2015; Wen et al. 2023). Wetland decline is particularly severe during prolonged dry periods. For example, in the Southern Nature Reserve, Monkey Swamp, Mole Marsh and the East Marsh along the Gum Cowal – Terrigal System, by 2008, at some of these sites almost all seasonal or intermittent wetlands had been replaced by terrestrial species that had transformed the wetlands into a dry form of shrubland.

Phragmites australis (common reed) – a keystone semi-aquatic grass species

The ecological community formerly was associated with the largest, most northerly area of *Phragmites australis* (common reed) beds in south-eastern Australia (EPA 1995; Kingsford 2000; Whitaker et al. 2015). However, the extent of wetlands dominated by common reeds has shown longer term decline. A decline of 50% was noted between 1963 and 1972 (Brander 1987 cited in Kingsford & Thomas 1995). Reed wetlands underwent a severe decline of 61% between 1991 and 2008. Driver & Knight (2007) in Bowen & Simpson (2010) reported that common reed was no longer present at their Integrated Monitoring of Environmental Flows Program (IMEF) monitoring site in the Southern Nature Reserve during the 2005-2006 field survey. By 2013, the extent of common reed was estimated to have been 4,864 ha (Bowen et al. 2019).

Common reed beds are known to be highly persistent as they can survive under a wide range of inundation regimes, including almost permanently inundated conditions. But they typically require flooding events every 1-2 years to maintain persistence (Roberts & Marston 2011). Common reed beds in the southern Ramsar site have particularly declined in extent. These beds were flooded once between 2016-2019 and were considered in poor condition prior to the 2020-2022 flood events (Schweizer et al. 2022), indicative of a long-term decline in extent and condition within the ecological community.

Paspalum distichum (water couch) - a keystone semi-aquatic grass species

Water couch require frequent inundation with persistent surface water for much of the year (Roberts & Marston 2011). Water couch wetlands decreased by 40% between 1949 and 1991 (Brereton 1994; Kingsford & Thomas 1995). In 1991 these wetlands were estimated to be 12,900 ha but had declined to about 912 ha in 2008, representing a very severe decline of 93%. Following post Millenium Drought flows, water couch was estimated to have been 5,354 ha in 2013 (a decline of 59% compared to the 1991 benchmark). Preliminary analysis for the period 2016-2023, indicate that there may have been recovery in extent, but condition varied across the ecological community. For example, water couch in the southern Macquarie Marshes was in intermediate condition in the periods 2016-2017 and 2022-2023 but for the eastern Macquarie Marshes water couch had an intermediate condition in 2016-2017 which improved to excellent condition in 2022-2023 (NSW DCCEEW in draft a). Water couch is even less resilient than common reed, which may have contributed to water couch losses in other areas of the Macquarie Marshes (Bowen et al. 2017; Sandi et al. 2019). Recovery from rootstocks is slower than from seeds and more likely to fail as regeneration depends on the presence of mature, healthy plants with trailing stems (DECCW 2010).

Overall, seasonal or intermittent wetlands altered in area from 18,837 ha in 1991 to 2378 ha in 2008 that remained in good condition ([Table E1](#) and [Table E2a](#)). Another 3835 ha were considered to be in intermediate condition. This represents a severe to very severe decline of 66-87% over that dry period.

The severe to very severe declines in seasonal or intermittent wetland extent observed between 1991 and 2008 (Bowen & Simpson 2010) are additional to substantial declines that occurred during the previous decades. Most areas identified as seasonal or intermittent wetlands in 1991 were replaced by encroaching native chenopod shrubs by 2008. This changed the vegetation from wetland to a drier chenopod shrubland comprised of the relatively short-lived species, *Sclerolaena muricata* (black roly-poly) and *Salsola australis* (buckbush or soft roly-poly). These chenopod shrubs historically have been opportunistic establishers of seasonal or intermittent wetland vegetation (Paijmans 1981 in Bowen & Simpson 2010). They have encroached more persistently into wetland sites due to more severe and prolonged dry phases such that the dry phases approach permanency. Some wetlands also were cleared for cultivation. There is also evidence of increasing salinity and a lack of groundcover to stabilise the soil such that areas of scald are developing through soil loss.

The area of wetland has increased again following more water in recent years. However, the loss of functionally significant plant species, and replacement with more dryland species such as chenopod vegetation is going to take time to recover. In addition, there is evidence that between 2013 and autumn 2022 and 2023, amphibious plants in the groundcover declined again and terrestrial species increased. Therefore, despite some large floods that lead to an increase in vegetation cover over the past decade, overall there has been a loss of cover for characteristic amphibious plants due to less water retained in the landscape overall. In addition, recovery of key aquatic or semi-aquatic species is likely to be challenged by the impacts of other multiple threats, particularly major hydrological changes, the spread of invasive species and climate change (as set out in [section 4](#)).

The overall conclusion is that seasonal or intermittent wetlands have undergone a severe to very severe decline in their extent and condition and that their replacement by more dryland shrubland is having a significant impact on the structure and function of the ecological community as a wetland.

Potential to recover

Comparisons for two functionally important plant species and key wetland assemblages indicate they have undergone a severe to very severe decline. These changes have fundamentally altered the ecological function of the ecological community. The Macquarie Marshes are nationally and internationally recognised as important habitat for 72 species of waterbirds, over half of which use the habitat as a breeding ground (Kingsford 2000). The decline and death of key native vegetation components throughout the Macquarie Marshes has led to reduced densities and numbers of waterbird species, as well as smaller aggregation sizes and less frequent breeding of waterbirds (Kingsford & Johnson 1999; DECCW 2010; Bino et al. 2014; Kingsford et al. 2017; Brandis et al. 2022; Porter et al. 2023).

The Macquarie Marshes have been deprived of adequate waterflows from long-term over-regulation of the Wambuul/Macquarie River. The degree of extraction is considerable. The density of earthworks in irrigated areas by 2005 had quadrupled since 1949 (Steinfeld & Kingsford 2008; 2011). The Wambuul/Macquarie River system covers nine large dams, eight weirs, four bypass channels and a river transfer scheme that supplies water for irrigation,

industry and towns (Kingsford 2000). The Macquarie River floodplain also contains 338 km of levees, 1648 km of channels, 54 off-river storages and 664 tanks (Steinfeld & Kingsford 2008; 2011). As the Macquarie Marshes is a flood-dependent community, the pressure from such water demands for irrigation and industry, exacerbated by drought, will likely lead to the continued decline in functionally significant species within the ecological community.

The extent and duration of environmental flows under current conditions of river regulation, water extraction and climate are limited and insufficient to provide the water needs to maintain wetland vegetation and remove accumulated salts from the soils within that floodplain (MDBC 2003; Neilsen & Brock 2009). Disturbance from the various threats in the Wetlands and inner floodplains of the Macquarie Marshes ecological community is likely to result in further decline in condition, and loss of wetland function as well as changed patterns of survival and recruitment, which may manifest over decades.

Some seasonal or intermittent wetland species may have capacity to recover quickly when hydrological connectivity is restored if longer-lived seed banks or rhizomes adapted to variable periods of wet-dry cycles are retained. They could respond quickly to inundation events. For example, substantial water couch regrowth occurred in autumn 2024, within 17 water couch sites, three were in flower and eight were fruiting (NSW DCCEEW in draft b). However, this may not apply to areas replaced by more dryland shrubs such as saltmarsh. It is also less likely to apply for longer-lived woody species such as river red gums and lignum that may have episodic recruitment dependent on particular flooding or other environmental cues, but where mature forms take a long time to develop and are impeded from reaching maturity by a range of threats.

Reductions in flood extent and frequency have resulted in declines in condition (and extent) of wetland vegetation in the Macquarie Marshes Ramsar site (Thomas et al. 2011, 2015; Ralph et al. 2016; Bowen et al. 2019; Mason et al. 2022). Increased flooding 2020–2022 has probably aided in the condition of vegetation within the Ramsar site. For example, at the northern Ramsar site annual flooding occurred across the reed beds of *Phragmites australis*, between 2016 and 2019, adequate for their water requirements (Schweizer et al. 2022). In the southern Ramsar site however, reed beds which are declining in extent (OEH 2012) were flooded only once between 2016 and 2019 and remained in poor condition for prolonged periods.

Conclusion

- Certain functionally important elements of the ecological community have undergone a **severe to very severe** decline, notably river red gum, lignum, and certain types of seasonal or intermittent wetlands such as reed and water couch marshland wetlands.
- The nature of multiple ongoing threats and insufficient environmental water flow allocations are likely to continue into the future, exacerbated by climate change.
- Restoration of the ecological community as a whole is unlikely to occur within the immediate to near future.

After preliminary assessment, the ecological community may have met the relevant elements of Criterion 3 to make it eligible for listing as **Endangered or Critically Endangered**. The assessment of this criterion will be finalised when additional important data, information, and analyses becomes available later in 2024 such as the Basin Plan Matter 7 (Commonwealth – MDBA/CEWO) and Matter 8 (States) reports.

Consultation Questions on criterion 3. *More recent data and analysis on trends will be available and will be incorporated when Murray-Darling Basin Plan reports are released soon. In addition to that:*

- Please provide any feedback on the preliminary assessment under Criterion 3 or further data or information that would support or update the assessment regarding trends in functionally significant species?
- If you can provide any additional information, please also provide any relevant references.

6.2.4 Criterion 4 – reduction in community integrity

Nominated under Criterion 4 as Critically Endangered. May be eligible under Criterion 4 for listing as **Endangered to Critically Endangered**

Category	Critically Endangered	Endangered	Vulnerable
The reduction in its integrity across most of its geographic distribution is:	very severe	severe	substantial
as indicated by degradation of the community or its habitat, or disruption of important community processes, that is:	very severe	severe	substantial
<i>such that restoration is unlikely (even with positive human intervention) within</i>	<i>the <u>immediate</u> future (10 years or 3 generations up to a maximum of 60 years)</i>	<i>the <u>near</u> future (20 years or 5 generations up to a maximum of 100 years)</i>	<i>the <u>medium-term</u> future (50 years or 10 generations up to a maximum of 100 years)</i>

Source: TSSC 2016

Evidence:

Multiple interacting threatening processes are causing severe reductions in integrity and degradation of ecological functions in the ecological community, across its geographic range. The ecological community has undergone severe changes in structure and function as a result of the threats outlined in [section 4.1](#).

The ecological community has experienced a reduction in integrity and associated degradation of community composition, habitat and processes, across most of its extent primarily because of:

- Altered hydrological regimes
- Changes in abundance and diversity of key species (further to the declines in functionally significant species as outlined fully in the criterion 3 analysis)
- Loss of connectivity
- Fire regimes that cause declines in biodiversity
- Invasive species and diseases
- Climate change

Reduction in integrity due to altered hydrological regimes

Altered hydrology particularly relates to changes in water flows in the ecological community (frequency, extent, magnitude and duration). These changes are a result of river regulation that have changed natural inundation and flooding patterns, exacerbated by drought and climate change. Environmental watering, to date, has been insufficient to completely address these changes. Assessment of environmental water requirements under the Basin Plan for the Macquarie Marshes reported significant changes to the flow regime of the Macquarie River due to river regulation and extraction since the construction of Burrendong Dam (MDBA 2012a, 2012b; DPIE 2020e; NSW DCCEE 2023). These include:

- reduced moderate-to-high flows in the Macquarie River and end-of-system flows
- a significant reduction in the frequency of floods and the area regularly inundated in the Macquarie Marshes
- an increase in the average period between large flows that exceed 200 GL at the Oxley gauge, as measured in the higher flow period between 1 June to 30 November. The

average period increased from 2.2 years to 4.7 years. A reduction in the average volume of large flows also was observed, from 328 to 278 GL per event

- a reduction in the number of small flows likely to cause flooding passing the Oxley gauge since construction of Burrendong Dam, and
- permanent low flows in some previously intermittent streams.

There have been major changes to the natural flow regime of the Macquarie River, particularly since the construction of Burrendong Dam in 1967 (Kingsford and Thomas 1995; Thomas et al. 2011). In a study of Macquarie Marsh sediment, Yu et al. (2015) concluded the increased sedimentation rate and turbidity between the 1940s and 1970s were related to land use change in the broader catchment. These changes have also affected flora and fauna. For example, waterbird populations (Kingsford & Thomas 1995; Kingsford & Johnson 1998; Kingsford 2000; Kingsford & Auld 2005) and the extent of semi-permanent wetland vegetation (Bowen & Simpson 2010; Thomas et al. 2010). The effects of water regulation have reduced flow variability within and between years within the ecological community, which generally favours introduced species with regular, seasonal life cycles, over native species that have life cycles adapted to highly variable patterns of water flow. It has also impacted longitudinal (stream) flow and lateral connectivity (overbank flow from the stream to the floodplain).

A study by Mason et al. (2022) detected depressed responses to flooding of semi-permanent wetland sites where the pre-flooding inundation interval exceeded identified inundation thresholds, in this case three years. Suppressed wetland recovery by exceeding inundation thresholds included changed species assemblages, increased terrestrial species cover and increased exotic species richness (compared to cover of native amphibious plant species).

An assessment undertaken by Wentworth Group (2020) considered expected and actual flows under the Basin Plan upstream of Ramsar-listed wetland sites in the northern Basin for the periods 2012/13-2018/19. It was found that the seven years from 2012 to 2019 were drier than the long-term average (1911-2019), included both dry and wet years. For the 2012/13-2018/19 period the Macquarie Marshes only received 63-78% of the flows expected.

As noted in Criterion 3 and [Table E1](#), the extent and condition of flood dependent woody communities has been impacted by changes in hydrological regimes. For example, the condition of river red gum woodlands and forest during dry periods had declined since 1990 by approximately 66-94% by 2008 and 52-68% by 2013 following extensive disruptions to flows and inundation regimes. So too, the extent of *Duma florulenta* - dominated shrublands had declined by about 66% in 2008 and 67% in 2013 (Capon et al. 2018; Bowen et al. 2019). Although recent surveys indicate that river red gum communities have expanded in extent following major flooding events and managed environmental flows, community condition has not improved beyond intermediate/poor in many surveyed areas (NSW DCCEEW in draft a).

Within the Murray-Darling Basin, Saintilan et al. (2022) noted that reduced flooding frequency has promoted expansion of river red gum regrowth into areas of reed beds and freshwater grasslands (Bren 1992; Colloff 2014; Bowen et al. 2017). Although spike-rush (*Eleocharis* spp.) swamps have shown post-drought recovery (Wassens et al. 2017), this has not been observed for wetland grasslands dominated by *P. spinescens* and *P. distichum*, which may have declined at several locations, often with river red gum regrowth expanding into these areas, albeit the trees may not survive to maturity (Vivian et al. 2015; Wassens et al. 2017; Saintilan et al. 2021).

The shift in high flow seasonality is likely to be contributing to fauna loss or decline in the Macquarie Marshes as the evolution and/or behavioural mechanism of the native organisms is

adapted to the natural flood timing (King et al. 2009). For example, the shifts in flow seasonality can lead to loss of cues for fish spawning and migration (Wen et al. 2013). Ideally, flows should occur annually for native fish dispersal and habitat maintenance. Prior to 2022-23, the lower Macquarie experienced prolonged cease to flow conditions in many other years (CEWH 2023).

Changes in abundance and diversity of key species - Waterbirds

Many waterbird species are opportunistic breeders, nesting when wetland conditions are suitable (Brandis 2010; Brandis 2011; Brandis et al. 2011). There are few wetlands in semi-arid eastern Australia that provide both breeding and foraging habitat such as the Macquarie Marshes ecological community, where nesting birds can form large aggregations (>10,000 nests) which are important for broader population growth (Brandis et al. 2021).

Aggregating breeding waterbird species have specific nesting requirements which dictate where nesting occurs. Vegetation structure and condition are essential in providing breeding platforms that influence reproductive success (Leslie 2001; Bechet 2009; Frederick 2009). There is anecdotal evidence that site fidelity exists in colonially breeding waterbirds in Australia. For example, marked intermediate egrets returned to natal sites (where they were hatched) in the Macquarie Marshes (Brandis et al. 2022).

Waterbirds are responsive to changes in the ecological character of wetlands and their inundation patterns. Impacts to bird fauna have been well studied through the long-term Eastern Australia Aerial Waterbird Survey conducted annually (October-November) since 1983 (Kingsford et al. 2012; Brandis et al. 2021, 2022, 2023). Key findings from the Eastern Australia Aerial Waterbird Survey include:

- Aggregating waterbird breeding is closely connected to flooding with large flows and flooding extent resulting in large, numerous breeding events.
- Numbers of breeding waterbirds exhibited considerable variation over the survey period, but highs and lows generally corresponded to periods of flooding and drying.
- Significant shifts in the composition of waterbird communities over time were also apparent in regulated wetlands, particularly Macquarie Marshes.
- Water volume and extent is important to breeding initiation, while flood duration and water quality are critical to successful breeding events.
- During the 2007-2020 survey period, waterbird aggregation breeding events exceeding 100,000 nests occurred once in 2010-11 (125,422) (Brandis et al. 2022).
- During the high flow periods of 2021-2022 (116,000) and 2022-23 (116,000) nests were recorded. Inundation of rookery sites over the survey period was maintained though the management of flood mitigation releases following Spring inflows including tributary and managed environmental flows (Brandis et al. 2023).
- Additional environmental water flows supported inundation of waterbird rookery sites and foraging grounds and successful completion of waterbird breeding during 2021-2023.

Aggregating waterbirds are important components in wetland ecosystems and are often used as indicators of wetland health (Kingsford 1999). Meeting the requirements of inundation duration, water depth and timing of flows are critical components of water management that support ecologically functional large-scale rookeries successfully aggregating waterbird breeding. In the Macquarie Marshes where there are many rookery sites with a diverse range of aggregating breeding species e.g., ibis, egrets, herons, cormorants, it is a challenging task to support all sites with environmental water. Reductions in flow can drop water levels, reducing the duration of

flooding and triggering desertion by adult birds with high chick mortality, particularly in ibis (Kingsford 1998; Brandis et al. 2011; Brandis et al. 2022). This is particularly true for sites where mechanisms for water delivery are limited (Brandis et al. 2023). For example, during 2016-2017, late-nesting straw-necked ibis, glossy ibis and royal spoonbill colonies at Zoo Paddock suffered significant losses (more than 80%) from ground-based predators as floodwaters receded, and it was not possible to deliver environmental water to maintain water levels (Brandis 2017).

Management of flows is also important to ensure good water quality. Poor water quality and stagnant water can result in blue-green algae, large quantities of decomposing vegetation and promote conditions that can result in avian botulism outbreaks and other diseases (Brandis et al. 2019, 2023). Severe dry periods from 2009 typically restricted inundation to core wetland areas as there is little to no tributary flows and environmental water to the wetlands was limited in volume, extent and duration. Surveys of the number of waterbird nests in the Macquarie Marshes ecological community during these drier periods found that they were restricted and ranged from 4-2661 (Brandis et al. 2022).

Aggregating waterbird breeding is closely tied to overbank flooding and inundated wetlands (Kingsford & Thomas 1995). Analysis of historical flows and aggregating waterbird breeding (all species) found that large or numerous breeding events were closely linked to large flow events (Brandis & Bino 2016; Brandis et al. 2023). Despite recent large breeding aggregations in 2021-2022 (Brandis et al. 2023) at Macquarie Marshes, there has been an ongoing trend of smaller aggregations and less breeding events in recent decades, and the success of breeding events has been poor in many years. McGinnis et al. (2023) found that there has been a 30% decline in preferred foraging habitat for some waterbird colonies in the Macquarie Marshes (for the period 2013-2022 compared to 1988-1997). Overall declines in hydrology and aquatic vegetation together mean a broader loss of integrity and disruption of key ecological processes for the ecological community.

Changes in abundance and diversity of key species - Woodland birds

Floodplain ecosystems are under stress from multiple threatening processes including changes to the hydrologic regimes (Robertson & Rowling 2000; Mac Nally et al. 2011; Mott et al. 2020). Floodplain wetlands such as the Macquarie Marshes tend to have higher productivity than surrounding non-floodplain/dryland habitats, and a microclimate that is moderated from temperature extremes by the presence of water in streams and river channels. Floodplains become important refuges for terrestrial/woodland birds during times of drought (Selwood et al. 2015, Nimmo et al. 2016, Selwood et al. 2018). They also enhance resilience by supporting post-drought recovery and recolonization of non-floodplain habitats (Selwood et al. 2019).

Blackwood et al. (2010) undertook autumn and spring bird surveys among stands of river red gums in the Macquarie Marshes following a long dry period. Species richness, abundance and microhabitat preferences were recorded at each site along with vegetation characteristics. It was found that:

- Healthier vegetation had higher abundances of foliage specialist birds, reflecting greater canopy cover. Foliage specialists, such as striated pardalote, weebill, grey fantail and crested shrike-tit, were most affected by river red gum decline, with declining canopy cover causing decreased abundances. Live branch specialists, such as galah and white-breasted cuckoo-shrike were most abundant at healthy sites.

- Floodplain communities in poor health had high abundances of birds that are typical of disturbed, open agricultural areas for example, crested pigeon and rufous songlark. Some sites also had a higher abundance of dead tree specialists, such as hooded robin, southern whiteface and crested pigeons.
- The bird communities of three terrestrial sites further out on the floodplain, and chosen for comparison, were similar to those of the poor and intermediate categories. This indicated the wetland system had become more terrestrial during prolonged dry periods.
- Patterns of the woodland bird community significantly correlated with changes in tree health and habitat structure which included: canopy density, bare ground cover, shrub cover, percentage of dead branches and presence of large coarse-woody debris.
- Good quality sites were typified by trees with a dense canopy, more leaf litter and a low green herbaceous understorey. Poor sites had trees with thin or absent canopy, more bare ground and a tall, dry, shrubby understorey. The abundance of small trees was significantly different among health categories, with high abundance at good sites reflecting more favourable flooding conditions in recent years. There was no difference in abundance of hollows among the three health categories, but the number of fruiting river red gums differed, being higher for healthier trees.

Changes in the woodland bird community and associated vegetation features are linked with flood and fire history, reflecting long term degradation. Habitat quality of poor sites are likely to degrade further, as dead trees fall over or burn, reducing the availability of perches and nesting hollows. The loss of mature trees with hollows impacts the breeding of many woodland birds such as *Cacatua galerita* (sulphur-crested cockatoo), the endangered *Lophochroa leadbeateri* (pink cockatoo), the vulnerable *Neophema chrysostoma* (blue-winged parrot), *Ninox connivens* (barking owl) and the vulnerable *Polytelis swainsonii* (superb parrot). Loss of mature trees also impacts waterbirds that nest in hollows, such as *Anas castanea* (chestnut teal), *Chenonetta jubata* (Australian wood duck) and *Tadorna tadornoides* (Australian shelduck).

Changes in abundance and diversity of key species - Fish

Delivering a native fish connection flow is dependent on sufficient water being available at a time best suited for fish to move and disperse (CEWO 2020). In addition, water temperature is critical for spawning by both native and invasive species. For example, following a flow event three alien species recruited earlier than native species. Alien fish spawning was able to occur before temperatures were high enough to stimulate native fish spawning (Rayner et al. 2015). Releases of cold water from Burrendong Dam depress the annual thermal maxima by 8-12°C and displace high temperatures by 1-3 months (Lugg 1999; Preece & Wales 2004). This cooling may extend to the Macquarie Marshes (Boys et al. 2009) contributing to low rates of native fish spawning and recruitment, and the dominance of alien species (Rayner et al. 2015).

Observations following a large winter flood which was supplemented by two environmental watering events in September 2010 and 2011 indicated a strong recruitment response amongst alien but not native fish species (Rayner et al. 2015). This was attributed to the timing of flows providing optimal conditions for spawning amongst alien fish species with spawning thresholds for native fish not being met. Following this event, alien fish species outnumbered native fish species by more than four to one. According to the Sustainable Rivers Audit (MDBA 2015), the condition of the native fish community in the Macquarie Marshes at this time was considered extremely poor (Stocks et al. 2016). In addition, the community was dominated by small to medium sized species with freshwater catfish, golden perch and Murray cod only present in low numbers.

Flows for native fish flow specialists were met in 2012-13, 2020-21, 2021-22 and 2022-23. However, prolonged drought conditions prior to 2020 resulted in the maximum interval of four years between flow events being exceeded. In 2019-20, tributary flows contributed to priming and dispersal flows. Spawning flows were not achieved at times that temperatures were suitable, and/or the required flow rates were not achieved along the Macquarie River/Wambuul down to Marebone. (CEWH 2023). Disruption to river channel and overbank flow have impacted other aquatic species such as freshwater mussels, which are extremely vulnerable when rivers dry out during intense drought or periods of low flow such as during the Millennium drought. For example, *Velesunio ambiguus* (floodplain mussels) can survive for months under drying conditions in certain circumstances when temperatures are low. However, *Alathyria jacksoni* (river mussels) can only survive for weeks under the same conditions with survival times decreasing to days for both species as temperatures increase (CEWH 2023).

Reduction in integrity from loss of connectivity

The hydrological connection between the floodplain, streams and river, is of critical importance to ecological functions and interactions for the Macquarie Marshes (Goode & Harvey 2009; Steinfeld & Kingsford 2011; Karimi et al. 2021). Vegetation communities on the floodplain require periodic inundation to maintain condition (Wen et al. 2009; Thapa et al. 2020) and germination (Capon & Brock 2006). The floodplain flora and fauna depend on the river for dispersal and replenishment, and in turn, riverine species depend on the floodplain for food, nurseries and refuges (Walker 2001). Overbank flow provides linkages between the river and floodplain and consequent exchange of water, organic material, nutrients and organisms (Junk et al. 1989; Robertson et al. 1999; Tockner et al. 2000; Junk & Wantzen 2004). Connectivity with the floodplain not only provides critical habitats for short-lived species but supports recruitment and growth of medium-long lived species (for example golden perch and Murray cod) by providing productive recruitment habitats and increasing in-stream productivity and subsequently food resources (MDBA 2017). Connectivity of the waterways of the ecological community with the floodplain is also critical for influencing exchange of nutrients and biota as well as maintaining wetting and drying cycles. These cycles support ecological functions and interactions (Goode & Harvey 2009). An aquatic ecosystem may appear to be continuous, or as large patches. However, it may in effect be fragmented by barriers to water and movement such as the inclusion of works that modify the natural flow of the system.

The river channel, unlike most floodplain habitats within the Macquarie Marshes, is generally characterised by strong currents, unstable sediments and a shallow light zone. The distribution of aquatic/emergent plants is influenced by the frequency of flooding and exposure (Walker et al. 1994; Blanch & Walker 1998; Blanch et al. 1999, 2000). Wetlands are adapted to intermittent periods of wetting and drying and the wetting-drying sequence is also important for habitats within the river channel habitat of the ecological community (Passfield et al. 2008). Changes in the water level in the channel affect the growth of biofilms that provide food for fish, snails and other grazing invertebrates (Walker 2001). However, regulation has tended to decrease the frequency of overbank flows and connectivity between the channel and floodplain (Walker 1991).

Overbank flows are a critically important driver of biological diversity in river systems and provide connectivity with adjacent floodplains (Steinfeld & Kingsford 2011; Karimi et al. 2021). Overbank flows inundate habitats beyond the river channel, creating opportunities for species to move to new habitats. This can provide opportunities to breed in non-permanent water bodies that are connected to the main channel. Hydrological connectivity via overbank flows also help

to maintain water quality in refuge habitats and floodplains that provide temporary aquatic habitats for opportunistic species. Overbank flows provide roosting and nesting habitat for waterbirds, with each species requiring specific depth and duration of inundation beneath nests if successful fledging is to occur (Arthur et al. 2012; Rogers & Ralph 2011; Wakeley et al. 2007). Overbank flows fill floodplain depressions (cut-off meanders, billabongs), used by frogs, turtles and some species of fish (Chessman 2011; Wassens et al. 2013) (Karimi et al. 2021).

As outlined in [section 1.2.4](#), river channels within the ecological community transport water, sediment and other material, and provide a corridor for dispersal, and the floodplain is the site of key biological processes. Connectivity along the river channel, between the channel and floodplain, as well as throughout the drainage network is important for flora and fauna species. For example, Leigh & Zampatti (2013) found from radio tracking of Murray cod that connectivity between the main channel and off-channel habitats was critical to their movement and reproductive success. The floodplain is dependent on flows in the river and the fauna and flora of the channel also depends on access to floodplain habitats and resources.

Large flood events occurred during 2010-11, inundating about 80% of the Ramsar site, with significant flooding also occurring in 2016-17 (about 75% inundated) to improve connectivity. This was preceded by a three-year period comprising relatively small inundation events. Between 2009-2017, all four Ramsar sections received some inundation in areas each year. However, lower proportions of the southern Ramsar section have generally been inundated in response to particular events compared with other sections. For example, in 2010, the northern section and Wilgara were almost entirely inundated while only about 50% of the southern section was flooded (Capon et al. 2018).

The Wambuul/Macquarie River Valley experienced very hot and dry conditions between 2017 and 2022. During this period rainfall was well below average, and the highest temperatures were recorded. Inflows to Burrendong Dam have been extremely low during this time, with the lowest inflows on record. With new drought of record conditions in the Wambuul/Macquarie River Valley, access to general security and planned environmental water accounts was restricted. This limited the volume of NSW and Commonwealth water for the environment that was delivered to support wetland vegetation and native fish in 2018-19. Further flow restrictions were put in place in 2019-20. Consequently, no water for the environment was able to be delivered as the extreme drought continued. The mid- Wambuul/Macquarie River was shut off downstream of Warren in late August 2019, resulting in cease to flow conditions, necessitating the rescue of native fish from drying refuge pools over summer. Ongoing very hot and dry conditions affected the condition of vegetation in the Macquarie Marshes. In addition, during the spring and summer large areas had little or no ground cover. A fire in spring 2019 also burnt large areas of the north marsh reedbed (part of the Ramsar site) (CEWO 2020). Together, these factors contribute to a high degree of fragmentation and reduced connectivity of the natural Macquarie Marshes system.

Therefore, regulation (and infrastructure) and reduced flows have led to hydrological disconnection within different wetland habitats and the ecological community more broadly.

Loss of integrity due to changing fire regimes

Part of the threat from fire to the ecological integrity of the Macquarie Marshes is large, high intensity wildfires that could occur after prolonged dry periods and under adverse weather conditions. Such fires threaten river red gum, reed bed and woodland vegetation components of the ecological community (OEH 2013). Fires are becoming more frequent, more severe and

larger due to increasing drought incidence and severity on fuel moisture and the increasing incidence of severe fire weather conditions during dry periods. For example, in 2019, record drought coupled with an intense wildfire impacted about 3000 ha of reedbed in the Macquarie Marshes. Approximately 86% (3000 ha) of the northern reedbed, which also included some river red gum woodland, was severely burnt following a lightning strike.

Reedbeds can withstand low intensity fires, particularly when soil moisture is high. Severe hot fires that damage the underground stems (rhizomes) may impact the ability of reeds to recover. During prolonged drought conditions, flows to the northern reedbed had ceased for around 10 months. This left soil moisture within the reedbed depleted and stalled recovery until environmental flows instigated regrowth (CEWO 2021).

Ephemeral wetlands dominated by tall species such common reed (*Phragmites* sp.) and cumbungi (*Typha domingensis*) require an interval of more than two years between fire events and ideally would include two sustained periods (six or more months) of inundation to allow wetland biota to complete several lifecycles (DPIE 2020f).

High intensity wildfires have also occurred in common reed beds within the northern Macquarie Marshes during 2013-14, 2014-15 and 2015-16. DPIE (2020f) noted that entire reedbeds may burn out during dry conditions and that fire thresholds have been exceeded for large areas within the northern extent of the ecological community.

Loss of integrity due to invasive species and disease

Invasive plant and animal species can change the structure and floristic diversity of natural vegetation by smothering and shading out native plants, changing soil structure and chemical composition and limiting recruitment of native plants through grazing and trampling, and competition for nutrients and water (section 4.1). Several feral/unmanaged animal species have been recorded in and adjacent to the Macquarie Marshes and subject the ecological community and the broader landscape to individual and compounding impacts such as potentially major habitat disturbance, predation of native animals, competition for resources such as through herbivory, weed spread and direct transmission of disease and parasites.

Introduced mammal fauna, including *Capra hircus* (goat) and *Sus scrofa* (feral pig), have spread across the distribution of the ecological community (OEH 2012).

Goats and pigs damage the ecological community by impacting plant species richness, removing mature and establishing flora species, opening up the canopy and ground layers and destroying soil structure when exposing the substrate to direct sunlight, inducing drying. These disturbances also influence soil chemistry and fungal and microbial life. These activities can also help to spread pathogens into the wetlands. Although mostly herbivorous, pigs will predate upon and compete with native fauna including earthworms, centipedes, beetles, crustaceans and other arthropods, snails, frogs, lizards, snakes, small ground nesting birds and their eggs, small mammals, turtles and crayfish (Choquenot et al. 1996; Mitchell 2010; Wishart et al. 2013).

Lepus capensis (brown hare) and *Oryctolagus cuniculus* (rabbit) also degrade vegetation and soils in the ecological community. These effects are likely to be amplified during dry periods and in post-fire environments, reducing seedling establishment as well as survival of resprouting foliage, and degrading habitat for a range of ground-dwelling fauna that shelter and forage in the ecological community. Occurrences of the ecological community adjacent to or within grazing lands are also exposed to degradation, unless effective exclusion fencing is maintained. Total

grazing pressure and trampling within wetlands directly removes vegetation, particularly in the wetter areas which is used by fauna species such as *Hydromys chrysogaster* (rakali), reptiles and amphibians for shelter.

Felis catus (feral cat), *Vulpes vulpes* (red fox) and, to a lesser extent, *Rattus rattus* (black rat) prey on native fauna that are part of the ecological community, particularly ground dwelling reptiles, mammals and ground feeding and nesting birds. Foxes can also spread weed species through seed distribution or soil disturbance. Trends in fox densities are estimated to range up to 4/km² in wetlands and productive areas (Hradsky et al. 2021). Cats and foxes may be responsible for declines in a range of common and rare vertebrate wetland fauna due to predation of adults, juveniles and eggs. This includes reptiles such as *Chelodina expansa* (broad-shelled turtle), *Chelodina longicollis* (eastern long-necked turtle), *Emydura macquarii* (Macquarie River turtles) (Ocock et al. 2018; Chessman 2022), threatened birds such as *Botaurus poiciloptilus* (Australasian bittern) and amphibians. Predation by carnivorous fauna also increases in a post-fire environment (Brock 1998; OEH 2012).

Invasive weeds degrade the biodiversity of the *Wetlands and inner floodplains of the Macquarie Marshes* ecological community because they change the wetland habitat and species composition. The seeds of many weed species within the ecological community have been introduced either in fodder, via the coats or digestive systems of introduced and native grazing animals or as purposeful introductions as pasture species (Casanova 2006).

Phyla canescens (lippia) is widespread throughout the ecological community, particularly in riparian and floodplain areas, and a particular threat to the *Paspalum distichum* (water couch) meadows. Lippia plants are highly competitive. Even though the plants lose their above-ground parts due to prolonged inundation, as waters recede, they can re-establish quickly from the crown of the tap root and return to pre-disturbance cover within 85 days (Macdonald 2008; Roberts & Marston 2011). The drying out of cracking floodplain soils covered with lippia can result in the collapse of creek banks and other steep slopes during droughts (McCosker 1994; Crawford 2008; Whalley et al. 2011). Floodplain erosion affects water quality through the introduction of sediments to water channels (Arp & Cooper 2004; Casanova 2006).

Other introduced plants include *Cuscuta campestris* (golden dodder), *Eragrostis pilosa* (lovegrass), *Lycium ferocissimum* (African boxthorn), *Phyla canescens* (lippia), *Solanum* spp. (nightshades), *Xanthium occidentale* (noogoora burr) and *X. spinosum* (Bathurst burr). These invasive species degrade the ecological community by smothering native plant species and transforming vegetation structure and animal habitats (Whalley et al. 2011).

NSW DPE (2020) noted that within river red gum forest and woodland and non-woody wetland sites, about 29% of plant species were exotic. Terrestrial species distribution and presence are dependent on hydrological regimes, with exotic species richness typically decreasing as inundation duration increases. Capon et al. (2018) reviewed the total exotic species cover of key vegetation types within the Macquarie Marshes Ramsar site for the period 2007-2017. More exotic species were recorded from river red gum woodland and forest sites than any in other vegetation communities. The cover of exotic species, both in terms of cover percentage and proportion of total cover, peaked in dominance for lignum shrubland during 2013-2014 (about 32%) and water couch marsh during 2015-2016 (about 40%).

The ecological community supports diverse frog fauna (at least 18 species) across a range of habitat types. The amphibian disease chytridiomycosis, caused by the pathogen *Batrachochytrium dendrobatidis*, has dramatically affected amphibians across eastern Australia,

causing population declines. Amphibian infection prevalence and mortality rates are dependent on ambient environmental conditions: being highest during cooler months and at higher elevations (Ocock et al. 2013). During fieldwork undertaken in the Macquarie Marshes by Ocock et al. (2013), seven frog species were found to be infected with the *Batrachochytrium dendrobatidis* pathogen. Although these species appeared abundant, long-term, quantitative distribution and abundance data are absent, preventing an accurate assessment of frog population trends. Wassens (2008) noted that in other arid regions of Australia, amphibian population declines have been observed in similar habitats.

There is a general declining trend of native fish species recorded within the Macquarie Marshes and Macquarie River. Rayner et al. (2009, 2015) and Stock et al. (2016) concluded that the condition of fish species within the Macquarie Marshes was in poor condition and possibly declining. Eight native fish species were observed for the period 2007-08, seven in 2010-11 and six in 2014-15 (Capon et al. 2018). There has been an increased ratio of alien to native fish, including *Cyprinus carpio* (European carp), *Gambusia holbrooki* (eastern gambusia) and *Perca fluviatilis* (redfin), observed between 2009 and 2015 (Rayner et al. 2009, 2015; Capon et al. 2015; Cruz et al. 2020). Observations following a large winter flood which was supplemented by two environmental watering events in September 2010 and 2011 indicated a strong recruitment response amongst alien but not native fish species (Rayner et al. 2015). This was attributed to the timing of flows providing optimal conditions for spawning amongst alien fish species with spawning thresholds for native fish not being met at that time. Following this event, alien fish species outnumbered native fish species by 4.3:1. The Sustainable Rivers Audit (MDBA 2015), found that the Macquarie Marshes was dominated by small to medium sized species with native freshwater catfish, golden perch and Murray cod only present in low numbers. Capon et al. (2018) noted that high carp recruitment has also been observed following flow events. Cruz et al. (2020) found that two non-native species were particularly abundant during a major flooding event, outnumbering native species in a ratio of 32:1, with *Gambusia holbrooki* the most abundant species, comprising 87% of all native and non-native individuals captured.

Reduction in integrity due to climate change

Climate change is having direct ecological effects (e.g. from more severe drought); and it interacts with other factors such as water flows and fire regimes. More severe droughts exacerbate the ecological impacts of river regulation (Mathwin et al. 2022). Declines in rainfall (locally and within the catchment) directly affect plants, and changes hydrology within the ecological community. For example, through slower growth to maturity, reduced fecundity and increased mortality during extended droughts (Keith et al. 2014). The capture of small and medium flood events in headwater dams and other infrastructure reduces downstream wetland inundation (Frazier & Page 2006) and amplifies drought impacts (van Dijk et al. 2013). The flood peak and frequency of overbank flooding are reduced and may be displaced over time (Nilsson & Berggren 2000). Consequently, connectivity between river and floodplain decreases (Kingsford 2000; Thomas et al. 2011).

Greater fire frequency and intensity due to changed climatic conditions affects the ability of plants to recover and recruit, as well as impacting on faunal populations. A drying climate will lead to hotter and more frequent fires, which may have a much greater effect than currently assumed because of shallow water levels of this ecological community during dry periods and seasons (Rawson 2016; Saintilan et al. 2022). Functionally significant species such as river red gums are particularly susceptible to severe or frequent fire. Mature, established lignum plants are more resilient and can persist in an inactive, dormant state for long periods, actively growing

again when conditions become favourable during flooding or heavy rainfall (Craig et al. 1991). However, the likelihood of successful regeneration from dormancy becomes highly variable if flood frequencies decline and dry periods become extended (Freestone et al. 2017). Predicted increase in the frequency of droughts and a decline in rainfall and surface water availability as a result of climate change is likely to significantly impact the condition and extent of existing mature lignum shrublands and their capacity to regenerate from dormancy (Roberts & Marston 2011; Freestone et al. 2017; Neilson et al. 2017). The individual and combined effects from threats, particularly those exacerbated by climate change, are adversely affecting recovery.

Conclusion

The combination of threats has impacted the structure, species assemblage and ecological function across the range of the ecological community.

This represents a **severe to very severe** reduction in integrity across most of its geographic distribution, as indicated by a **severe to very severe** disruption of important community processes. After preliminary assessment, the ecological community may have met the relevant elements of Criterion 4 to make it eligible for listing as **Endangered to Critically Endangered**. However, additional data won't be finalised until important data, information, and analyses, such as the Basin Plan Matter 7 (Commonwealth – MDBA/CEWO) and Matter 8 (States) reports, becomes available later in 2024.

Consultation Questions on listing assessment

- Please provide any feedback on the preliminary assessment under Criterion 4 or provide further data or information on changes in integrity and processes that would support or update the assessment.

6.2.5 Criterion 5 – rate of continuing detrimental change

Nominated under Criterion 5 as Endangered. May be eligible under Criterion 5 for listing as **Vulnerable to Endangered**

Category	Critically Endangered	Endangered	Vulnerable
Its rate of continuing detrimental change is: as indicated by:	very severe	severe	substantial
(a) rate of continuing decline in its geographic distribution, or a population of a native species that is believed to play a major role in the community, that is: OR	very severe	severe	serious
(b) intensification, across most of its geographic distribution, in degradation, or disruption of important community processes, that is:	very severe	severe	serious
<i>an observed, estimated, inferred or suspected detrimental change over the immediate past, or projected for the immediate future (10 years or 3 generations, up to a maximum of 60 years), of at least:</i>	80%	50%	30%

Source: TSSC 2016

Evidence:

Decline in extent (and condition) of vegetation of seasonal or intermittent wetland, shrubland wetland, and river red gum was variable but significant over the period from 1991 to 2008 and 2013.

- For seasonal or intermittent wetland areas at Macquarie Marshes there was a reduction in the area from 51,365 ha in 1991 to 13,991 ha in 2008 (73% decline) and 39,182 ha in 2013 (24% decline) (Bowen & Simpson 2010; Capon et al. 2018; Bowen et al. 2019). This decline in seasonal or intermittent wetland areas is indicative of changes in hydrological regimes.
- Lignum shrubland wetland reduced in area from 4,395 ha in 1991 to 1507 ha in 2008 (66% decline) and 1,442 ha in 2013 (68% decline) and river cooba shrubland wetland had reduced from 20,258 ha in 1991 to 5,727 ha in 2008 (72% decline). Following a wet period with increased river flows, river cooba increased to 20,954 ha in 2013. However, this is a 16% reduction compared to 1991 and indicates an overall declining trend in extent. It does not consider age cases or condition (Bowen & Simpson 2010; Capon et al. 2018; Bowen et al. 2019).
- Preliminary comparison of vegetation extent for the 2013-2022 period, indicated that non-woody wetlands increased from 19,000 ha to 21,000 ha. However, lignum and river cooba shrublands decreased in extent from 21,000 ha to 12,000 ha (43%) (NSW DCCEEW (in draft a).

NSW DPE (2020) noted that during the 2014-2019 Matter 8 reporting period (apart from 2016-2017) only 1-4% of lignum and river cooba shrubland were inundated. For lignum shrubs to remain vigorous with the potential for provisioning waterbird nesting habitat, flooding is required every 1–3 years, which in a five-year period is equivalent to flooding occurring 1.6-5 times. Therefore, hydrological requirements were not met for most of the known distribution of lignum-river cooba communities in the ecological community. An increase in the duration of dry, inter-flood periods is likely to result in a loss of condition and/or mortality of established lignum shrubs over time, altering their value as habitat (Capon et al. 2009; Balcombe et al. 2011; Nielson et al. 2017). Lignum provides significant nesting habitat for waterbirds.

An indication of the change in the wetland vegetation communities and a general drying trend is the increasing dominance of chenopod shrubland that displaces the wetland vegetation sub-communities in the ecological community, including as understorey of river red gum woodland. Two species of dryland chenopods, *Sclerolaena muricata* (black roly-poly) and *Salsola australis* (prickly saltwort), can become dominant species in areas formerly supporting seasonal or intermittent wetland (of mostly common reed, water couch, mixed marsh and cumbungi) and in the understorey of other flood dependant vegetation of the ecological community. These are naturally occurring species which are usually minor components of the understorey in flood dependant woodlands or as a low shrubland community in areas of very infrequent inundation. They are not usually present as dominant species in areas of frequent inundation historically. The presence of these terrestrial species as dominant components of communities which have formerly been composed of flood dependant wetland vegetation indicates a drying trend.

The ecological community provides substantial foraging and nesting habitat for waterbirds (Kingsford & Johnson 1998; Brandis et al. 2022; Porter et al. 2023) and other fauna species (Shelly 2005; Thomas et al. in CSIRO 2010; DPE 2023). The Macquarie Marshes are one of Australia's key aggregating waterbird breeding sites (Kingsford & Thomas 1995, Kingsford & Johnson 1998, Kingsford & Auld 2005, Brandis 2010, Bino et al. 2014; Brandis et al. 2022). Under prolonged drought or insufficient inundation (i.e. short duration), all wetland components will be stressed and suffer a reduction in the ecological values they provide. For example, lignum shrubland is an important habitat for nesting waterbirds and *Stictonetta naevosa* (freckled duck) (Foster 2015), a contribution not provided in the degraded state. With the reduction in extent and condition of these wetland vegetation communities and/or replacement with dryland species such as native chenopods, there has been a decrease in essential habitat for wetland birds and other wetland fauna. The impacts of this decline are most obvious in the decrease in the average numbers of birds sighted, species diversity and the number of waterbird breeding events in the Macquarie Marshes (Kingsford & Johnson 1998; Kingsford & Thomas 1995; Kingsford & Auld 2005; Brandis et al. 2022; Porter et al. 2023).

Higginson et al. (2022) demonstrated the important role that environmental water plays in filling the gaps between large flood events and, in doing so, maintaining the condition and resilience of common reedbeds. Data collected from a large inland reedbed in semi-arid western New South Wales showed common reedbeds managed with environmental water transitioned into a good condition following a large-scale flood, although reeds not managed with environmental water were in a critical condition prior to the flood.

Regulated flows to the Macquarie Marshes are unlikely to adequately control the long-term decline of the ecological community as a whole. Environmental flow allocations are only anticipated to be sufficient to sustain parts of the ecological community. Notwithstanding the recent increased flows resulting from a wetter period following the prolonged Millennium Drought, future demand for water resources, for example, for agricultural activities, and the potential impacts of climate change are likely to result in continued decline in wetland vegetation with resultant decreases in habitat and foraging resources for wetland fauna.

Climate change - general

Climate change is expected to reduce water resources, altering the volume and pattern of flow in rivers. A recent study by the MDBA found that climate change is one contributor to the reduced flows experienced by the northern Basin since the year 2000 (MDBA 2018). These climate change induced reductions in flow will affect all aspects of Basin condition and raise new

management issues (MDBA 2019). In the Macquarie River, average flood volume per event is projected to decrease by 25%, and inter-flood period increase by nearly 20% (CSIRO 2008; Saintilan et al. 2021).

Climate change projections indicate a small increase in total annual rainfall in the northern Basin (where the ecological community occurs) is more likely in the medium to long-term (Ekström et al., 2015; Nielson et al. 2017; BOM & CSIRO 2018; AdaptNSW 2024). However, higher temperatures are also expected to lead to an increased dependency on river flows, as crops and native vegetation have less access to soil moisture and suffer increased losses from transpiration (OEH 2014).

This may be further compounded by increased growth rates associated with higher concentrations of carbon dioxide. Studies have shown that increased carbon dioxide can further reduce catchment inflows by as much as 28% (Ukkola et al. 2015; MDBA 2019a). Saintilan et al. (2022) noted that increased atmospheric carbon dioxide can contribute to some plants surviving more in floodplain areas, but with decreased inundation extent and frequency of flood events. This can preference terrestrial species over those that tolerate or respond to inundation (Stokes et al. 2010; Sim et al. 2012). In a study of tree resilience and grassland vulnerability due to climate change by Saintilan et al. (2021), it was concluded that the decline of C₄ grasslands, such as water couch, is likely to be exacerbated under climate change projections for the Macquarie Marshes region.

For the NSW Central West and Orana climate region (where the ecological community occurs) the majority of models predict that spring rainfall will decrease, and autumn rainfall will increase for the region in the near future (2020-2039) to far future (2060-2079). In addition, increases for severe fire weather (+3.5 additional days per year) are projected in the prescribed burning period (spring) and peak fire risk period (summer) (OEH 2014).

Increasing temperature

Key animals and vegetation of the ecological community have both temperature and watering requirements (and tolerances) and these are less likely to be met under climate change, with adverse outcomes (MDBA 2019). As air temperatures increase there will be a corresponding increase in water and sediment temperatures, which will lead to changes in species distribution and breeding patterns. For example, anthropogenic climate change is emerging as an additional hazard to freshwater turtles, expressed through such phenomena as effects of warming on temperature-dependent sex determination (Mitchell & Janzen 2010) and habitat loss from increasing frequency and severity of drought (Chessman 2011).

Sediment temperature is highly correlated with maximum daily temperatures (Ooi et al. 2009; Ooi et al. 2012) and these relationships have indicated that a 4°C increase in the maximum air temperature will equate to a 10°C increase in sediment temperature (Ooi et al. 2009). Research has indicated that once sediment temperatures exceed 40°C for extended periods there will be declines in the viability and germination of many wetland plants (Nielsen et al. 2015).

Temperatures have risen across Australia and the Murray-Darling Basin since the start of national records in 1910, and especially since 1950. Both the Northern Basin, where the ecological community occurs, and Southern Basins have experienced warming during the period from 1910 to 2019 with the northwest (between 0.15 and 0.20 °C per decade) warming at a greater rate than the southwest (between 0.05 and 0.10 °C per decade). Associated with this rise in temperatures there has been a marked increase in the incidence of extreme daily heat events.

Record-warm monthly and seasonal temperatures have been observed in recent years and are made significantly more likely by climate change (BOM 2020). For example, for the period 2018-19, Dubbo broke monthly mean temperatures by around 2°C (BOM 2019a).

Brandis et al. (2022) noted that the impacts of climate change that are likely to have the greatest impact on waterbirds that breed in large aggregations include; changes to habitat availability and suitability as a result of changes to hydrological systems, changes to environmental cues that waterbirds use to make decisions regarding movement and breeding as a result of rainfall and temperature changes, and physiological impacts (e.g., reproduction, heat stress, mortality, disease exposure) as a result of temperature changes.

Increases in mean annual air temperature of +0.70°C for the near future (2020-2039) have been projected for the region where the ecological community occurs. Mean annual air temperature are projected to increase by +2.11°C for 2060-2079 for the region with increases across all seasons. The number of hot days over 35°C is projected to increase by 9.1 days for 2020-2039 and by 27.0 days for 2060-2079 (AdaptNSW 2024). Increases in maximum and minimum temperature throughout the year are expected to increase potential evapotranspiration. Daily minimum temperatures (overnight lows) are also expected to increase (BOM 2020; AdaptNSW 2024). For example, Dubbo recorded 27 consecutive days above 35°C for the period 2018-19 whereas the previous record was 18 days in 2009 (BOM 2019a). Evapotranspiration is predicted to increase (MDBA 2019) by about 7% in this region (Nielson et al. 2017).

Changes in rainfall

Since the late 1990s there has also been a shift in rainfall patterns relative to the long-term average in the northern Murray-Darling Basin where the ecological community occurs (MDBA 2019). Prior to 2012, dry conditions were most common from May to November, when ambient temperatures and water losses to evapotranspiration tended to be low. For the July 2012 to June 2018 period, seasonal dry periods have tended to occur between September and April (BOM 2019b; MDBA 2020). This change in seasonal pattern can have a significant impact on stream and aquatic health (BOM 2019b).

In 2017–18, the Murray–Darling Basin experienced a strong decline in root zone soil moisture content which is a direct impact of low rainfall. Severe soil moisture deficiencies occurred in 33% of the Murray-Darling Basin, mostly in NSW, and another 41% experienced serious deficiencies. The most affected catchments included the Macquarie; these catchments were also found to have lower-than-average streamflow and mostly in their headwater areas (BOM 2019b). Reductions in flooding frequency also promote the invasion into reed beds and freshwater grasslands, such as *Paspalum distichum* (water couch), by eucalypts such as river red gum regrowth (Colloff 2014; Bowen et al. 2017).

If currently agreed water sharing outcomes shift further away from environmental use, as predicted by Prosser et al. (2021), and the overall volumes of water provided to wetlands decreases further, then ecosystem vulnerabilities will increase and accelerate beyond that driven by climate change alone (Muller & Whiterod 2024). Unregulated flows (i.e. those that exceed the regulating capacity of MDB infrastructure) can no longer be relied upon to achieve long-term ecological outcomes and avoid on-going ecological decline (Capon et al. 2018; MDBA 2019; Mason et al. 2022; Schweizer et al. 2022; Muller & Whiterod 2024).

Conclusion

Detrimental change over the near past through decline in semi-permanent wetlands and flood-dependent shrubland wetland extent, replacement or encroachment of terrestrial species and consequent loss of habitat and foraging resources for wetland fauna including nesting waterbirds has led to degradation and disruption of important ecological processes in the Wetlands and inner floodplains of the Macquarie Marshes ecological community.

This represents a **substantial to severe** rate of continuing detrimental change as indicated by a **substantial to severe** disruption of important community processes. After preliminary assessment the ecological community may have met the relevant elements of Criterion 5 to make it eligible for listing as **Vulnerable to Endangered**. However, additional data won't be finalised until important data, information, and analyses, such as the Basin Plan Matter 7 (Commonwealth – MDBA/CEWO) and Matter 8 (States) reports, becomes available later in 2024.

Consultation Questions on listing assessment. *More recent data and analysis on trends will be available and will be incorporated when Murray-Darling Basin Plan reports are released soon. In addition to that:*

- Please provide any feedback on the preliminary assessment under Criterion 5 or further data or information that would support or update the assessment of rate of detrimental change.
- If you can provide any additional information, please also provide any relevant references.

6.2.6 Criterion 6 – quantitative analysis showing probability of extinction

Not eligible under Criterion 6

Category	Endangered	Vulnerable	Critically Endangered
A quantitative analysis shows that its probability of extinction, or extreme degradation over all of its geographic distribution, is:	at least 50% in the immediate future	at least 20% in the near future	at least 10% in the medium-term future
<i>timeframes</i>	<i>10 years or 3 generations (up to a maximum of 60 years)</i>	<i>20 years or 5 generations (up to a maximum of 100 years)</i>	<i>50 years or 10 generations (up to a maximum of 100 years)</i>

Source: TSSC 2016

Evidence:

Quantitative analysis of the probability of extinction or extreme degradation over all its geographic distribution has not been undertaken. There is unlikely to be sufficient information to determine the eligibility of the ecological community for listing in any category under this criterion.

Consultation Questions on listing assessment

- Please provide any feedback on the preliminary assessment under Criterion 6 or further data or information that would support or update the assessment?
- If you can provide any additional information, please also provide any relevant references.

Appendix A - Species lists

This Appendix lists the assemblage of native species that characterises the ecological community throughout its range at the time of listing, particularly characteristic and frequently occurring vascular plants at [Table A1](#) and macroscopic animals at [Table A2](#). The ecological community also includes fungi, cryptogamic plants and other species; however, these are relatively poorly documented.

The species listed may be abundant, rare, or not necessarily be present in any given patch of the ecological community, and other native species not listed here may be present. The total list of species that may be found in the ecological community is considerably larger than the species listed here.

Species presence and relative abundance varies naturally across the range of the ecological community based on factors such as historical biogeography, soil properties (e.g., moisture, chemical composition, texture, depth and drainage), topography, hydrology and climate. They also change over time, for example, in response to disturbance (by hydrological changes, fire, or grazing), or to the climate and weather (e.g., seasons, floods, drought and extreme heat or cold). The species recorded at a particular site can also be affected by sampling scale, season, effort and expertise. In general, the number of species recorded is likely to increase with the size of the site.

Scientific names used in this Appendix are nationally accepted names as per the Atlas of Living Australia, as at the time of writing.

A1 Flora

Table A1: Characteristic, frequently occurring or threatened flora. Sources: Atlas of Living Australia; Harden 1990–1993; Shelly 2005 in OEH 2012a; P. Berney pers. comm. and T. Hosking pers. comm.

Scientific name	Common name/s	EPBC status	NSW status
Canopy tree species			
<i>Acacia pendula</i>	balaar, weeping myall		
<i>Acacia salicina</i>	black sally wattle, cooba		
<i>Acacia stenophylla</i>	balkura, river cooba		
<i>Alectryon oleifolius</i>	Boonaree, western rosewood		
<i>Atalaya hemiglauc</i>	whitewood, cattle bush		
<i>Casuarina cristata</i>	belah		
<i>Eucalyptus camaldulensis</i>	river red gum		
<i>Eucalyptus coolabah</i>	coolibah, coolabah		
<i>Eucalyptus largiflorens</i>	black box		
<i>Geijera parviflora</i>	dogwood, wilga		
Understorey tree and shrub species			
<i>Aeschynomene indica</i>	budda pea		
<i>Atriplex nummularia</i>	cabbage saltbush		
<i>Atriplex vesicaria</i>	bladder saltbush		
<i>Capparis mitchellii</i>	wild orange		
<i>Duma florulenta</i>	barrgay, lignum		
<i>Enchylaena tomentosa</i> var. <i>tomentosa</i>	ruby saltbush, barrier saltbush		
<i>Malacocera tricornis</i>	goat head		

Scientific name	Common name/s	EPBC status	NSW status
<i>Maireana aphylla</i>	cotton bush		
<i>Maireana brevifolia</i>	cottonbush		
<i>Maireana decalvans</i>	black cotton-bush		
<i>Myoporum montanum</i>	boobialla		
<i>Sclerolaena muricata</i>	black roly-poly		
<i>Sclerolaena stelligera</i>			
<i>Sclerolaena tricuspidis</i>	giant red burr		
<i>Sida cunninghamii</i>	ridge sida		
<i>Sida fibulifera</i>	pin sida		
<i>Sida trichopoda</i>	high sida		
Fern species			
<i>Azolla rubra</i>	karearea		
<i>Marsilea costulifera</i>	narrow-leaf nardoo		
<i>Marsilea drummondii</i>	clover fern, nardoo		
<i>Marsilea mutica</i>	large-leaf nardoo		
Herb, orchid and sedge/graminoid species			
<i>Abutilon malvifolium</i>	bastard marshmallow		
<i>Alternanthera denticulata</i>	lesser joyweed		
<i>Alternanthera nana</i>	hairy joyweed		
<i>Amaranthus macrocarpus</i>	Boggabri weed		
<i>Atriplex lindleyi</i>	baldoo		
<i>Atriplex leptocarpa</i>	creeping saltbush		
<i>Atriplex pseudocampanulata</i>	fan saltbush		
<i>Atriplex semibaccata</i>	Australian saltbush		
<i>Atriplex suberecta</i>	lagoon saltbush		
<i>Austrostipa scabra</i>	needle grass		
<i>Boerhavia dominii</i>	tah-vine		
<i>Brachyscome debilis</i>	weak daisy		
<i>Brachyscome dentata</i>	lobe-seed daisy		
<i>Brachyscome paludicola</i>	swamp daisy		
<i>Calotis hispidula</i>	Bogan flea		
<i>Calotis scabiosifolia</i> var. <i>scabiosifolia</i>	rough burr-daisy		
<i>Calotis scapigera</i>	tufted burr-daisy		
<i>Carex appressa</i>	tall sedge		
<i>Centipeda minima</i>	spreading sneezeweed		
<i>Chloris divaricata</i> var. <i>divaricata</i>	slender chloris		
<i>Chloris truncata</i>	star grass		
<i>Cotula australis</i>	common cotula		
<i>Crinum flaccidum</i>	Murray lily		
<i>Cullen tenax</i>	emu grass		
<i>Cynogeton procerum</i>	water ribbons		
<i>Cynodon dactylon</i>	star grass		
<i>Cyperus bifax</i>	Downs flat-sedge		
<i>Cyperus concinnus</i>	trim flat-sedge		
<i>Cyperus difformis</i>	dirty Dora		
<i>Cyperus exaltatus</i>	flat-sedge		
<i>Cyperus victoriensis</i>	flat sedge		
<i>Damasonium minus</i>	star fruit		
<i>Daucus glochidiatus</i>	native carrot		
<i>Dichondra repens</i>	creeping dichondra, kidney weed		
<i>Diplachne fusca</i>	brown beetle grass		
<i>Dysphania pumilio</i>	clammy goosefoot		
<i>Echinochloa colona</i>	awnless barnyard grass		
<i>Eclipta platyglossa</i>	yellow eclipta		

Scientific name	Common name/s	EPBC status	NSW status
<i>Eleocharis plana</i>	flat spike-sedge		
<i>Eleocharis pusilla</i>	small spike rush		
<i>Eleocharis sphacelata</i>	kaya, tall spike-rush		
<i>Epilobium hirtigerum</i>	hairy willow herb		
<i>Eragrostis parviflora</i>	weeping lovegrass		
<i>Erodium crinitum</i>	blue crowfoot		
<i>Euphorbia drummondii</i>	balsam, caustic weed		
<i>Glinus lotoides</i>	hairy carpet-weed		
<i>Goodenia fascicularis</i>	mallee goodenia		
<i>Goodenia glauca</i>	pale goodenia		
<i>Haloragis aspera</i>	grey raspwort		
<i>Haloragis glauca</i>	grey raspweed		
<i>Hibiscus richardsonii</i>			
<i>Juncus aridicola</i>	tussock rush		
<i>Juncus subsecundus</i>	finger rush		
<i>Lemna disperma</i>	common duck-weed		
<i>Lepidium fasciculatum</i>	bundled peppergrass		
<i>Leptochloa digitata</i>	canegrass		
<i>Ludwigia peploides</i> subsp. <i>montevidensis</i>	clove-strip		
<i>Lythrum hyssopifolia</i>	hyssop loosestrife		
<i>Maireana ciliata</i>	fissure weed		
<i>Maireana coronata</i>	crown fissure-weed		
<i>Maireana enchylaenoides</i>	wingless fissure-weed		
<i>Maireana pentagona</i>	hairy bluebush		
<i>Mentha australis</i>	Australian mint		
<i>Myriophyllum</i> spp.	milfoil		
<i>Roepera glauca</i>	pale twinleaf		
<i>Sclerolaena brachyptera</i>			
<i>Sclerolaena calcarata</i>	copper burr		
<i>Senecio runcinifolius</i>	tall groundsel		
<i>Sesbania cannabina</i> var. <i>cannabina</i>	danchi, yellow bush-pea		
<i>Sida corrugata</i>	corrugated sida		
<i>Solanum esuriale</i>	comyn, quena		
<i>Sporobolus caroli</i>	fairy grass		
<i>Sporobolus mitchellii</i>	creeping sporobolus, swamp ratstail grass		
<i>Tetragonia tetragonoides</i>	native spinach		
<i>Tragus australianus</i>	small burrgrass		
<i>Trianthema triquetrum</i>	red spinach		
<i>Typha domingensis</i>	narrowleaf cumbungi		
<i>Vittadinia cuneata</i>	New Holland daisy		
<i>Wahlenbergia capillaris</i>	tufted bluebell		
<i>Zaleya galericulata</i> subsp. <i>australis</i>			
Scrambler/climber/epiphyte species			
<i>Amyema lucasii</i>	yellow-flowered mistletoe		
<i>Amyema miquelii</i>	box mistletoe		
<i>Capparis lasiantha</i>	nepine		
<i>Convolvulus angustissimus</i>	Australian dodder		
<i>Einadia nutans</i>	climbing saltbush		
<i>Glycine clandestina</i>	twining glycine		

Sources: EPBC status refers to species listed under the EPBC Act at the time this document was prepared; NSW status refers to species listed under the *Biodiversity Conservation Act 2016* at the time this document was prepared.

A2 Fauna

Table A2: Non-avian fauna recorded in the ecological community. Source: Atlas of Living Australia; Gray & Hosking 2003; Turak et al. 2002; Sustainable River Audit in OEH 2012a; OEH 2012; Capon et al. 2018; Ocock et al. 2024.

Scientific name	Common name/s	EPBC status	NSW status ^{Error!} Bookmark not defined.
Mammals			
<i>Austronomus australis</i>	white-striped freetail bat		
<i>Chalinolobus gouldii</i>	Gould's wattled bat		
<i>Chalinolobus morio</i>	chocolate wattled bat		
<i>Chalinolobus picatus</i>	little pied bat		
<i>Hydromys chrysogaster</i>	rakali		
<i>Macropus fuliginosus</i>	western grey kangaroo		
<i>Macropus giganteus</i>	eastern grey kangaroo		
<i>Micronomus norfolkensis</i>	eastern freetail bat		
<i>Osphranter robustus</i>	wallaroo		
<i>Osphranter rufus</i>	red kangaroo		
<i>Ozimops planiceps</i>	little mastiff bat		
<i>Ozimops</i> sp. (big penis)	mastiff bat		
<i>Ozimops</i> sp. (little penis)	mastiff bat		
<i>Nyctophilus geoffroyi</i>	lesser long-eared bat		
<i>Nyctophilus gouldi</i>	Gould's long-eared bat		
<i>Petaurus breviceps</i>	sugar glider		
<i>Petaurus norfolcensis</i>	squirrel glider		
<i>Planigale tenuirostris</i>	narrow-nosed planigale		
<i>Pteropus poliocephalus</i>	grey-headed flying fox	V	
<i>Pteropus scapulatus</i>	little red flying-fox		
<i>Rattus tunneyi</i>	pale field rat		
<i>Saccolaimus flaviventris</i>	yellow-bellied sheathtail bat		
<i>Scotorepens balstoni</i>	inland broad-nosed bat/ western broad-nosed bat		
<i>Scotorepens greyii</i>	little broad-nosed bat		
<i>Scotorepens orion</i>	eastern broad-nosed bat		
<i>Sminthopsis crassicaudata</i>	fat-tailed dunnart		
<i>Sminthopsis macroura</i>	stripe-faced dunnart		
<i>Tachyglossus aculeatus</i>	short-beaked echidna		
<i>Trichosurus vulpecula</i>	common brushtail possum		
<i>Vespadelus baverstocki</i>	inland forest bat		
<i>Vespadelus regulus</i>	southern forest bat		
<i>Vespadelus vulturnus</i>	little forest bat		
<i>Wallabia bicolor</i>	swamp wallaby		
Reptiles			
Agamidae	dragons		
<i>Amphibolurus burnsi</i>	Burns' dragon		
<i>Amphibolurus muricatus</i>	jacky lizard		
<i>Diporiphora nobbi</i>	nobbi dragon		
<i>Intellagama lesueurii</i>	water dragon		
<i>Lophognathus gilberti</i>	Gilbert's dragon		
<i>Pogona barbata</i>	bearded dragon		
<i>Tympanocryptis tetraporophora</i>	Eyrean earless dragon		
Pythonidae	pythons		
<i>Morelia spilota</i>	carpet / diamond-python		

Scientific name	Common name/s	EPBC status	NSW status ^{Error!} Bookmark not defined.
Chelidae	turtles		
<i>Chelodina expansa</i>	broad-shelled turtle		
<i>Chelodina longicollis</i>	eastern long-necked turtle		
<i>Emydura macquarii</i>	Macquarie River turtle		
Diplodactylidae	geckoes		
<i>Diplodactylus tessellatus</i>	tessellated gecko		
<i>Lucasium damaeum</i>	beaded gecko		
<i>Oedura marmorata</i>	marbled velvet gecko		
<i>Strophurus intermedius</i>	Eastern spiny-tailed gecko		
Elapidae	elapid snakes		
<i>Acanthophis antarcticus</i>	common death adder		
<i>Austrelaps ramsayi</i>	highland copperhead		
<i>Brachyuropsis australis</i>	coral snake		
<i>Demansia psammophis</i>	yellow-faced whipsnake		
<i>Denisonia devisi</i>	De Vis's banded snake		
<i>Furina diadema</i>	red-naped snake		
<i>Hemiapsis damelii</i>	grey snake	E	E
<i>Pseudechis australis</i>	King brown snake		
<i>Pseudechis guttatus</i>	blue-bellied black snake		
<i>Pseudechis porphyriacus</i>	red-bellied black snake		
<i>Pseudonaja mengdeni</i>	gwardar, western brown snake		
<i>Pseudonaja textilis</i>	common brown snake		
<i>Suta dwyeri</i>	Dwyer's snake		
<i>Suta spectabilis</i>	mallee black-headed snake		
<i>Suta suta</i>	curl snake		
<i>Vermicella annulata</i>	bandy-bandy		
Gekkonidae	geckoes		
<i>Christinus marmoratus</i>	marbled gecko		
<i>Gehyra dubia</i>	dubious dtella		
<i>Gehyra variegata</i>	tree dtella		
<i>Heteronotia binoei</i>	Bynoe's gecko		
Pygopodidae	legless lizards		
<i>Delma inornata</i>	patternless delma		
<i>Delma plebeia</i>	leaden delma		
<i>Lialis burtonis</i>	Burton's snake-lizard		
<i>Pygopus nigriceps</i>	hooded scaly-foot		
Scincidae	skinks		
<i>Concinnia tenuis</i>	bar-sided forest-skink		
<i>Cryptoblepharus australis</i>	inland snake-eyed skink		
<i>Ctenotus allotropis</i>	brown-blazed wedgesnout ctenotus		
<i>Ctenotus ingrami</i>	unspotted yellow-sided ctenotus		
<i>Ctenotus regius</i>	pale-rumped ctenotus		
<i>Ctenotus robustus</i>	robust ctenotus		
<i>Ctenotus strauchii</i>	eastern barred wedgesnout ctenotus		
<i>Egernia striolata</i>	tree skink		
<i>Eulamprus quoyii</i>	eastern water-skink		
<i>Lampropholis delicata</i>	dark-flecked garden sunskink		
<i>Lerista punctatovittata</i>	eastern robust slider		
<i>Lerista timida</i>	dwarf burrowing skink		
<i>Menetia greyii</i>	common dwarf skink		
<i>Morethia boulengeri</i>	Boulenger's snake-eyed skink		

Scientific name	Common name/s	EPBC status	NSW status ^{Error!} Bookmark not defined.
<i>Morethia obscura</i>	shrubland morethia skink		
<i>Tiliqua rugosa</i>	bobtail		
<i>Tiliqua scincoides</i>	eastern bluetongue		
Typhlopidae	blind snakes		
<i>Anilius bituberculatus</i>	prong-snouted blind snake		
<i>Anilius proximus</i>	proximus blind snake		
Varanidae	goannas		
<i>Varanus gouldii</i>	Gould's goanna		
<i>Varanus tristis</i>	black-headed monitor		
<i>Varanus varius</i>	lace monitor		
Fish			
<i>Bidyanus bidyanus</i>	silver perch	E	V
<i>Craterocephalus fulvus</i>	unspeckled hardyhead		
<i>Craterocephalus stercusmuscarum</i>	flyspeckled hardyhead		
<i>Hypseleotris</i> spp.	carp gudgeons		
<i>Leiopotherapon unicolor</i>	spangled perch		
<i>Maccullochella peelii</i>	Murray cod	V	
<i>Macquaria ambigua</i>	golden perch		
<i>Melanotaenia fluviatilis</i>	Murray River rainbowfish/ crimson-spotted rainbowfish		
<i>Nematalosa erebi</i>	bony bream		
<i>Philypnodon grandiceps</i>	flathead gudgeon		
<i>Philypnodon macrostomus</i>	dwarf flathead gudgeon		
<i>Retropinna semoni</i>	Australian smelt		
<i>Tandanus tandanus</i>	freshwater catfish		
Introduced species			
<i>Carasius auratus</i>	goldfish*		
<i>Cyprinus carpio</i>	European carp*		
<i>Gambusia holbrooki</i>	eastern gambusia *		
<i>Perca fluviatilis</i>	redfin*		
Amphibians			
<i>Crinia parinsignifera</i>	eastern sign-bearing froglet		
<i>Crinia signifera</i>	common eastern froglet		
<i>Crinia sloanei</i>	Sloane's froglet	E	V
<i>Cyclorana alboguttata</i>	striped burrowing frog		
<i>Cyclorana platycephalus</i>	water-holding frog		
<i>Cyclorana verrucosa</i>	rough frog		
<i>Limnodynastes fletcheri</i>	barking frog		
<i>Limnodynastes salmini</i>	salmon striped frog		
<i>Limnodynastes tasmaniensis</i>	spotted grass frog		
<i>Litoria caerulea</i>	green tree frog		
<i>Litoria latopalmata</i>	broad-palmed frog		
<i>Litoria peronii</i>	Peron's tree frog		
<i>Litoria rubella</i>	little red tree frog		
<i>Neobatrachus pictus</i>	painted burrowing frog		
<i>Neobatrachus sudellae</i>	Suddel's frog		
<i>Notaden bennettii</i>	crucifix frog		
<i>Platyplectrum ornatum</i>	ornate burrowing frog		
<i>Uperoleia rugosa</i>	wrinkled toadlet		
Invertebrates			
Phylum Arthropoda			
Class Arachnida	mites, spiders		

Scientific name	Common name/s	EPBC status	NSW status ^{Error!} Bookmark not defined.
<i>Suborder Trombidiformes</i>	freshwater mites		
Class Crustacea			
<i>Subclass Ostracoda</i>	seed shrimps		
<i>Subclass Copepoda</i>	copepods		
<i>Subclass Branchiopoda</i>			
Order Diplostraca			
<i>Sub-order Cladocera</i>	water fleas		
<i>Subclass Malacostraca</i>			
Order Isopoda			
<i>Family Cirolanidae</i>	isopods		
Order Decapoda			
<i>Family Atyidae</i>	freshwater shrimps		
<i>Family Palaemonidae</i>	freshwater prawns		
<i>Family Parastacidae</i>	freshwater crayfish		
<i>Class Collembola</i>	springtails		
<i>Class Insecta</i>			
Order Ephemeroptera			
<i>Family Leptophlebiidae</i>	mayflies		
<i>Family Caenidae</i>	mayflies		
<i>Family Baetidae</i>	mayflies		
Order Odonata			
<i>Family Coenagrionidae</i>	damsel flies		
<i>Family Isostictidae</i>	damsel flies		
<i>Family Aeshnidae</i>	dragonflies		
<i>Family Gomphidae</i>	dragonflies		
<i>Family Corduliidae</i>	dragonflies		
Order Hemiptera	bugs		
<i>Family Gerridae</i>	water striders		
<i>Family Hebridae</i>	velvet water bugs		
<i>Family Corixidae</i>	waterboatmen		
<i>Family Naucoridae</i>	creeping waterbugs		
<i>Family Nepidae</i>	water scorpions		
<i>Family Notonectidae</i>	backswimmers		
<i>Family Veliidae</i>	small water striders		
Order Coleoptera	beetles		
<i>Family Dytiscidae</i>	predacious diving water beetles		
<i>Family Carabidae</i>	ground beetles		
<i>Family Chrysomelidae</i>	leaf beetles		
<i>Family Curculionidae</i>	weevils		
<i>Family Hydraenidae</i>	minute rove beetles		
<i>Family Staphylinidae</i>	rove beetles		
<i>Family Hydrophilidae</i>	scavenger water beetles		
Order Diptera	two-winged flies		
<i>Family Culicidae</i>	mosquitoes		
<i>Family Tabanidae</i>	march/horse flies		
<i>Family Ceratopogonidae</i>	biting midges		
<i>Family Simuliidae</i>	blackflies		
<i>Family Chironomidae</i>	midges		
<i>Sub-family Chironominae</i>	blood worms		
<i>Sub-family Orthocladiinae</i>	non-biting midges		
<i>Sub-family Tanypodinae</i>	non-biting midges		
Order Trichoptera	caddisflies		

Scientific name	Common name/s	EPBC status	NSW status ^{Error!} Bookmark not defined.
<i>Family Ecnomidae</i>			
<i>Family Leptoceridae</i>	longhorned caddisflies		
<i>Family Hydroptilidae</i>	micro caddisflies		
Phylum Mollusca	molluscs		
Class Bivalvia	bivalves		
<i>Family Cyrenidae</i>	pea clams		
<i>Corbicula australis</i>	freshwater mussel		
<i>Family Hyriidae</i>			
<i>Alathyria condola</i>			
<i>Alathyria jacksoni</i>	southern river mussel		
<i>Vesunio ambiguus</i>	floodplain/billabong mussel		
Class Gastropods	snails and slugs		
<i>Family Physidae</i>			
<i>Family Planorbidae</i>			
<i>Glyptophysa novaehollandica</i>	pouched snail		
<i>Isidorella hainesii</i>			
<i>Family Viviparidae</i>			
<i>Notopala kingi</i> or <i>suprafasciata</i>			
Key: EPBC status refers to species listed under the EPBC Act at the time this document was prepared; NSW status refers to species listed under the <i>Biodiversity Conservation Act 2016</i> at the time this document was prepared. Listed under the NSW Biodiversity Conservation Act 2016 - Critically endangered (CR), Endangered (E), Vulnerable (V); listed under the EPBC Act - Critically endangered (CR), Endangered (E), Vulnerable (V).			

Table A3: Wetland avian species recorded in the ecological community. Source: Atlas of Living Australia; OEH 2012a; list based upon NSW OEH atlas records (as at 2012) and the Flora and Fauna of the Macquarie Marshes Region (Shelly 2005).

Scientific name	Common name	EPBC Status	NSW Status	Habitat
Waterbirds				
<i>Anas castanea</i>	chestnut teal			
<i>Anas gracilis</i> (Syn. <i>A. gibberifrons</i>)	grey teal			Br
<i>Anas superciliosa</i>	Pacific black duck			Br
<i>Anhinga novaehollandiae</i>	Australian darter			Br
<i>Antigone rubicunda</i> (Syn. <i>Grus rubicundus</i> , <i>G. rubicunda</i>)	brolga		V	Br
<i>Anseranas semipalmata</i>	magpie goose		V	Br
<i>Ardea alba modesta</i> (Syn. <i>Ardea modesta</i>)	eastern great egret	M/C/J		Br
<i>Ardea intermedia</i>	intermediate egret			Br
<i>Ardea pacifica</i>	white-necked (pacific) heron			Br
<i>Aythya australis</i>	hardhead			Br
<i>Biziura lobata</i>	musk duck			Br
<i>Botaurus poiciloptilus</i>	Australasian bittern	E	E	
<i>Bubulcus ibis</i> (Syn. <i>Ardea ibis</i>)	cattle egret	M/C/J		Br
<i>Chenonetta jubata</i>	Australian wood duck			Br
<i>Cygnus atratus</i>	black swan			Br
<i>Dendrocygna arcuata</i>	wandering whistling- duck			
<i>Dendrocygna eytoni</i>	plumed whistling-duck			Br
<i>Egretta garzetta</i>	little egret			Br
<i>Egretta novaehollandiae</i>	white-faced heron			Br
<i>Egretta picata</i>	pied heron			Br
<i>Ephippiorhynchus asiaticus</i>	black-necked stork		E	
<i>Fulica atra</i>	Eurasian coot			Br
<i>Gallinula tenebrosa</i>	dusky moorhen			Br
<i>Hypotaenidia philippensis</i> (Syn. <i>Gallirallus philippensis</i>)	buff-banded rail			
<i>Ixobrychus dubius</i>	Australian little bittern			Br
<i>Lewinia pectoralis</i>	Lewin's rail			
<i>Malacorhynchus membranaceus</i>	pink-eared duck			Br
<i>Microcarbo melanoleucos</i> (Syn. <i>Phalacrocorax melanoleucos</i>)	little pied cormorant			Br
<i>Nettapus coromandelianus</i>	cotton pygmy-goose		E	
<i>Nettapus pulchellus</i>	green pygmy-goose			
<i>Nycticorax caledonicus</i>	nankeen (rufous) night heron			Br
<i>Oxyura australis</i>	blue-billed duck		V	Br
<i>Pelecanus conspicillatus</i>	Australian pelican			
<i>Phalacrocorax carbo</i>	great cormorant			Br
<i>Phalacrocorax sulcirostris</i>	little black cormorant			Br
<i>Phalacrocorax varius</i>	pied cormorant			
<i>Platalea flavipes</i>	yellow-billed spoonbill			Br
<i>Platalea regia</i>	royal spoonbill			Br
<i>Plegadis falcinellus</i>	glossy ibis	M/B/C		Br
<i>Podiceps cristatus</i>	great crested grebe			Br
<i>Poliiocephalus poliocephalus</i>	hoary-headed grebe			Br

Scientific name	Common name	EPBC Status	NSW Status	Habitat
<i>Porphyrio porphyrio</i>	purple swamphen			Br
<i>Porzana fluminea</i>	Australian spotted crane			
<i>Porzana pusilla</i>	Baillon's crane			
<i>Porzana tabuensis</i> (Syn. <i>Zapornia tabuensis</i>)	spotless crane			Br
<i>Stictonetta naevosa</i>	freckled duck		V	Br
<i>Spatula querquedula</i> (Syn. <i>Anas querquedula</i>)	Garganey (teal)	M/B/C/J/R		
<i>Spatula rhynchotis</i>	Australasian shoveler			Br
<i>Tachybaptus novaehollandiae</i>	Australasian grebe			Br
<i>Tadorna tadornoides</i>	Australian shelduck			
<i>Threskiornis moluccus</i> (Syn. <i>T. Molucca</i>)	Australian white ibis			Br
<i>Threskiornis spinicollis</i>	straw-necked ibis			Br
<i>Tribonyx ventralis</i> (Syn. <i>Gallinula ventralis</i>)	black-tailed native-hen			
<i>Zapornia tabuensis</i> (Syn. <i>Porzana tabuensis</i>)	spotless crane			Br
Waders				
<i>Actitis hypoleucos</i>	common sandpiper	M/B/C/J/R		
<i>Calidris acuminata</i>	sharp-tailed sandpiper	V/M/B/C/J/R		
<i>Calidris ferruginea</i>	curlew sandpiper	CE/M/B/C/J/R		
<i>Calidris ruficollis</i>	red-necked stint	M/B/C/J/R		
<i>Charadrius ruficapillus</i>	red-capped plover			
<i>Chlidonias hybrida</i> (Syn. <i>C. hybridus</i>)	whiskered tern			Br
<i>Chroicocephalus novaehollandiae</i> (Syn. <i>Larus novaehollandiae</i>)	silver gull			
<i>Euseyonis melanops</i>	black-fronted dotterel			Br
<i>Erythronyx cinctus</i>	red-kneed dotterel			Br
<i>Gallinago hardwickii</i>	Latham's/ Japanese snipe	V/M/B/J/R		
<i>Gelochelidon nilotica</i>	gull-billed tern	M/C		
<i>Himantopus himantopus</i>	Pied/ black-winged stilt			Br
<i>Hydroprogne caspia</i> (Syn. <i>Sterna caspia</i>)	Caspian tern	M/J		
<i>Limosa lapponica</i>	bar-tailed godwit	M/B/C/J/R		
<i>Limosa limosa</i>	black-tailed godwit	E/M/B/C/J/R	V	
<i>Recurvirostra novaehollandiae</i>	red-necked avocet			
<i>Rostratula australis</i> (Syn. <i>R. benghalensis</i>)	Australian painted snipe	E	E	
<i>Stiltia isabellae</i>	Australian pratincole			
<i>Tringa glareola</i>	wood sandpiper	M/B/C/J/R		
<i>Tringa nebularia</i>	common greenshank	M/B/C/J/R		
<i>Tringa stagnatilis</i>	marsh sandpiper, Little Greenshank	M/B/C/J/R		
<i>Vanellus miles</i>	masked lapwing			Br
<i>Vanellus tricolor</i>	banded lapwing			

Key:

EPBC status refers to species listed under the EPBC Act when this document was prepared.

NSW status refers to species listed under the *Biodiversity Conservation Act 2016* when this document was prepared.

Listed under the EPBC Act - Critically endangered (CR), Endangered (E), Vulnerable (V), migratory (M);

Listed under international migratory bird agreements- Bonn Convention (B), CAMBA (C), JAMBA (J), ROKAMBA (R).

Listed under the NSW Biodiversity Conservation Act 2016 - Critically endangered (CR), Endangered (E), Vulnerable (V).

Identified breeding habitat (Br).

Table A4: Woodland avian species recorded in the ecological community recorded in the Wetlands and inner floodplains of the Macquarie Marshes ecological community

Source: Atlas of Living Australia; Blackwood et al. 2010; list based upon NSW OEH atlas records (as at 2012) and the Flora and Fauna of the Macquarie Marshes Region (Shelly 2005).

Scientific name	Common name	EPBC Status	NSW Status	Declining
Raptors				
<i>Accipiter cirrocephalus</i>	collared sparrowhawk			
<i>Accipiter fasciatus</i>	brown goshawk			
<i>Aquila audax</i>	wedge-tailed eagle			
<i>Circus approximans</i>	swamp harrier			
<i>Circus assimilis</i>	spotted harrier		V	
<i>Elanus axillaris</i>	black-shouldered kite			
<i>Falco berigora</i>	brown falcon			
<i>Falco cenchroides</i>	nankeen kestrel			
<i>Falco hypoleucos</i>	grey falcon	V	V	
<i>Falco longipennis</i>	Australian hobby			
<i>Falco peregrinus</i>	peregrine falcon			
<i>Falco subniger</i>	black falcon		V	
<i>Haliaeetus leucogaster</i>	white-bellied sea eagle		V	
<i>Haliastur sphenurus</i>	whistling kite			
<i>Hamirostra melanosternon</i>	black-breasted buzzard		V	
<i>Hieraaetus morphnoides</i>	little eagle		V	
<i>Lophoictinia isura</i>	square-tailed kite		V	
<i>Milvus migrans</i>	black kite			
<i>Pandion cristatus</i> (Syn. <i>Pandion haliaetus cristatus</i>)	Eastern/ Australian osprey		V	
Ground birds				
<i>Ardeotis australis</i>	Australian bustard		E	
<i>Burhinus grallarius</i>	bush stone-curlew		E	
<i>Coturnix pectoralis</i>	stubble quail			
<i>Dromaius novaehollandiae</i>	emu			D
<i>Synoicus ypsilophora</i>	brown quail			
<i>Turnix pyrrhotorax</i>	red-chested button-quail			
<i>Turnix varia</i>	painted button quail			
<i>Turnix velox</i>	little button-quail			
Pigeons and doves				
<i>Geopelia cuneata</i>	diamond dove			
<i>Geopelia humeralis</i>	bar-shouldered dove			
<i>Geopelia placida</i>	peaceful dove			
<i>Ocyphaps lophotes</i>	crested pigeon			
<i>Phaps chalcoptera</i>	common bronzewing			
Parrots				
<i>Aprosmictus erythropterus</i>	red winged parrot			
<i>Barnardius zonarius</i>	Australian ringneck			
<i>Barnardius zonarius barnardi</i>	mallee ringneck			
<i>Cacatua galerita</i>	sulphur-crested cockatoo			
<i>Cacatua sanguinea</i>	little corella			
<i>Calyptorhynchus banksii</i>	red-tailed black-cockatoo			

Scientific name	Common name	EPBC Status	NSW Status	Declining
<i>Calyptorhynchus lathami</i>	glossy black cockatoo		V	
<i>Eolophus roseicapillus</i>	galah			
<i>Lophochroa leadbeateri</i> <i>leadbeateri</i>	pink cockatoo	E	V	
<i>Melopsittacus undulatus</i>	budgerigar			
<i>Neophema chrysostoma</i>	blue-winged parrot	V	V	
<i>Neophema pulchella</i>	turquoise parrot		V	
<i>Neopsephotus bourkii</i>	Bourke's parrot			
<i>Northiella haematogaster</i>	blue bonnet			
<i>Nymphicus hollandicus</i>	cockatiel			
<i>Platycercus adscitus</i>	pale-headed rosella			
<i>Platycercus eximius</i>	eastern rosella			
<i>Polytelis swainsonii</i>	superb parrot	V	V	
<i>Psephotus haematonotus</i>	red rumped parrot			
<i>Psephotellus varius</i>	mulga parrot			
Cuckoos				
<i>Cacomantis flabelliformis</i>	fan-tailed cuckoo			
<i>Centropus phasianinus</i>	pheasant coucal			
<i>Chalcites basalis</i> (Syn. <i>Chrysococcyx basalis</i>)	Horsfield's bronze cuckoo			
<i>Chalcites lucidus</i>	shining bronze-cuckoo			
<i>Chalcites osculans</i>	black-eared cuckoo			
<i>Heteroscenes pallidus</i>	pallid cuckoo			
Kingfishers, Rollers and Bee eaters				
<i>Ceyx azureus</i> (Syn. <i>Alcedo azurea</i>)	azure kingfisher			
<i>Dacelo novaeguineae</i>	laughing kookaburra			
<i>Eurystomus orientalis</i>	dollarbird			
<i>Merops ornatus</i>	rainbow bee-eater			
<i>Todiramphus pyrrhopygius</i> (Syn. <i>Halcyon pyrrhopygia</i>)	red-backed kingfisher			
<i>Todiramphus sanctus</i>	sacred kingfisher			
Night birds				
<i>Aegotheles cristatus</i>	Australian owlet-nightjar			
<i>Eurostopodus argus</i>	spotted nightjar			
<i>Podargus strigoides</i>	tawny frogmouth			
<i>Ninox connivens</i>	barking owl			
<i>Ninox</i> (<i>novaeseelandiae</i>) <i>boobook</i>	southern boobook			
<i>Tyto javanica</i>	eastern barn owl			
Swifts, Swallows and Martins				
<i>Apus pacificus</i>	fork-tailed swift			
<i>Cheramoeca leucosterna</i>	white-backed swallow			
<i>Hirundapus caudacutus</i>	white-throated needletail			
<i>Hirundo neoxena</i>	welcome swallow			
<i>Petrochelidon ariel</i>	fairy martin			
<i>Petrochelidon nigricans</i> (Syn. <i>Hirundo nigricans</i>)	tree martin			
Larks, Robins and Flycatchers				

Scientific name	Common name	EPBC Status	NSW Status	Declining
<i>Anthus novaeseelandiae</i>	Australasian/ Richard's pipit			
<i>Cinchoramphus cruralis</i>	brown songlark			
<i>Cinchoramphus mathewsi</i>	rufous songlark			
<i>Cinclosoma punctatum</i>	spotted quail-thrush			
<i>Climacteris picumnus</i>	brown treecreeper			
<i>Colluricincla harmonica</i>	grey shrike-thrush			
<i>Coracina maxima</i>	ground cuckoo-shrike			
<i>Coracina novaehollandiae</i>	black-faced cuckoo-shrike			
<i>Coracina papuensis</i>	white-bellied cuckoo-shrike			
<i>Daphoenositta chrysoptera</i>	varied sittella		V	D
<i>Eopsaltria australis</i>	eastern-yellow robin			D
<i>Falcunculus frontatus</i>	crested/eastern shrike-tit			D
<i>Lalage tricolor</i> (Syn. <i>L. sueurii</i>)	white-winged triller			
<i>Melanodryas cucullata</i>	hooded robin	E		D
<i>Microeca fascians</i>	jacky winter			D
<i>Mirafrja javanica</i>	Singing/ Horsfield's bushlark			D
<i>Myiagra inquieta</i>	restless flycatcher			D
<i>Oreoica gutturalis</i>	crested bellbird			D
<i>Pachycephala pectoralis</i>	golden whistler			
<i>Pachycephala rufiventris</i>	rufous whistler			D
<i>Petroica goodenovii</i>	red-capped robin			D
<i>Petroica phoenicea</i>	flame robin			
<i>Pomatostomus ruficeps</i>	chestnut-crowned babbler			
<i>Pomatostomus superciliosus</i>	white-browed babbler			D
<i>Pomatostomus temporalis</i>	grey-crowned babbler			D
<i>Rhipidura albiscapa</i>	grey fantail			
<i>Rhipidura leucophrys</i>	willie wagtail			
Warblers and Wrens				
<i>Acanthiza apicalis</i>	inland thornbill			
<i>Acanthiza chrysorrhoa</i>	Yellow-rumped thornbill			
<i>Acanthiza nana</i>	yellow thornbill			
<i>Acanthiza reguloides</i>	buff-rumped thornbill			
<i>Acanthiza uropygialis</i>	chestnut-rumped thornbill			D
<i>Acrocephalus australis</i>	clamorous reed warbler			
<i>Aphelocephala leucopsis</i>	southern whiteface			D
<i>Cinchoramphus timoriensis</i> (Syn. <i>Megalurus timoriensis</i>)	tawny grassbird			
<i>Cisticola exilis</i>	golden-headed cisticola			
<i>Gerygone fusca</i>	western gerygone			
<i>Malurus cyaneus</i>	superb fairy-wren			
<i>Malurus lamberti</i>	variegated fairy-wren			
<i>Malurus leucopterus</i>	white-winged fairy-wren			
<i>Malurus splendens</i>	splendid fairy-wren			
<i>Poodytes gramineus</i> (Syn. <i>Megalurus gramineus</i>)	little grassbird			
<i>Smicronis brevirostris</i>	weebill			
Honeyeaters, Pardalotes and their allies				
<i>Acanthagenys rufogularis</i>	spiny-cheeked honeyeater			

Scientific name	Common name	EPBC Status	NSW Status	Declining
<i>Dicaeum hirundinaceum</i>	mistletoebird			
<i>Entomyzon cyanotis</i>	blue-faced honeyeater			
<i>Epthianura albifrons</i>	white-fronted chat			
<i>Epthianura aurifrons</i>	orange chat			
<i>Epthianura tricolor</i>	crimson chat			
<i>Gavicalis virescens</i>	singing honeyeater			
<i>Grantiella picta</i>	painted honeyeater			
<i>Manorina flavigula</i>	yellow-throated miner			
<i>Manorina melanocephala</i>	noisy miner			
<i>Melithreptus brevirostris</i>	brown-headed honeyeater			
<i>Melithreptus gularis gularis</i>	black-chinned honeyeater (eastern subspecies)		V	
<i>Pardalotus punctatus</i>	spotted pardalote			
<i>Pardalotus rubricatus</i>	red-browed pardalote			
<i>Pardalotus striatus</i>	striated pardalote			
<i>Philemon citreogularis</i>	little friarbird			
<i>Philemon corniculatus</i>	noisy friarbird			
<i>Plectorhyncha lanceolata</i>	striped honeyeater			
<i>Ptilotula penicillata</i> (Syn. <i>Lichenostomus penicillatus</i>)	white-plumed honeyeater			
<i>Sugomel niger</i>	black honeyeater			
<i>Zosterops lateralis</i>	silveryeye			
Finches				
<i>Aidemosyne modesta</i> (Syn. <i>Neochmia modesta</i>)	plum-headed finch			
<i>Stagonopleura guttata</i>	diamond firetail	V	V	
<i>Stizoptera bichenovii</i> (Syn. <i>Taeniopygia bichenovii</i>)	double-barred finch			D
<i>Taeniopygia guttata</i>	zebra finch			
Other Passerines				
<i>Artamus cinereus</i>	black-faced woodswallow			
<i>Artamus cyanopterus</i>	dusky woodswallow			D
<i>Artamus leucorhynchus</i>	white-breasted woodswallow			
<i>Artamus minor</i>	little woodswallow			
<i>Artamus personatus</i>	masked woodswallow			
<i>Artamus superciliosus</i>	white-browed woodswallow			D
<i>Chlamydera maculata</i> (Syn. <i>Ptilonorhynchus maculatus</i>)	spotted bowerbird			
<i>Corcorax melanorhamphos</i>	white-winged cough			
<i>Corvus bennetti</i>	little crow			
<i>Corvus coronoides</i>	Australian raven			
<i>Corvus mellori</i>	little raven			
<i>Cracticus nigrogularis</i>	pied butcherbird			
<i>Cracticus torquatus</i>	grey butcherbird			
<i>Grallina cyanoleuca</i>	magpie lark			
<i>Gymnorhina tibicen</i> (Syn. <i>Cracticus tibicen</i>)	Australian magpie			
<i>Oriolus sagittatus</i>	olive-backed oriole			
<i>Strepera graculina</i>	pied currawong			

Scientific name	Common name	EPBC Status	NSW Status	Declining
<i>Struthidea cinerea</i>	apostlebird			D
Introduced birds				
<i>Anas platyrhynchos</i>	mallard			
<i>Columba livia</i>	rock dove			
<i>Passer domesticus</i>	house sparrow			
<i>Sturnus vulgaris</i>	common starling			
<i>Turdus merula</i>	Eurasian/ common blackbird			
Key: EPBC status refers to species listed under the EPBC Act when this document was prepared. NSW status refers to species listed under the <i>Biodiversity Conservation Act 2016</i> when this document was prepared. Listed under the EPBC Act - Critically endangered (CR), Endangered (E), Vulnerable (V), migratory (M); Listed under <i>Biodiversity Conservation Act 2016</i> - Critically endangered (CR), Endangered (E), Vulnerable (V); and declining woodland species* (D) Declining woodland species in NSW sheep-wheat belt as identified by Reid (1999)				

Consultation Questions on species lists

- Please note fauna or flora species incorrectly recorded; please provide details. Please provide information on any other flora and fauna species missing from the description and key interactions between species and with habitat?
- Please provide additional fauna you would like to see included in the lists, particularly commonly encountered fauna, characteristic invertebrates and those with important ecological functions in the ecological community. Please suggest further reference information/ sources.

Appendix B - Relationship to other vegetation classification and mapping systems

Ecological communities are complex to classify. States and Territories apply their own systems to classify vegetation communities, which may be fundamentally different to nationally-listed threatened ecological communities. Reference to vegetation and mapping units as equivalent to the ecological community, at the time of listing, should be taken as indicative rather than definitive. A unit that is generally equivalent may include elements that do not meet the key diagnostics and minimum condition thresholds. Conversely, areas mapped or described as other units may sometimes meet the key diagnostics for the ecological community. Judgement of whether the ecological community is present at a particular site should focus on how the site meets the description ([section 1.2](#)), the key diagnostic characteristics ([section 2.1](#)) and minimum condition thresholds ([section 2.3](#)).

State vegetation mapping units are not the ecological community being listed. However, for many sites (but not all) certain vegetation map units will correspond sufficiently to provide indicative mapping for the national ecological community, where the description matches.

On-ground assessment is vital to finally determine if any area is an occurrence of the ecological community.

B1 Relationship to New South Wales vegetation classifications

[Table B1](#) describes the Plant Community types (PCT) that may intergrade with or are floristically similar to the ecological community. These are usually dominated by the same species, whereas the Macquarie Marshes is complex in its structure and species diversity. The vegetation communities described are based on the NSW Integrated BioNet Vegetation Data program which provides a digital inventory and map of native vegetation communities across New South Wales.

Table B1: NSW Plant community types (PCT) that intergrade with the Macquarie Marshes. Source: (DPE 2022a).

PCT ID	PCT name	Vegetation formation
36	River Red Gum tall to very tall open forest / woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains Bioregion	Forested Wetlands
53	Shallow freshwater wetland sedgeland in depressions on floodplains on inland alluvial plains and floodplains	Freshwater Wetlands
168	Derived Copperburr shrubland of the NSW northern inland alluvial floodplains	Arid Shrublands (Chenopod sub-formation)
181	Common Reed - Bushy Groundsel aquatic tall reedland grassland wetland of inland river systems	Freshwater Wetlands
182	Cumbungi rushland wetland of shallow semi-permanent water bodies and inland watercourses	Freshwater Wetlands
204	Water Couch marsh grassland wetland of frequently flooded inland watercourses	Freshwater Wetlands
241	River Coobah swamp wetland on the floodplains of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion	Freshwater Wetlands
247	Lignum shrubland wetland on regularly flooded alluvial depressions in the Brigalow Belt South Bioregion and Darling Riverine Plains Bioregion	Freshwater Wetlands

PCT ID	PCT name	Vegetation formation
454	River Red Gum grassy chenopod open tall woodland (wetland) on floodplain clay soil of the Darling Riverine Plains Bioregion and western Brigalow Belt South Bioregion	Semi-arid Woodlands (Grassy sub-formation)

Aquatic components of the National ecological community partially align with the NSW 'Lowland Darling River aquatic ecological community' described in the 'Final recommendation' by the NSW Fisheries Scientific Committee and listed by the Government of NSW as endangered under the *Fisheries Management Act 1994* (the Act) in 2007.

The aquatic ecological community of the lowland Darling River aquatic ecological community includes all native fish and aquatic invertebrates within all natural creeks, rivers, streams and associated lagoons, billabongs, lakes, anabranches, flow diversions to anabranches and floodplains of the Darling River within NSW, including the regulated tributaries (Gwydir, Namoi, Macquarie, Castlereagh, and Bogan rivers).

Consultation Questions

- How could we improve on the information provided to assist with identifying the ecological community, particularly differences to other map/vegetation units?
- Is the list of corresponding map/vegetation units complete and accurate?
- Should the NSW vegetation class PCT 40 - Coolabah open woodland wetland with chenopod/grassy ground cover on grey and brown clay floodplains be considered part of the ecological community?
- Should the NSW vegetation class PCT 454 - River Red Gum grassy chenopod open tall woodland (wetland) on floodplain clay soil of the Darling Riverine Plains Bioregion and western Brigalow Belt South Bioregion be considered part of the ecological community?

Appendix C – Detailed description of biology and ecological processes

There are three main factors driving the diversity, dynamics and distribution of plants and animals and their habitats in the Macquarie Marshes:

- Hydrology (temporal and spatial flow variability of flows and water levels).
- Connectivity (between the Wambuul/Macquarie River, its tributaries and floodplain woodlands and wetlands).
- Sediment and nutrient transport (influencing productivity and water chemistry).

Flow regime, wetting and drying, connectivity, sediments and nutrients, and biota all interact to support the ecological productivity of the ecological community.

Flow regime

In the Macquarie Marshes the flow regime, which includes flood timing, frequency, duration, extent and depth (volume), is highly variable. Although the natural pattern has been modified by diversions and regulation, the flow regime of the ecological community has always been marked by erratic sequences of flood and drought which are also highly variable between years and decades (Maheshwari et al. 1995).

The biota supported by the ecological community has basic requirements for survival, growth and reproduction that are related to flow regimes (Walker et al. 1995; Rogers & Ralph 2011). The life cycles of many native species are opportunistic, tolerant and capable of rapid dispersal to cope with widely varying river flows. However, there are limits that, once exceeded, can change the ecological character of the community. Regulation has reduced flow variability within and between years, and generally favoured introduced species (with their regular, seasonal life cycles) over native species.

The temporal variability of flow influences the health and productivity of the ecological community. For example:

- Native fish species in the ecological community and lower Wambuul/Macquarie River usually recruit during spring and early summer and require appropriate flows to induce spawning, protect eggs and promote larval and juvenile fish survival and prevent wash out of larvae and prey from nursery habitats (Humphries et al. 2002). Restoration of late winter–spring floods would provide optimal feeding and growth conditions for adult fish before spawning (Humphries et al. 2002) as well as providing floodplain habitats with a rich supply of food for larval and juvenile fish (Gehrke et al. 1995).
- Most frogs in the ecological community need flooding in spring or summer to initiate breeding and a water depth of between 10–50 cm for anywhere from 30–180 days depending on the species. Provided the habitat is available this ensures conditions are suitable for egg laying, algal growth for feeding tadpoles and time for metamorphosis (Young 2001; OEH 2012a).
- The three turtle species recorded in the ecological community (broad-shelled turtle, eastern snake-necked turtle and Murray short-necked turtle) are water dependent and only leave the water to lay their eggs. To breed successfully turtles need good reserves of fat that can only be obtained during floods. Their main foods are fish, yabbies, aquatic invertebrates and algae. Unlike frogs that need a flood to trigger their breeding, turtles

need a flood to provide ample food before they can lay eggs. They lay their eggs in a shallow burrow of wet soil next to water. Changes to floodplain soils through compaction or earthworks can have a significant impact on their ability to dig burrows. Predation by foxes as a consequence of poor burrows can cause up to 95% mortality of eggs and young.

- Research and observation in the ecological community indicate that river red gum forest and woodland requires inundation in winter, spring or summer every one to three years and that inundation lasts for a minimum of four to seven months but for no longer than 24 months. The key requirement is cycles of flooding and drying that enable soil aeration and water penetration into the root zone. Lignum shrubland occurs in areas flooded at frequencies of once in two to ten years for durations of three to 12 months. The optimal flood times for growth and recruitment are spring and summer to maintain soil moisture. The vegetation of seasonal or intermittent wetlands such as water couch, common reed and mixed marsh needs to be inundated for at least eight years out of ten with water couch requiring inundation for at least six months of the year (DECCW 2010).
- Waterbirds usually breed in response to large floods that inundate the ecological community (Kingsford & Johnson 1998). A flooding requirement of between 180,000 megalitres and 300,000 megalitres, depending on antecedent conditions, is a general guideline. In the past this volume has supported successful breeding of about 4,000 pairs of egrets and 10,000 pairs of ibis in the four most secure aggregation sites: Bora, Willancorah, Zoo Paddock and Gum Cowal-Terrigal (OEH 2012a). River regulation is estimated to have decreased aggregation sizes by about 100,000 nests every eleven years, decreasing the frequency of breeding events (Kingsford & Johnson 1998; OEH 2012a).
- In addition to water volume, aggregation sites and feeding areas need to be inundated for a minimum of four to five months between August and March. Although smaller flows do not generally support successful nesting waterbird breeding, they do enable other flood-dependent waterbird species to breed such as cormorants, herons, spoonbills and ducks. (Marchant & Higgins 1990; Jones 2009; DECCW 2010). Smaller flows are also important for maintaining wetland vegetation for habitat as well as aquatic invertebrates and fish as prey for waterbirds (Jenkins & Wolfenden, 2006).
- Waterbirds need to gain condition before breeding so food availability both prior to and during nesting and egg-laying is critical for successful waterbird breeding. There is generally a lag time between the commencement of a flood and the commencement of waterbird breeding. Most waterbirds need to increase their fat reserves before egg-laying and then require suitable food types for their young.
- The types of food eaten by waterbird species varies with their morphology. Some species rely totally on plant material, others on a range of food types found in or on the edges or wetlands. The food types of various waterbirds are detailed in [Table C2](#).
- Floodplain soils contain a substantial egg bank that produces a massive pulse in microinvertebrate biomass within the first 28 days after flooding (Jenkins & Wolfenden, 2006). This underpins food webs in the Marshes and eventually enables waterbirds to breed successfully. The availability of water couch seed may underpin the success of breeding for magpie geese in the ecological community as they require not only reed or

cumbungi for nest construction, but also large areas of aquatic grasses for food for young (Marchant & Higgins 1990; OEH 2012a).

Wetting and drying

In a natural system wetting and drying cycles are driven by stream inflow or floodplain flooding and many wetlands in semi-arid Australia are adapted to these cycles (Passfield et al. 2008). The wetting-drying sequence is also important for habitats within the river channel component of the ecological community. Primarily, changes in the water level in the channel affect the growth of biofilms, which is a layer of living microorganism including algae, fungi and bacteria, in a polysaccharide matrix coating submerged gravel, rocks, plant, leaves, wood, etc. (also called epilithon, aufwuchs, epiphyton, periphyton). Biofilms provide food for fish, snails and other grazing invertebrates (Walker 2001). Within floodplain systems, the interaction between temperature and flow also contributes to the structuring of biotic communities (Tockner et al. 2000).

The duration and the time of year the wetlands hold water (hydroperiod) is largely responsible for determining what amphibian species can breed successfully in the wetland. It determines not only the length of time that amphibian larvae have for developing to the point where they can leave the water for land, but also the number and types of predators to which they are exposed (Tarr and Babbitt, undated). Amphibians, both as tadpoles and as adults, contribute to the diet of waterbirds and fish and are important for their role in the food chain.

Studies of wetting and drying cycles in the Macquarie Marshes have shown that microinvertebrate diversity has been reduced by loss of flooding (Jenkins 2006). Also more permanently flowing creeks are not as productive as floodplain areas that have been flooded. Invertebrate communities are more productive and diverse after an environmental allocation has inundated dry creeks and floodplain, than in regulated creeks (Jenkins et. al. 2008).

Connectivity

Connectivity between the Wambuul/Macquarie River and its floodplain woodlands and wetlands interact with sediment trapping, substrate stabilisation, soil formation, and nutrient cycling to maintain the mosaic of wetland types found in the Macquarie Marshes.

Adequate hydrological flows are important to maintain connectivity between stream channels and floodplain wetlands. Reduction in connectivity can severely impact resilience and result in rapid decline of components of the ecological community.

While connectivity requirements vary with the species in question, generally, connectivity provides pathways for dispersal, increasing pollination and the spread of propagules among individuals and populations. In addition, the diversity and abundance of fauna in the ecological community depend on connectivity to adjacent ecological communities. During flow events, fish are likely to move into the Marshes from adjacent main channel habitats, directly upstream and downstream, but also from tributaries such as the Marthaguy Creek. The composition of the fish sub-community found at a particular site or within a particular creek of the Marshes is likely to be regulated by a combination of local habitat characteristics, recent and historical flows and the degree of longitudinal and lateral connectivity to habitats, including the floodplain (Jenkins et al. 2004; Rayner et. al.2009; DECCW 2010).

Sediments and nutrients

Trapping and stabilisation of sediment and accumulation of organic matter allows the formation of the fertile self-mulching clay soils in the ecological community. These soils slow water flow, allowing assimilation of sediments and nutrients (and contaminants). This process allows for biological growth or development, including cycling of particular nutrients or elements from the environment through one or more organisms back to the environment. This includes primary production and the carbon, nitrogen and phosphorus cycles (DSEWPaC 2012). These fertile soils support the range of flood-dependent vegetation types that provide habitat for a vast array of waterbirds and other fauna.

Ecological productivity

Floods drive ecological productivity initiating a new cycle of nutrient absorption, recycling and release. Nutrients arrive with incoming floodwaters and in turn, nutrients and organic carbon are released from the floodplain as water recedes (Baldwin & Mitchell 2000; OEH 2012a). This provides conditions for a burst of primary production for organisms such as bacteria, phytoplankton and macrophytes which support higher level organisms, as well as enabling tree growth.

Densities of microinvertebrates (for example, rotifers, cladocerans, ostracods and copepods) found in habitats of the floodplain and temporary channels of the ecological community are some of the highest reported for wetlands anywhere in the world (Jenkins & Wolfenden 2006 in OEH 2012a). Microcrustaceans, such as cladocerans, ostracods and copepods are the preferred prey (particularly cladocerans) for the larvae of most native fish species (OEH 2012a). Microinvertebrates are also vital to the successful recruitment of native fish by providing their first food source after hatching (Geddes & Puckridge 1989).

Micro-invertebrates in turn are consumed by macroinvertebrates (including beetles, bugs and a variety of flies), fish and waterbirds. (Jenkins & Wolfenden 2006 in DSEWPaC 2012). Many waterbirds, such as pink-eared ducks feed exclusively on microinvertebrates while many ducks, egrets, ibis and spoonbills feed on macroinvertebrates.

Invertebrates break down organic matter, feeding on unstable carbon compounds, algae, bacteria, fungi and protozoans (Boon & Shiel 1990; Bunn & Davies 1999; OEH 2012a). Invertebrates therefore indirectly affect nutrient cycles and the flux of energy that are mediated by bacteria (Boon & Shiel 1990; Baldwin & Mitchell 2000; OEH 2012a).

Floodplain wetland food web linkages between waterbirds, fish, macroinvertebrates, microinvertebrates, organic matter, nutrients, bacteria, fungi and algae are represented in Figure C1. Maintenance of the food web and other ecological processes is essential to maintaining the integrity of the ecological community. Regular inundation of the floodplain is essential for all ecological processes in the Macquarie Marshes (Lake 2012).

Characteristic vegetation and fauna

The range of vegetation types and environments in the ecological community (open water, vegetated swamps and marshes, shrub-dominated swamps and seasonally flooded forests and woodlands) provide a large range of habitats for aquatic fauna such as waterbirds. The vegetation provides essential ecological resources for the ecological community in the form of shelter, food, breeding and nesting sites.

The vegetation along the channels also acts as a filter for sediments, phosphorous and organic nitrogen thus improving the quality of water entering the streams. The vegetation of the ecological community is also important habitat for terrestrial animals and birds. It is highly productive because of the proximity to water and the fertility of soil and sediment deposited by floods in the ecological community. Trees along riverbanks provide large sources of nectar and seed and good breeding sites (Hankinson & Soutar 2008).

Although many fauna species that inhabit this ecological community may also occur in other types of wetlands or extend into adjoining non-wetland areas, the nationally threatened status of several faunal species, such as *Rostratula australis* (Australian painted snipe) and *Botaurus poiciloptilus* (Australasian bittern), is a consequence of the decline in wetland habitats generally, including the decline of the ecological community.

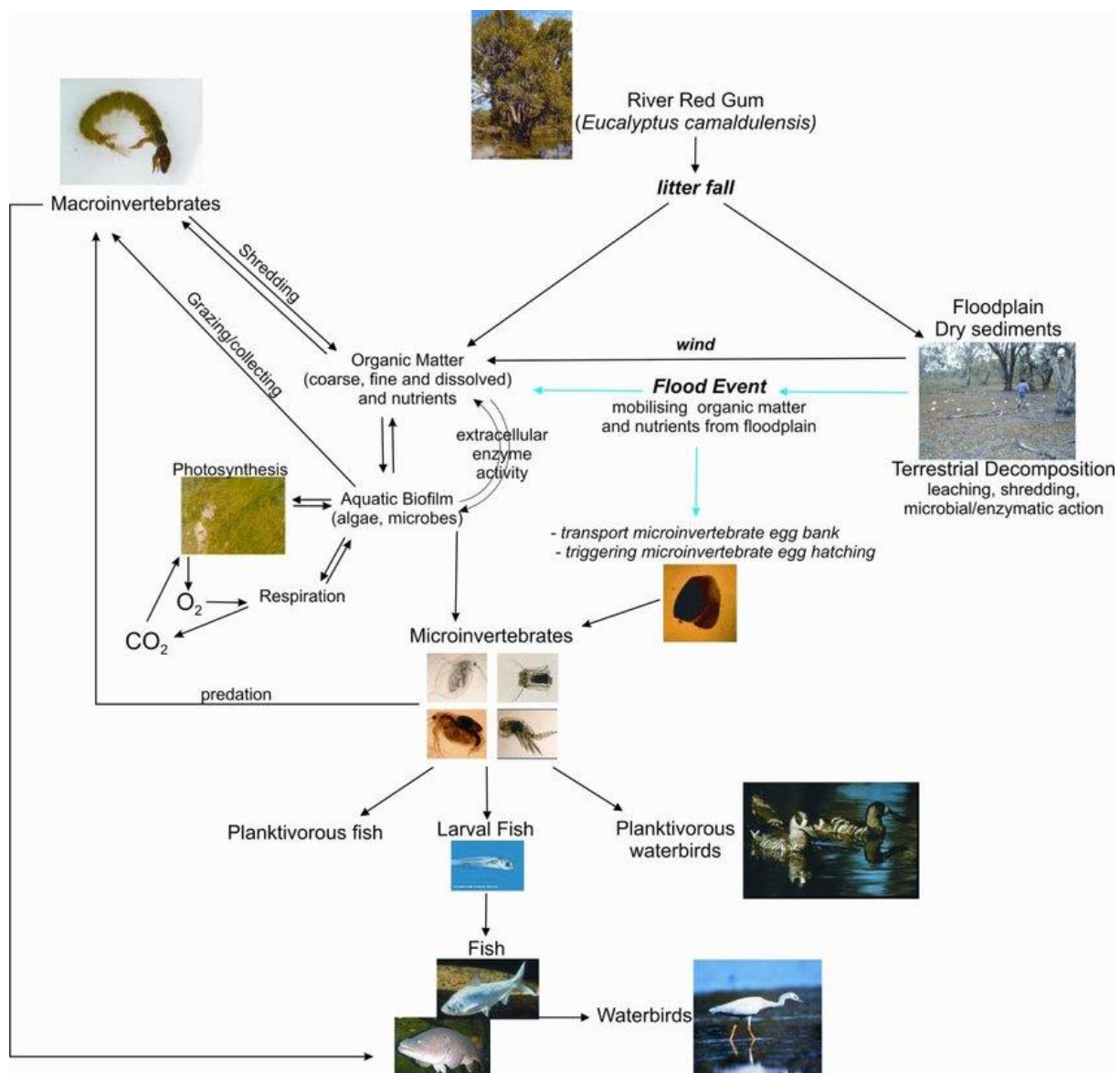


Figure C1: Floodplain wetland food web showing linkages between trees, waterbirds, fish, macro- invertebrates, microinvertebrates, organic matter, nutrients, bacteria, fungi and algae. Source: Jenkins et al. 2012.

Characteristic vegetation

Eucalyptus camaldulensis (river red gum) forests and woodlands are a distinctive feature of the ecological community and river red gum is considered a keystone species. A keystone species is one that has a disproportionately large effect on its environment relative to its abundance or biomass. There are two hallmarks of keystone species: their presence is crucial in maintaining the organisation and diversity of their ecological communities, and these species are 'exceptional', relative to the rest of the community, in their importance (Mills et al. 1993).

River red gum communities provide extensive habitat and resources for a range of aquatic, amphibious and terrestrial fauna. They also provide essential resources to the river in the form of dissolved organic carbon, structural features such as snags, and temperature moderation of the river by shading (Roberts & Marston 2011).

Duma florulenta (lignum) and *Acacia stenophylla* (river cooba) shrubland are important flood-dependent species in the ecological community. Lignum occurs as a shrubland in only a few parts of the ecological community but also occurs throughout the Macquarie Marshes as an understorey plant, often in association with river cooba or river red gum (DECCW 2010).

The extensive areas of common reed and water couch and stands of *Typha domingensis* (cumbungi) provide critical habitat for waterbirds and other wetland animals in the ecological community (DECCW 2010). However, much of the 19,000 ha that supported these vegetation types in 1991 no longer contains flood-dependent vegetation. More than half has been replaced by chenopod shrubland due to changed flow regimes (Bowen & Simpson 2010).

Characteristic waterbirds and their breeding

Waterbirds and terrestrial birds, including migratory species, are important features of the Wetlands and inner floodplains of the Macquarie Marshes ecological community. The mosaic of vegetation in and adjoining the ecological community provides crucial nesting, feeding and/ breeding habitat for both waterbird and terrestrial bird species. The plants (shrubs and trees) growing near water bodies provide shade and shelter, buffer from temperature extremes and create habitat for fish. The vegetation also provides a constant source of fine organic materials through leaf fall, providing food for the invertebrates and fish that form the diet of some bird species (Hankinson & Soutar 2008). The ecological community is also recognised as a refuge for waterbirds during dry times (MMIC 1951; OEH 2012a).

The Macquarie Marshes is recognised for supporting some of Australia's largest recorded waterbird breeding aggregations, 10,000 to 300,000 adult waterbirds relying on the ecological community in some seasons for their breeding, feeding and habitat requirements (Kingsford & Auld 2005; OEH 2012a). The ecological requirements for breeding waterbirds in the Macquarie Marshes include nesting sites, food and specific flow size, timing and durations.

Waterbird habitat components include preferred locations and vegetation for shelter and nest sites, adequate water needed to flood breeding sites and feeding areas, and the availability of preferred food items (DECCW 2010). Most breeding sites are located in seasonal or intermittent wetland vegetation and river red gum forest and woodland, requiring frequent and prolonged flooding (Kingsford & Auld 2005).

Nesting sites - Nesting sites for breeding waterbird aggregations vary between species with some species nesting on the ground but most requiring some form of vegetation — live or dead trees, tree hollows, shrubs and/or reeds. Information on nesting sites for breeding waterbird

aggregations is presented in [Table C1](#). The type of food utilised by waterbirds is presented in [Table C2](#).

Table C1: Vegetation type used by nesting waterbirds in the Wetlands and inner floodplains of the Macquarie Marshes (the list is not exhaustive). Source: OEH 2012a.

Vegetation Type	Waterbird species
Live trees <ul style="list-style-type: none"> river red gum is the most utilised live nesting tree, with river cooba also an important species 	great egret, cattle egret, intermediate egret, little egret, white-faced heron, pied heron, rufous night heron, great cormorant, little pied cormorant, little black cormorant and yellow-billed spoonbill.
Live or dead trees	darther and whitenecked (Pacific) heron.
Tree hollows <ul style="list-style-type: none"> uses a number of different tree species including river red gum 	Australian wood duck
Tree hollows and/or ground nesting <ul style="list-style-type: none"> commonly recorded breeding throughout the ecological community and use tree species including river red gum 	grey teal, Australasian shelduck and Pacific black duck
Shrubs and/or reed nesting <ul style="list-style-type: none"> nest sites are hidden within the shrubs and reeds but for ibis and royal spoonbill the shrubs and reeds are flattened to provide platforms for nests most important plant species are lignum, common reed, cumbungi and marsh club-rush 	blue-billed duck, freckled duck, hardhead, musk duck, pink-eared duck, magpie goose, little bittern, Eurasian coot, dusky moorhen, black-tailed native-hen, purple swamphen, glossy ibis, Australian
Ground, floating or island nesting <ul style="list-style-type: none"> most important plant species are cumbungi, common reed and several sedge and rush species 	Australasian shoveler, black swan, plumed whistling-duck, black-fronted dotterel, red-kneed dotterel, masked lapwing, brolga, whiskered tern, great crested grebe, hoary-headed grebe, Australasian grebe, black-winged stilt.
Cumbungi	magpie geese have only been recorded breeding on cumbungi

Terrestrial birds

Regulation of rivers worldwide has reduced the ecological resilience and biodiversity of riparian and floodplain ecosystems and their dependent biota. Most knowledge of this is of the effects on aquatic organisms, but some terrestrial animals, such as woodland birds, may also be dependent on flows (Blackwood et al. 2010). Woodland birds use wetlands, floodplains and riparian areas for habitat, foraging, breeding, and watering (Johnson et al. 2007). For example, river red gums provide habitat and food for a large variety of woodland birds (Stefano 2002 in Blackwood et al. 2010). Many once common woodland bird species are now considered to be declining in south-east Australia. Reid (1999) listed 20 woodland bird species whose numbers in New South Wales have declined significantly since the 1980's. 18 of these species are found commonly in the ecological community including *Climacteris picumnus* (brown tree creeper), *Pomatostomus temporalis* (grey-crowned babbler), *Melanodryas cucullata* (hooded robin) and *Stagonopleura guttata* (diamond firetail) that are listed as threatened under the NSW *Biodiversity Conservation Act 2016*.

The main reason for a decline in woodland bird species is loss of habitat, fragmentation of woodland vegetation and simplification or degradation of the remaining woodland vegetation (Ford et al. 2001). Large intact woodlands with native shrubs and groundcover plants are now extremely rare in the south-east Australia particularly on fertile soils such as those found in or near the ecological community (Yates & Hobbs 1997).

Table C2: Waterbirds and food type. Source: Scott 1997.

Food type	Waterbird species
Aquatic macrophytes e.g. <i>Vallisneria</i> spp. (ribbonweeds)	<ul style="list-style-type: none"> black swans and coots
Seedheads, buds, leaves and other plant parts	<ul style="list-style-type: none"> magpie geese, plumed whistling ducks, maned ducks
Invertebrates and other small animals <ul style="list-style-type: none"> microinvertebrates are particularly important for breeding waterbird aggregations 	<ul style="list-style-type: none"> dabblers in shallow water and mud for invertebrates and seeds – e.g. pacific black duck, grey teal and chestnut teal; filterers or sievers in shallow water and mud – e.g. pink-eared duck, Australasian Shoveler and spoonbills waders in mud flats that eat crustaceans, worms and other invertebrates e.g. probers along water's edge or in damp ground for beetles, grubs and insects e.g. glossy ibis, straw-necked ibis and Australian white ibis shallow water 'hunters' for invertebrates (crustaceans) and vertebrates (frogs, tadpoles, small fish) – e.g. egrets and rufous night heron divers underwater feeding on benthic invertebrates – e.g. blue-billed duck and musk duck
Fish	<ul style="list-style-type: none"> Australian pelican, cormorants, darter, terns

Oliver & Parker ((2006) in Blackwood et al. 2010) found that, river red gum woodlands and forests in the NSW central Murray catchment had the highest total bird abundance and species richness when compared with other woodland types and tree planting sites. 18 of the 20 declining woodland bird species of the sheep-wheat belt are found in the Macquarie Marshes. River red gum forest and woodlands are an important and extensive plant community in the ecological community (DECC 2009 in OEH 2012a).

Mammals

Planigale tenuirostris (narrow-nosed planigale), a small marsupial mouse, is found only in cracking grey soils. Water rats live in permanent water bodies and can tolerate a range of water quality including high salinity. However, they cannot tolerate cold water (<5C°) or high levels of turbidity. As they collect most of their food from water (aquatic insects, fish, yabbies, mussels and frogs) turbidity levels can affect their ability to find food. Water rats normally only breed once a year.

Further information on the functional role, characteristics and/or requirements of characteristic fauna of the ecological community is presented in [Table C3](#).

Table C3: Selected fauna species, their functional role, characteristics and/or requirements within the Macquarie Marshes

Taxon	Functional Role	Ecological Characteristics/Requirements	References
Macroinvertebrates	<ul style="list-style-type: none"> multiple functional groups - e.g. shredders, grazers, gatherers, filterers, predators influence nutrient cycling, primary production, decomposition and translocation of materials important link between primary producers, detrital deposits, and higher trophic levels in aquatic food webs important source of food for fish (+ larvae) good environmental indicators 	<ul style="list-style-type: none"> at least 100 macroinvertebrate taxa recorded including nematodes, worms, molluscs, water insects, crayfish, shrimps and many other forms 	Jenkins et. al. 2007
<i>Maccullochella peelii</i> (Murray cod)	<ul style="list-style-type: none"> large bodied fish apex predator (adults - fish and crustaceans; larvae - zooplankton) long lived 	<ul style="list-style-type: none"> floods/freshes not needed to trigger spawning, but gain significant benefits from increased flow which improve larval survivorship spawning triggered by increasing temperature and day length cover-oriented at all life-stages (snags, rocks) 	Lintermans, 2007; Ye & Zampatti 2007.
<i>Bidyanus bidyanus</i> (silver perch)	<ul style="list-style-type: none"> large bodied fish, omnivore 	<ul style="list-style-type: none"> inhabits warm, sluggish, standing waters with cover provided by woody debris and reeds as well as fast-flowing, turbid waters similar to cod re floods/freshes highly migratory (adults spawning related, up to 517 km; juveniles dispersal related) 	Koehn & O'Connor 1990; Reynolds 1983; Lintermans 2007.
Frogs	<ul style="list-style-type: none"> as tadpoles and as adults, contribute to the diet of waterbirds and fish and are important for their role in the food chain 	<ul style="list-style-type: none"> generally need flooding in spring or summer to initiate breeding and a water depth of between 10–50 cm for anywhere from 30 to 180 days depending on the species provided the habitat is available this ensures conditions are suitable for egg laying, algal growth for feeding tadpoles and time for metamorphosis 	Young 2001; OEH 2012a; DPE 2023; Coleman et al. 2024
<i>Pseudechis porphyriacus</i> (red-bellied black snake)	<ul style="list-style-type: none"> preys on fish, tadpoles, frogs, lizards, snakes, mammals and the occasional aquatic invertebrate 	<ul style="list-style-type: none"> a wetland specialist 	Greer 2006
Waterbirds	<ul style="list-style-type: none"> maintaining wetland connectedness (even in the absence of direct hydrologic links) via bird-mediated dispersal of aquatic organisms top order consumer in the food web of the ecological community 	<ul style="list-style-type: none"> use vegetation associations in the EC for nesting and breeding (live trees, shrubs, reed, ground, floating or island), shelter, feeding nesting waterbird species (CNS) such as the straw-necked ibis, magpie geese, intermediate egret, rufous/nankeen night heron, royal spoonbill minimum requirement for CNS to breed successfully is flooding of a sufficient volume and duration for 	Ralph & Rogers 2011; Amezcaga et al. 2002; Kingsford & Thomas 1995; (Jenkins & Wolfenden 2006; (Marchant & Higgins 1990; Jones 2009 in AEMP 2010).

Taxon	Functional Role	Ecological Characteristics/Requirements	References
		aggregation sites and feeding areas to be inundated for a minimum of 4–5 months between August and March <ul style="list-style-type: none"> flows are also critical both for maintaining wetland vegetation and for completing the life cycles of aquatic invertebrates, an important food source for some smaller flows do not generally support successful CNS breeding, but do enable other flood-dependent waterbird species to breed, e.g. cormorants, herons, spoonbills and ducks 	
Woodland birds	<ul style="list-style-type: none"> pollination of plants seed dispersal control of pests 		

Consultation Questions

- Please note if you agree with the extra information on key biology and ecology in this Appendix. If not, please specify how can it be clarified.
- Please provide any fauna or flora species details incorrectly recorded in this Appendix; please provide details.
- Please provide additional information on fauna you would like to see included, particularly commonly encountered fauna, characteristic invertebrates and those with important ecological functions in the ecological community. Please suggest further reference information/ sources.

Appendix D – Detailed description of national context and existing protection

Land use history

The Macquarie Marshes have existed in their current location and maintained their general wetland state for the last 6000 to 8000 years (Yonge & Hesse 2002 in OEH 2012a). Natural and human-induced landscape change in the region dates back to pre-European use by First Nations people and has continued to the present time. Following European (and other non-Indigenous) settlement, grazing in the region was undertaken from the 1830s, irrigated agriculture from the 1840s, the scale of which increased following completion of Burrendong Dam in 1967 (OEH 2012a).

National context

The combination of ecological characteristics found in the Macquarie Marshes is what makes the Wetlands and inner floodplains of the Macquarie Marshes ecological community unique in Australia's national context. The ecological community captures the immense diversity of flora and fauna that is reliant on the inundation patterns of the Macquarie Marshes. In terms of wetland habitat it:

- supports one of the three most extensive *Eucalyptus camaldulensis* (river red gum) woodlands (about 6000 ha) in the Murray-Darling Basin;
- supports the largest extensive *Phragmites australis* (common reed) beds in the northern Murray-Darling Basin; and
- is one of only two locations in the Murray-Darling Basin with extensive *Paspalum distichum* (water couch) marsh (approximately 900 ha) (DSEWPac 2012).

The Wetlands and inner floodplains of the Macquarie Marshes ecological community is recognised as one of the most important wetlands in Australia for waterbirds:

- it provides habitat for some 72 species of waterbirds (including 43 species which breed in the Marshes (Kingsford 2000), including for at least 17 species of migratory bird species listed under the EPBC Act, Bonn Convention and/or international agreements for the protection of migratory birds and their habitats¹
- is one of the most important waterbird aggregation breeding sites in Australia for both species diversity and nesting density (Kingsford & Auld 2003) including for significant breeding aggregations of *Plegadis falcinellus* (glossy ibis), *Threskiornis molucca* (Australian white ibis), *Threskiornis spinicollis* (straw-necked ibis), *Ardea intermedia* (intermediate egret) and *Nycticorax caledonicus* (Nankeen (rufous) night heron); and is known to support large numbers of nesting waterbirds (specifically ibis, egrets, cormorants and night herons) when appropriate conditions exist (greater than 200,000 megalitres) (DSEWPac 2012).

¹ Japan-Australia Migratory Bird Agreement (JAMBA), China-Australia Migratory Bird Agreement (CAMBA) and Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).

- provides nesting sites and habitat in the river red gum forest and woodland for both waterbirds and for declining populations of woodland birds that depend on the rivers and wetlands of the ecological community because these are often the more productive areas in an otherwise dry environment.

National wetland classification

An Interim Australian National Aquatic Ecosystem (ANAE) Classification Framework (Module 2, Version 1) to describe and classify the range of aquatic ecosystems and habitats across Australia was developed by the Aquatic Ecosystem Task Group and endorsed by the Standing Council on Environment and Water in 2012. The framework considers classification attributes at multiple scales (region, landscape, aquatic system and habitat). The available aquatic system descriptors characterise the national ecological community by six broad level categories: estuarine, lacustrine, palustrine, riverine, riverine floodplain and non-riverine floodplain. However, a full ANAE technical assessment, would involve detailed spatial and on-ground evaluation that would likely identify the associated aquatic ecosystem types present.

The Directory of Important Wetlands (DIWA) collates information about nationally and internationally important (i.e., Ramsar) wetlands in Australia. It uses a classification system slightly modified from the Ramsar Convention to classify Australian wetlands into 42 types. The Macquarie Marshes ecological community includes seven different types of wetlands (i.e. under DIWA classification [Table D2](#)). Most wetland sites contain more than one type of wetland.

Table D2: Directory of Important Wetlands of Australia (DIWA) classification system for wetlands of national importance within the ecological community.

Number	Description (B - Inland wetlands)
B1	Permanent rivers and streams; includes waterfalls
B2	Seasonal and irregular rivers and streams
B4	Riverine floodplains; includes river flats, flooded river basins, seasonally flooded grassland, savanna and palm savanna
B9	Permanent freshwater ponds (< 8 ha), marshes and swamps on inorganic soils; with emergent vegetation waterlogged for at least most of the growing season
B10	Seasonal/intermittent freshwater ponds and marshes on inorganic soils; includes sloughs, potholes; seasonally flooded meadows, sedge marshes
B13	Shrub swamps; shrub-dominated freshwater marsh, shrub carr, alder thicket on inorganic soils
B14	Freshwater swamp forest; seasonally flooded forest, wooded swamps; on inorganic soils

Table D3: Level of protection for the *Wetlands and inner floodplains of the Macquarie Marshes* in reserves and/or as Ramsar sites. Sources: OEH 2012a; DECCW 2010.

Protected Area	Area (ha)	Type of protection#
Ginghet Nature Reserve	6,239	State Nature Reserve
Macquarie Marshes Nature Reserve – northern section	11,716	State Nature Reserve and Ramsar
Creswell addition to Macquarie Marshes Nature Reserve – northern section	688	State Nature Reserve and Ramsar
Pillicawarrina addition to Macquarie Marshes Nature Reserve – northern section	*2,800	State Conservation Area
U-block	189	Ramsar
Macquarie Marshes Nature Reserve – southern section	6,476	State Nature Reserve and Ramsar
Macquarie Marshes Nature Reserve –Ninia	924	State Nature Reserve
Wilgara Wetlands	583	Ramsar
Total – Macquarie Marshes Nature Reserve	22,604	
Total – Ramsar wetlands	19,652	
Total – All sites	29,615	

#**State conservation areas** are lands reserved to protect and conserve significant or representative ecosystems, landforms, natural phenomena or places of cultural significance, while providing opportunities for sustainable visitation, enjoyment, use of buildings and research. The principal difference between the management, objectives and principles of national parks and state conservation areas is that mineral and petroleum exploration and mining may be permitted in state conservation areas.

Nature reserves are areas of land in a predominantly untouched, natural condition which have high conservation value. Their primary purpose is to protect and conserve their outstanding, unique or representative ecosystems, native plant and animal species or natural phenomena. Scientific research is an important objective in nature reserves, as it increases our understanding of their values and provides the information needed to conserve them. Nature reserves have few visitor facilities, such as picnic areas, lookouts and walking tracks, and visitation is carefully managed to minimise disturbance.

National parks are areas of land protected for their unspoiled landscapes, outstanding or representative ecosystems, native plant and animal species and places of natural or cultural significance. In addition to their role in conservation, national parks provide opportunities for public appreciation and enjoyment, sustainable visitor use and scientific research.

***State Conservation Area** not included as mineral and petroleum exploration and mining may be permitted in such reserves.

Appendix E – Supporting information for eligibility for listing against EPBC Act criteria

The EPBC Act identifies six criteria against which to assess whether an ecological community is eligible for listing. The *Guidelines* for ecological community nominations (TSSC, 2013) give indicative qualitative and quantitative thresholds for these criteria to guide the assessments of threatened ecological communities under the EPBC Act.

Measuring changes in the extent or integrity of wetland systems is challenging because this often involves hydrological or functional changes, rather than outright loss of entire aquatic units. Sometimes, components of aquatic systems are clearly lost, for example, removal of fringing floodplain vegetation, draining individual wetlands and this provides some indication of decline in extent. In many cases, however, changes to wetland systems are more subtle than outright loss, involving changes in inundation patterns or water quality.

Benchmark state(s) may be used to assess when decline or loss has occurred for a wetland system. A benchmark state is the reference condition against which future comparisons can be made. It is recognised that the *Wetlands and inner floodplains of the Macquarie Marshes* ecological community is now a regulated aquatic system that has been subject to major and permanent changes, dating back to 1896. Therefore, using pre-European or pre-regulation condition as a benchmark state for the ecological community is impractical (particularly so as a target for management actions). A benchmark state that is more indicative of change over recent decades is considered the state of the ecological community around 1990, when the last large flood of the 20th century was recorded for the region around the ecological community. The 1990s benchmark acknowledges the period of 'good' flow conditions after water flows were regulated and before the Millennium Drought. It is also before the pervasive spread and establishment of common carp (*Cyprinus carpio*) throughout the upper Murray-Darling Basin system.

The 1990s benchmark date also marks a period of systematic biological studies of the ecological community. For example, the *Directory of Important Wetlands in Australia* was first published in 1993 and established a boundary of approximately 200,000 ha for the Macquarie Marshes. The Wetlands GIS of the Murray-Darling Basin Series 2.0 (MDBC 1993) and Kingsford and Thomas (1995) also provided information about the maximum wetland extent and extent of historical floods. The period since 1991 coincides with survey data on the composition and extent of vegetation, waterbirds and other fauna in the ecological community.

For the purposes of this criteria assessment, it is important to specify how and when decline or loss within the ecological community may be considered to have occurred with respect to the 1990s benchmark state(s).

Loss is when elements of the ecological community have undergone irreversible or permanent change from their presumed natural state. Examples include drainage of wetlands, clearing patches of native vegetation, and replacement of natural systems with crops, improved pastures or developments and structures.

Decline implies long-term degradation and loss of function as evidenced by one or more of these criteria:

- key species or suites/guilds of species of the ecological community have undergone a long-term change in numbers or health with a concomitant loss of functional integrity — for example changes in vegetation patterns or waterbird abundance
- the physico-chemical conditions that underpin wetland ecology are changed so the system no longer functions as per the benchmark state — for instance increased salinity or altered nutrient levels
- the hydrological patterns of the ecological community have altered significantly, for instance, loss of regular water flows, changed inundation patterns such as a shift from permanent to temporary wetlands or seasonal to episodic wetlands
- recovery from these changes is unlikely within the foreseeable future, even with positive human intervention.

E1 Extent of the Macquarie Marshes

Table E1: Estimated extent of vegetation and wetlands (hydro-ecological functional groups) that occur within and near the Wetlands and inner floodplains of the Macquarie Marshes. Source: Kingsford & Thomas 1995; Bowen & Simpson 2010; DPE 2013; Bowen et al. 2019.

Hydro-ecological functional group	Extent 1991 (ha)	Extent 2008 (ha)	Extent 2013 (ha)
<i>A. Ecological community – wetland components</i>			
<i>River red gum</i>			
River Red Gum tall to very tall open forest (wetland) (36)	2676	2711	2527
River Red Gum tall woodland (wetland) (36a)	17,694	18,171	20,798
River Red Gum grassy chenopod open tall woodland (wetland) (454)	19,769	18,808	18,534
River ed gum sub total	40,139	39,690	41,859
<i>Semi-permanent wetlands</i>			
Common Reed-Bush groundsel aquatic tall reedland grassland wetland (PCT 181)	5458	2317	4864
Cumbungi rushland wetland of shallow semi-permanent water bodies and inland watercourses (182)	457	0	1534
Water Couch marsh grassland wetland (204)	12,918	912	5354
Shallow freshwater wetland sedgeland (53)	7878	3528	6476
Semi-permanent wetlands sub total	26,711	6757	18,228
<i>Flood-dependent shrubland wetland</i>			
River coobah - lignum swamp wetland (241)	20,258	5727	19,512
Lignum shrubland wetland (247)	4395	1507	1442
Flood-dependent shrubland wetland sub total	24,653	7234	20,954
<i>B. Lagoons</i>			
Permanent and semi-permanent freshwater lagoons (238)	420	124	396
<i>Channel</i>			
Channel - open water	95	138	138
<i>Watercourse</i>			
Watercourse - open water	129	127	128
Total (A + B)	92,147	54,070	80,703
<i>C. Vegetation in the Macquarie Marshes region excluded from the ecological community</i>			
Black Box woodland wetland (37)	17,700	16,169	18,713
Coolibah open woodland wetland (40)	8792	8320	8645
Sub total	26,492	24,489	27,364
Non flood-dependent floodplain vegetation	114,036	109,397	92,090
Invasive native terrestrial shrubland	4	14,847	313
Total (C)	140,532	148,733	119,767
Total (A + B + C)	232,532	202,803	200,470

Table E2a: Condition of Seasonal or intermittent wetland components of the *Wetlands and inner floodplains of the Macquarie Marshes* ecological community, as assessed in 2008 during the Millennium Drought. Source: Bowen & Simpson 2010.

Vegetation type	Condition	2008 extent (hectares)	Condition type in 2008 (%)
Seasonal or intermittent wetland	Good [<10% cover of exotic or encroaching native species]	2378	12.9
	Intermediate [10-50% cover of exotic or encroaching native species]	3835	20.8
	Poor [>50% cover of exotic or encroaching native species]	12,262	66.4
	TOTAL	18,475	100

Table E2b: Condition of key river red gum wetland components of the *Wetlands and inner floodplains of the Macquarie Marshes* ecological community. Source: Bowen & Simpson 2010; Bowen et al. 2019.

Vegetation type	Condition class	Extent 1991 (ha)	Extent 2008 (ha)	Condition 2008 (%)	Extent 2013 (ha)	Condition 2013 (%)
River red gum (open forest, woodland, grassy woodland) (PCT 36, 36a, 454)	Good [0-10% dead canopy]	36,350	2179	6	12,843	31
	Intermediate [10-40% dead canopy]	3748	13,401	34	19,232	46
	Intermediate – Poor [40-80% dead canopy]	41	8513	21	5342	13
	Poor [80-100% dead canopy]	0	15,595	39	4442	10
	Total	40,139	39,688		41,859	

Table E3: Estimated extent of key wetland components (Hydro-ecological functional groups) of the *Wetlands and inner floodplains of the Macquarie Marshes* ecological community. Source: Kingsford & Thomas 1995; Bowen & Simpson 2010; DPE 2013; Bowen et al. 2019.

Hydro-ecological functional group	Extent 1991 (ha)	Extent 2008 (ha)	Extent 2013 (ha)
<i>River red gum</i>			
River Red Gum tall to very tall open forest (wetland) (36)	2676	2711	2527
River Red Gum tall woodland (wetland) (36a)	17,694	18,171	20,798
River Red Gum grassy chenopod open tall woodland (wetland) (454)	19,769	18,808	18,534
Sub total	40,139	39,690	41,859
<i>Semi-permanent wetlands</i>			
Common Reed-Bush groundsel aquatic tall reedland grassland wetland (PCT 181)	5458	2317	4864
Cumbungi rushland wetland of shallow semi-permanent water bodies and inland watercourses (182)	457	0	1534
Water Couch marsh grassland wetland (204)	12,918	912	5354
Shallow freshwater wetland sedgeland (53)	7878	3528	6476
Sub total	26,711	6757	18,228
<i>Flood-dependent shrubland wetland</i>			
River coobah - lignum swamp wetland (241)	20,258	5727	19,512
Lignum shrubland wetland	4395	1507	1442
Sub total	24,653	7234	20,954
<i>Lagoons</i>			
Permanent and semi-permanent freshwater lagoons (238)	420	124	396
<i>Channel</i>			
Channel - open water	95	138	138
<i>Watercourse</i>			
Watercourse - open water	129	127	128
Total	92,147	54,070	80,703

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