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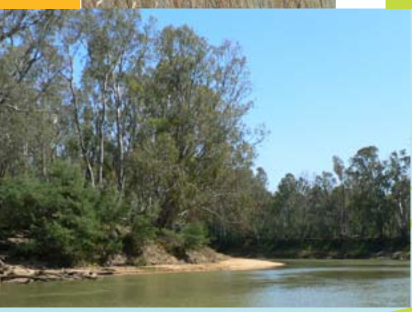

NSW Central Murray Forests

Ramsar Site

Ecological Character Description

Australian Government

Department of Sustainability, Environment, Water, Population and Communities

NSW Central Murray Forests Ramsar site

Ecological Character Description

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Introductory Notes
This Ecological Character Description (ECD Publication) has been prepared in accordance with the *National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands (National Framework) (Department of the Environment, Water, Heritage and the Arts, 2008).*

The Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) prohibits actions that are likely to have a significant impact on the ecological character of a Ramsar wetland unless the Commonwealth Environment Minister has approved the taking of the action, or some other provision in the EPBC Act allows the action to be taken. The information in this ECD Publication does not indicate any commitment to a particular course of action, policy position or decision. Further, it does not provide assessment of any particular action within the meaning of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth), nor replace the role of the Minister or his delegate in making an informed decision to approve an action.

The *Water Act 2007* requires that in preparing the [Murray-Darling] Basin Plan, the Murray Darling Basin Authority (MDBA) must take into account Ecological Character Descriptions of declared Ramsar wetlands prepared in accordance with the National Framework.

This ECD Publication is provided without prejudice to any final decision by the Administrative Authority for Ramsar in Australia on change in ecological character in accordance with the requirements of Article 3.2 of the Ramsar Convention.

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Note: There may be differences in the type of information contained in this ECD publication, to those of other Ramsar wetlands.

Cover photos (left to right):

Central Murray Forests – Jeanette Muirhead (SEWPAC)
Central Murray Forests – Jeanette Muirhead (SEWPAC)
Ibis – Sarah Young (SEWPAC)
Barr Creek in Central Murray Forests – John Baker (SEWPAC)
Central Murray Forests – Jeanette Muirhead (SEWPAC)

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Glossary

Definitions of words associated with ecological character descriptions (DEWHA 2008 and references cited within).

Benefits	benefits/services are defined in accordance with the Millennium Ecosystem Assessment definition of ecosystem services as "the benefits that people receive from ecosystems (Ramsar Convention 2005, Resolution IX.1 Annex A). See also Ecosystem Services.
Biogeographic region	a scientifically rigorous determination of regions as established using biological and physical parameters such as climate, soil type, vegetation cover, etc (Ramsar Convention 2005).
Biological diversity	the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species (genetic diversity), between species (species diversity), of ecosystems (ecosystem diversity), and of ecological processes. This definition is largely based on the one contained in Article 2 of the Convention on Biological Diversity (Ramsar Convention 2005).
Change in ecological character	is defined as the human-induced adverse alteration of any ecosystem component, process, and/or ecosystem benefit/service (Ramsar Convention 2005, Resolution IX.1 Annex A).
Community	an assemblage of organisms characterised by a distinctive combination of species occupying a common environment and interacting with one another (ANZECC and ARMCANZ 2000).
Community composition	all the types of taxa present in a community (ANZECC and ARMCANZ 2000).
Conceptual model	wetland conceptual models express ideas about components and processes deemed important for wetland ecosystems (Gross 2003).
Contracting Parties	are countries that are Member States to the Ramsar Convention on Wetlands; 163 as at November 2012. Membership in the Convention is open to all states that are members of the United Nations, one of the UN specialized agencies, or the International Atomic Energy Agency, or is a Party to the Statute of the International Court of Justice.
Critical stage	meaning stage of the life cycle of wetland-dependent species. Critical stages being those activities (breeding, migration stopovers, moulting etc.) which if interrupted or prevented from occurring may threaten long-term conservation of the species (Ramsar Convention 2005).
Ecological character	is the combination of the Ecosystem Components, processes and benefits/services that characterise the wetland at a given point in time.
Ecosystems	the complex of living communities (including human communities) and non-living environment (Ecosystem Components) interacting (through Ecological Processes) as a functional unit which provides inter alia a variety of benefits to people (Ecosystem Services). (Millennium Ecosystem Assessment 2005).
Ecosystem components	include the physical, chemical and biological parts of a wetland (from large scale to very small scale, for example habitat, species and genes) (Millennium Ecosystem Assessment 2005).

Ecosystem processes	are the changes or reactions which occur naturally within wetland systems. They may be physical, chemical or biological (Ramsar Convention 1996, Resolution VI.1 Annex A). They include all those processes that occur between organisms and within and between populations and communities, including interactions with the non-living environment, that result in existing ecosystems and bring about changes in ecosystems over time (Australian Heritage Commission 2002).
Ecosystem services	are the benefits that people receive or obtain from an ecosystem. The components of ecosystem services are provisioning (for example food and water), regulating (for example flood control), cultural (for example spiritual, recreational), and supporting (e.g nutrient cycling, ecological value) (Millennium Ecosystem Assessment 2005). See also Benefits.
Essential elements	a component or process that has an essential influence on the critical components, processes or services (CPS) of the wetland. Should the essential element cease, reduce, or is lost, it would result in a detrimental impact on one or more critical CPS. Critical CPS may depend in part or fully on essential elements, but an essential element is not in itself critical for defining the ecological character of the site.
Fluvial geomorphology	the study of water-shaped landforms (Gordon et al. 1999)
Indigenous species	a species that originates and occurs naturally in a particular country (Ramsar Convention 2005).
Limits of Acceptable Change	the variation that is considered acceptable in a particular component or process of the ecological character of the wetland without indicating change in ecological character which may lead to a reduction or loss of the criteria for which the site was Ramsar listed (modified from definition adopted by Phillips 2006).
List of Wetlands of International Importance ("the Ramsar List")	the list of wetlands which have been designated by the Ramsar Contracting Party in which they reside as internationally important, according to one or more of the criteria that have been adopted by the Conference of the Parties.
Ramsar	City in Iran, on the shores of the Caspian Sea, where the Convention on Wetlands was signed on 2 February 1971; thus the Convention's short title "Ramsar Convention on Wetlands".
Ramsar Criteria	Criteria for Identifying Wetlands of International Importance, used by Contracting Parties and advisory bodies to identify wetlands as qualifying for the Ramsar List on the basis of representativeness or uniqueness or of biodiversity values.
Ramsar Convention	Convention on Wetlands of International Importance especially as Waterfowl Habitat. Ramsar (Iran), 2 February 1971. UN Treaty Series No. 14583. As amended by the Paris Protocol, 3 December 1982, and Regina Amendments, 28 May 1987. The abbreviated names "Convention on Wetlands (Ramsar, Iran, 1971)" or "Ramsar Convention" are more commonly used.
Ramsar Information Sheet (RIS)	the form upon which Contracting Parties record relevant data on proposed Wetlands of International Importance for inclusion in the Ramsar Database; covers identifying details like geographical coordinates and surface area, criteria for inclusion in the Ramsar List and wetland types present, hydrological, ecological, and socioeconomic issues among others, ownership and jurisdictions, and conservation measures taken and needed.
Ramsar List	the List of Wetlands of International Importance.
Ramsar Sites	wetlands designated by the Contracting Parties for inclusion in the List of Wetlands of International Importance because they meet one or more of the Ramsar Criteria.

Waterbirds	"birds ecologically dependent on wetlands" (Article 1.2). This definition thus includes any wetland bird species. However, at the broad level of taxonomic order, it includes especially: • penguins: *Sphenisciformes*. • divers: *Gaviiformes*; • grebes: *Podicipediformes*; • wetland related pelicans, cormorants, darters and allies: *Pelecaniformes*; • herons, bitterns, storks, ibises and spoonbills: *Ciconiiformes*; • flamingos: *Phoenicopteriformes*: • screamers, swans, geese and ducks (wildfowl): *Anseriforme*s; • wetland related raptors: *Accipitriformes* and *Falconiformes*; • wetland related cranes, rails and allies: *Gruiformes*; • Hoatzin: *Opisthocomiformes*; • wetland related jacanas, waders (or shorebirds), gulls, skimmers and terns: *Charadriiformes;* • coucals*: Cuculiformes;* and • wetland related owls: *Strigiformes*.
Waterfowl	Waterbirds of the order Anseriformes, especially members of the family Anatidae, which includes ducks, geese, and swans.
Wetlands	are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres (Ramsar Convention 1987).
Wetland types	as defined by the Ramsar Convention's wetland classification system.

List of Abbreviations

ARI	Average recurrence interval
CAMBA	China Australia Migratory Bird Agreement
CEPA	Communication, Education, Participation and Awareness
CMS	Bonn Convention on Migratory Species
CPS	Components, Processes and Services
DECCW	Department of Environment, Climate Change and Water (NSW)
DEWHA	(former) Department of the Environment, Water, Heritage and the Arts (Commonwealth)
EAAF	East Asian Australasian Flyway
ECD	Ecological Character Description
EPBC Act	Environment Protection and Biodiversity Conservation Act, 1999 (Commonwealth)
ESFM	Ecologically Sustainable Forest Management
Forests NSW	Forests New South Wales
IUCN	International Union for Conservation of Nature
JAMBA	Japan Australia Migratory Bird Agreement
LAC	Limits of Acceptable Change
MWWG	Murray Wetlands Working Group
OEH	Office of Environment and Heritage (NSW)
RAOU	Royal Australian Ornithological Union
ROKAMBA	Republic of Korea Australia Migratory Bird Agreement
SEWPAC	Department of Sustainability, Environment, Water, Population and Communities

Executive Summary

The NSW Central Murray Forests Ramsar site is located in the south-east of NSW, within the Murray-Darling Drainage Division (bioregion). At the time of listing, the site covered approximately 84 000 hectares and was within the Shires of Conargo, Murray, Jerilderie and Berrigan. At the time of listing, the site was gazetted as State Forest under the management of Forests NSW, comprising the following three areas:

Millewa Forest Group – located in the eastern portion of the Ramsar site and covers an area of approximately 38 000 hectares. At the time of listing it Included Millewa State Forest, Gulpa Island State Forest, Moira State Forest and Tuppal State Forest.
Koondrook-Perricoota Forest Group - occurs in the western-most portion of the NSW Central Murray Forests and occupies an area of 34 500 hectares. It comprises Koondrook State Forest, Perricoota State Forest and Campbells Island State Forest.
Werai Forest Group - consists of the northern portion of the NSW Central Murray Forests and occupies an area of 11 400 hectares. At the time of listing it comprised Werai State Forest and Barratta Creek State Forest.

The Central Murray Forests Ramsar site is dominated by river red gum (*Eucalyptus camaldulensis*) forest and woodland, wet grasslands and marshes located on the floodplain of the Murray River. Riparian fringes of modern river channels and lower areas of the floodplain support river red gum forest. Higher, less frequently flooded portions of the floodplain support black box (*Eucalyptus largiflorens*) woodland with an understorey of flood-tolerant grasses and saltbushes. The most frequently inundated channels; drainage depressions and oxbow lagoons support reed beds, sedgelands and wet-grasslands. There are small areas of sandy soils on higher ground such as levees, old channels, dunes and lunettes, which support white cypress-pine (*Callitris glaucohylla*) woodland.

Wetland habitats at the site support nationally and internationally significant populations of wetland birds and fish. The wetlands also support at least three species of mammal, seven species of frog, three species of freshwater turtle and a number of reptile taxa closely associated with wetland and aquatic habitats (Leslie 2002).

The NSW Central Murray Forests Ramsar site was listed in 2003 and this is the point in time for which the ecological character description is based. The site met the following five criteria under conditions at the time of listing. The site however no longer meets criterion 5 due to lack of quantative evidence.

Criterion 1: Representative, rare, or unique example of a natural or near-natural wetland
The NSW Central Murray Forests are the largest complex of tree-dominated floodplain wetlands in southern Australia, making them a good representative of this wetland type in the Murray Darling Basin bioregion.

Criterion 2: Supports threatened species or threatened ecological communities.
There are eight threatened species, listed at the national and / or international scale supported by the wetlands within the Ramsar site, including: Australasian bittern (*Botaurus poiciloptilus*), Australian painted snipe (*Rostratula benghalensis*), Murray hardyhead (*Craterocephalus fluviatilis*), superb parrot (*Polytelis swainsonii*), swamp wallaby grass (*Amphibromus fluitans*), trout cod (*Maccullochella macquariensis*), silver perch (*Bidyanus bidyanus*), and Murray cod (*Maccullochella peelii peelii*).

Criterion 4: Supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.
The NSW Central Murray Forests Ramsar site provides habitat for 11 species of wetland bird listed under international migratory agreements (JAMBA, CAMBA and ROKAMBA) and is important for colonial nesting waterbirds, supporting breeding of thousands of birds during times of inundation. It is also important for breeding of native fish. In addition, the permanent rivers and wetlands within the site are recognised as drought refuge for native fauna in the semi-arid region.

Criterion 5: Regularly supports 20 000 or more waterbirds
Although, data is limited it was the opinion of local experts that total counts included colonial nesting waterbirds as well as waterfowl and other solitary nesters, would number greater than 20 000 during floodplain inundation (Webster, R. Personal communication; Leslie D. Personal communication)

Criterion 8: Important source of food for fishes, spawning ground, nursery and/or migration path for fish stocks
The site provides migratory routes between habitat in the Murray River, anabranches and floodplains and is considered important for recruitment of native fish (King et al. 2007).

Central to a description of the ecological character of a Ramsar site is the identification and description of critical components, processes and services, benchmarked to the time of listing. Limits of Acceptable Change (LAC) are developed for each of the identified critical components, process and services and an assessment of changes since listing, with respect to the LAC undertaken. LAC are a tool by which ecological change can be measured. However, ECDs are not management plans and LACs do not constitute a management regime for the Ramsar site.

Exceeding or not meeting LACs does not necessarily indicate that there has been a change in ecological character within the meaning of the Ramsar Convention. However, exceeding or not meeting LACs may require investigation to determine whether there has been a change in ecological character.

A summary of the component, processes and services critical to the ecological character of the NSW Central Murray Forests Ramsar site, together with the LAC and assessment of current conditions is provided in Table E1.

It has only been eight years since the designation of the Central Murray Forests Ramsar site and as such, there is little evidence of significant change to the ecological character of the site during this period. There is some evidence that tree health has declined in the forests in the period 2003 to 2010 (Cunningham et al. 2009). An assessment of current conditions with respect to LAC indicates that some of the LAC for hydrology have been exceeded. While there is little evidence that the site has changed in the past eight years; there is evidence that the site is on a trajectory of decline and it is thought that hydrological conditions at the time of listing were insufficient to maintain the ecological character of the site (data contained in NRC 2009; MDBA 2010).

In addition to changes in components, process and services, there have been a number of other important changes in the site since 2003:

Changes in landuse - From 1 July 2010 the Millewa Forest Group component of the Ramsar site (formally State forest) has been reserved as national park (about 90 percent of the area) and regional park (about 10 percent of the area) under the NSW *National Park Estate (Riverina Red Gum Reservations) Act 2010*. Also from 1 July 2010 the Werai Forest Group is no longer gazetted State forest but has been vested in the Minister for the Environment for transfer to the Aboriginal community. These alterations to land tenure have resulted in major land use changes including a restriction of logging activities in the area.

Changes in site management - From 1 July 2010 the NSW National Parks and Wildlife Service is the agency responsible for land management of the Millewa Forests Group component of the Ramsar site. Longer-term arrangements will see a joint management arrangement between the NSW National Parks and Wildlife Service and the the Aboriginal community. Also from 1 July 2010, the Werai Forest Group is no longer gazetted state forest but has been vested in the Minister for National Parks and Wildlife for transfer to traditional owners for conservation purposes.

There is a number of knowledge gaps associated with the ecological character of the NSW Central Murray Forests Ramsar site. The most significant of these relate to patterns of inundation at Werai Forest Group, extent and composition of floodplain marsh vegetation communities within all the Forest Groups and the abundance and community composition of fauna within the site. Monitoring to address these knowledge gaps and assess against LAC has been recommended.

Table E1: Summary of critical components, process and services, LAC and current conditions.

Critical components processes and services	Limit of Acceptable Change	Current conditions
Hydrology: • Inundation of the site is driven largely by flows within the Murray River. • The hydrology of the site is highly regulated and seasonality of low and moderate flow is determined largely by irrigation needs. • Large scale floods that inundate the forests are generally the result of rainfall events. • Groundwater may be important for maintaining tree health, but remains a knowledge gap.	*Number of events in any 10 year period (based on average recurrence intervals) for the specified flow events, not to be less than the following:* *Millewa Forest Group (Murray River flow downstream of Yarrawonga);* • *12 500 megalitres per day for 70 days – 5 events* • *16 000 megalitres a day for 98 days – 3 events* *Koondrook-Perricoota Forest Group (Murray River flow at Torrumbarry Weir);* • *16 000 megalitres per day for 90 days – 3 events* *Werai Forest Group (Edward River flow at Deniliquin);* • *5000 megalitres a day for 60 days – 4 events*	There is evidence that there has been a decline in small floods in the past decade as a result of water use, prolonged drought and potential effects of climate change. The hydrology LAC for small, in-channel and low lying wetlands has been exceeded.
	In any 20 year period the interval between the following flow events to be no more than: • *13 years for the Millewa Forest Group (Murray River downstream of Yarrawonga) – 25 000 megalitres a day for 60 days;* • *12 years for the Koondrook-Perricoota Forest Group (Murray River downstream of Torrumbarry) – 30 000 megalitres a day for 60 days; and* *15 years for the Werai Forest Group (Edwards River downstream of Deniliquin) – 18 000 megalitres a day for 30 days.*	There is evidence of a decline in moderate overbank flows in the past 20 years and although the LAC for maximum period between these flows has not been exceeded, the hydrology LAC based on average recurrence intervals of moderate overbank flows has been exceeded.

Critical components processes and services	Limit of Acceptable Change	Current conditions
	Number of events in any 20 year period (based on average recurrence intervals) for the specified flow events, not to be less than the following: *Millewa Forest Group (Murray River flow downstream of Yarrawonga);* • *25 000 megalitres per day for 60 days – 6 events* *Koondrook-Perricoota Forest Group (Murray River flow at Torrumbarry Weir);* • *30 000 megalitres per day for 60 days – 5 events* *Werai Forest Group (Edward River flow at Deniliquin);* • *18 000 megalitres a day for 30 days – 3 events.*	
	In any 50 year period the interval between the following flow events to be no more than: • *24 years for the Millewa Forest Group (Murray River downstream of Yarrawonga) – 60 000 megalitres a day for 14 days;* • *21 years for the Koondrook-Perricoota Forest Group (Murray River downstream of Torrumbarry) – 40 000 megalitres a day for 60 days; and* • *23 years for the Werai Forest Group (Edwards River downstream of Deniliquin) – 30 000 megalitres a day for 21 days.*	Large scale flood events are predominantly driven by climatic factors and are less influenced by water resource use (Maheshwari et al. 1993). There has not been a significant change in the frequency of these events in recent times and the hydrology LAC for wide scale flooding has not been exceeded.

Critical components processes and services	Limit of Acceptable Change	Current conditions
	Number of events in any 50 year period (based on average recurrence intervals) for the specified flow events, not to be less than the following: *Millewa Forest Group (Murray River downstream of Yarrawonga)* • *60 000 megalitres a day for 14 days – 7 events;* *Koondrook-Perricoota Forest Group (Murray River downstream of Torrumbarry)* • *40 000 megalitres a day for 60 day – 6 events; and* *Werai (Edward River at Deniliquin)* • *30 000 megalitres a day for 21 days – 6 events.*	
Vegetation: • The two critical wetland vegetation categories are river red gum forests and floodplain marshes. • Over 90 percent of the site is covered in inundation dependent forest and woodland (river red gum and black box), which has a combined extent of over 76 000 hectares. • River red gum forest is the dominant vegetation community, comprising 65 percent of the site. • Condition at the time of listing was poor to moderate, with less than 20 percent of the river red gum forest in good condition in both Millewa and Koondrook-Perricoota Forest Group.	*Extent of river red gum forest to be no less than:* • *20 000 hectares at Millewa Forest Group* • *17 800 hectares at Koondrook-Perricoota Forest Group* • *4700 hectares at Werai Forest Group* *Extent of river red gum woodland (includes river red gum / black box woodland) to be no less than:* • *3650 hectares at Millewa Forest Group* • *5900 hectares at Koondrook-Perricoota Forest Group* • *2700 hectares at Werai Forest Group* *River red gum condition to be "moderate" (according to the method of Cunningham et al. 2009) or better for at least 80 percent of forest.*	No recent mapping of forest extent is available, but there is no evidence of widespread loss of long-lived trees. Cunningham et al. (2009) indicated that 93 percent of trees in the Millewa Forest Group and 85 percent of trees in the Koondrook-Perricoota Forest Group were in moderate or better condition in 2009. Pennay (2009) indicated that projected foliage cover at Werai State Forest had improved from 1988 to 2009.

Critical components processes and services	Limit of Acceptable Change	Current conditions
• Floodplain marshes vary spatially and temporally within the site, both in terms of extent and community composition in response to wetting and drying. • Floodplain marshes include moira grass (*Pseudoraphis spinescens*) plains (regionally significant), giant rush (*Juncus ingens*) beds, common reed (*Phragmites australis*) beds, moist grasslands, herblands and semi-permanent marshes.	*Extent of floodplain marshes to be no less than:* • *1725 hectares at Millewa Forest Group* • *1360 hectares at Koondrook-Perricoota Forest Group* • *500 hectares at Werai Forest Group*	No recent assessment of extent of floodplain marshes. However, the 2010 floods are likely to have replenished the system.
Fish: • Data deficient. • Seventeen native species of fish have been recorded from within the site. • Results from surveys indicate that abundance varies considerably and that invasive species generally comprise 10 - 30 percent of the total abundance and up to 70 percent of biomass.	*A minimum of 11 native fish species in three out of five of surveys conducted in Barmah-Millewa Forest.*	Total native fish in the Barmah Millewa Forest in recent surveys ranges from 5 to 15 species (Barmah-Millewa Forum 2002; Jones 2006; King et al. 2007; MDBC 2007c; MDBC 2008) and equates to at least 11 native species in more than three in five surveys.
	Presence of Murray cod, trout cod and silver perch in three of five surveys.	All fish surveys to date have recorded both Murray cod and silver perch in the site (Barmah-Millewa Forum 2002; Jones 2006; MDBC 2008; King et al. 2009). Trout cod have been recorded in more than three in five surveys (Barmah-Millewa Forum 2002; Jones 2006; MDBC 2008; King et al. 2007)
Wetland birds: • Sixty-seven species of wetland bird have been recorded from the site. This includes 11 species listed under international migratory agreements and three threatened species: Australian painted snipe, (*Rostratula benghalensis australis*); superb parrot (*Polytelis*	*Successful breeding (80 percent chicks fledged) of colonial waterbirds in at least two years in ten.*	In the ten period January 2000 to December 2009 successful breeding of colonial nesting waterbirds occurred twice in 2000/1 and 2005/6 (MDBC 2007c; MDBC 2008).
	Presence of the Australasian bittern in Millewa Forest Group. Presence of the superb parrot and evidence of nesting in	The Australasian bittern has been recorded in the Millewa Forest Group

Critical components processes and services	Limit of Acceptable Change	Current conditions
swainsonii) and Australasian bittern (*Botaurus poiciloptilus*). • Over 100 000 birds have been recorded in the site during times of flood. • The site is significant for supporting breeding of colonial nesting waterbirds and contains a significant breeding population of superb parrot.	*Millewa Forest Group annually.*	in 2001 (BA 2008) and in 2006/7 (MDBC 2007a). The superb parrot has been observed breeding within the site annually in the last decade (Rick Webster, NPWS, personal communication).
Significant wetland types: The site supports the part of the largest remaining river red gum forest and provides a mosaic of vegetated wetland habitats.	This critical service is linked to changes in the frequency and duration of wetland wetting and drying as well as changes in extent and condition of wetland vegetation. Therefore no direct LAC has been developed and instead the critical service will be assessed indirectly through changes in the ARI and duration of specific flow events, extent and condition of river red gum forests and woodlands and extent of floodplain marshes. *See LAC for hydrology and vegetation.*	
Physical habitat: Central Murray Forests provides habitat for feeding and breeding of wetland birds.	This critical service is linked to changes in the frequency and duration of wetland wetting and drying as well as changes in extent and condition of wetland vegetation. In addition, wetland bird abundance can be used as a surrogate measure. Therefore no direct LAC has been developed and instead the critical service will be assessed indirectly through changes in the ARI and duration of specific flow events, extent and condition of river red gum forests and woodlands, extent of floodplain marshes and abundance of wetland birds. *See LAC for hydrology, vegetation and wetland birds.*	
Threatened species: The Ramsar site supports one plant species, three species of bird and six species of fish listed under the EPBC Act and / or the IUCN Red List.	This critical service is indicated by the presence of threatened species at the site. Therefore no direct LAC has been developed and instead the critical service will be assessed through presence of threatened species. *See LAC for wetland birds, native fish and vegetation*	
Ecological connectivity: The site provides important migratory routes between riverine, wetland and floodplain habitats for fish spawning and recruitment.	The site maintains connectivity between the river and floodplain wetlands and channels for fish spawning and recruitment. This service is maintained by hydrology and can also be indicated by the species richness and abundance of native fish. Therefore no direct LAC has been developed and instead the critical service will be assessed indirectly through changes in hydrology and native fish populations. *See LAC for hydrology and native fish.*	

1. Introduction

1.1 Site details

The NSW Central Murray Forests Ramsar site is located on the floodplain of the Murray River in south-eastern Australia, with the nearest boundary 33 kilometres south of the town of Deniliquin. It was nominated as a Wetland of International Importance under the Ramsar Convention in 2002 and officially designated in 2003. Site details for this Ramsar wetland are provided in Table 1.

At the time of listing the site was named the NSW Central Murray State Forests Ramsar site, reflecting land tenure at the time. Changes in land tenure in 2010 reduced the proportion of the site managed as State forest; the name of the site has therefore changed to NSW Central Murray Forests Ramsar site. This name is used throughout the ECD.

Table 1: Site details for the NSW Central Murray Forests Ramsar site.

Site Name	NSW Central Murray Forests (formerly NSW Central Murray State Forests)
Location in coordinates	Millewa Forest Group: 35° 49' 03" S, 144° 58' 00" E Werai Forest Group: 35° 19' 28" S, 144° 31' 44" E Koondrook-Perricoota Forest Group: 35° 43' 50" S, 144° 20' 04" E
General location of the site	Located on the floodplain of the Murray River in south-central New South Wales within the Murray-Darling Basin. The main channel of the Murray River forms the southern boundary of the Millewa and Koondrook-Perricoota Forest Groups, and the Edward River flows north from the Murray River through the Millewa and Werai Forest Groups. The town of Deniliquin is 33 km north of the Millewa Forest Group, 46 km south-east of the Werai Forest Group and 62 km north east of the Koondrook-Perricoota Forest Group.
Area	84 000 hectares (at the time of listing).
Date of Ramsar site designation	Designated on 20 May 2003.
Ramsar/DIWA Criteria met by wetland	Ramsar criteria 1, 2, 4, 8.
Management authority for the site	At the time of listing the site was managed by Forests NSW and is currently managed by Forests NSW and NSW National Parks and Wildlife Service.
Date the ECD applies	2003
Status of Description	This represents an update of an unpublished draft ECD produced in 2009 by GHD.
Date of Compilation	May 2011
Name(s) of compiler(s)	Ben Harrington (GHD) and Jennifer Hale on behalf of SEWPAC.
References to the Ramsar Information Sheet (RIS)	RIS compiled by OEH and SEWPAC in 2012.
References to Management Plan(s)	*Ecologically Sustainable Forest Management Plan Riverina NSW* (Forests NSW 2008a) – covers management of State forests within the site. *Draft Statement of Interim Management Intent for the Millewa Group – Murray Valley National Park and Murray Valley Regional Park* (OEH 2011) *Draft Statement of Interim Management Intent – Werai Lands* (OEH 2012) *The Barmah-Millewa Forest - Interim Icon Site Environmental Management Plan 2007-2008* (MDBC 2007a) *Interim Gunbower-Koondrook-Perricoota Forest Icon Site Environmental Management Plan* (MDBC 2007d) *Grazing Strategy for Riverina Region* (Leslie 2000).

1.2 Statement of purpose

As a contracting party to the Ramsar Convention, Australia is obliged to promote the conservation of listed sites, promote the wise use of wetlands and report any changes to the ecological character of those sites. Wise use is defined as "the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development" (Ramsar 2005). Thus understanding and describing the 'ecological character' of a Ramsar site is fundamental to promoting the conservation of Ramsar wetlands and being able to detect changes.

The Ramsar Convention has defined "ecological character" and "change in ecological character" as (Ramsar 2005):

"Ecological character is the combination of the ecosystem components, processes and benefits/services that characterise the wetlands at a given point in time":

and

"…change in ecological character is the human induced adverse alteration of any ecosystem component, process and or ecosystem benefit/service."

The EPBC Act lists Ramsar wetlands as matters of national environmental significance. Actions which have or are likely to have a significant impact on the ecological character of a Ramsar wetland are required to be referred, assessed and approved under the Act. The Act also provides for Ramsar management principles which guide the development of management plans by site managers.

In order to detect change it is necessary to establish a benchmark for management and planning purposes. An Ecological Character Description (ECD) forms the foundation on which a site management plan and associated monitoring and evaluation activities are based. It also forms the basis for the assessment of actions which are likely to impact on the Ramsar site.

The ECD provides details on the interactions between ecological components, processes and functions to give a comprehensive description of ecological character. This information supplements the Ramsar Information Sheet which is prepared at the time of designation. It conforms with a *National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands. Module 2 of Australian National Guidelines for Ramsar Wetlands – Implementing the Ramsar Convention in Australia* (DEWHA 2008) which was developed by Australian and state/territory governments.

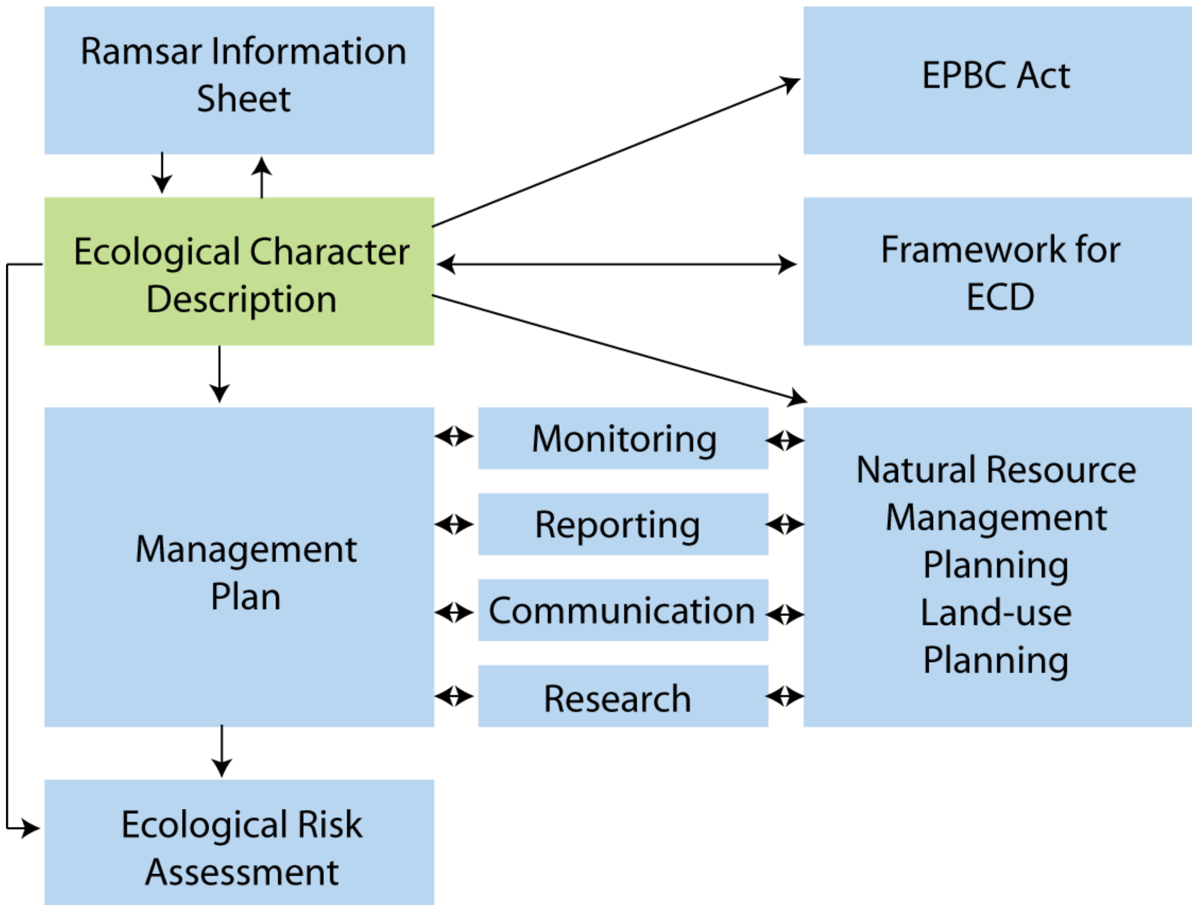

Figure 1: The ecological character description in the context of other requirements for the management of Ramsar sites (adapted from DEWHA 2008).

The National Framework

The framework emphasises the importance of describing and quantifying the ecosystem components, processes and benefits/services of the wetland and the relationship between them. It is also important that information is provided on the benchmarks or ecologically significant LAC that would indicate the need for their assessment to determine whether the ecological character has or is likely to change.

McGrath (2006) detailed the general aims of an ECD as follows:

1. To assist in implementing Australia's obligations under the Ramsar Convention, as stated in Schedule 6 (Managing wetlands of international importance) of the *Environment Protection and Biodiversity Conservation Regulations* 2000 (Commonwealth):
   a) To describe and maintain the ecological character of declared Ramsar wetlands in Australia; and
   b) To formulate and implement planning that promotes:
      i) Conservation of the wetland; and
      ii) Wise and sustainable use of the wetland for the benefit of humanity in a way that is compatible with maintenance of the natural properties of the ecosystem.
2. To assist in fulfilling Australia's obligation under the Ramsar Convention to arrange to be informed at the earliest possible time if the ecological character of any wetland in its territory and included in the Ramsar List has changed, is changing or is likely to change as the result of technological developments, pollution or other human interference.

3. To supplement the description of the ecological character contained in the RIS submitted under the Ramsar Convention for each listed wetland and, collectively, form an official record of the ecological character of the site.
4. To assist the administration of the EPBC Act, particularly:
   a) To determine whether an action has, will have or is likely to have a significant impact on a declared Ramsar wetland in contravention of sections 16 and 17B of the EPBC Act; or
   b) To assess the impacts that actions referred to the Minister under Part 7 of the EPBC Act have had, will have or are likely to have on a declared Ramsar wetland.
5. To assist any person considering taking an action that may impact on a declared Ramsar wetland whether to refer the action to the Minister under Part 7 of the EPBC Act for assessment and approval.
6. To inform members of the public who are interested generally in declared Ramsar wetlands to understand and value the wetlands.

1.3 Relevant treaties, legislation and regulations

This section provides a brief listing of the legislation and policy that is relevant to the description of the ecological character of the Ramsar site. There is a significant amount of legislation, particularly at the state/local level, relevant to the management of the site, which is documented more fully in the management plan for the site (Forests NSW 2008a) and as such is not repeated here.

International
Ramsar Convention
The Convention on Wetlands of International Importance Especially as Waterfowl Habitat, otherwise known as the Ramsar Convention, was signed in Ramsar Iran in 1971 and came into force in 1975. It provides the framework for local, regional and national actions, and international cooperation, for promoting the conservation and wise use of wetlands. Wetlands of International Importance are selected on the basis of their international significance in terms of ecology, botany, zoology, limnology and or hydrology.

Migratory bird bilateral agreements and conventions
Australia is party to a number of bilateral agreements, initiatives and conventions for the conservation of migratory birds. These are relevant to the NSW Central Murray Forests Ramsar site because the site supports a number of migratory birds listed under these agreements. The bilateral agreements are:

- *JAMBA* – The agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment, 1974;
- *CAMBA* - The Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment 1986;
- *ROKAMBA* - The Agreement between the Government of Australia and the Republic of Korea for the Protection of Migratory Birds and their Environment, 2006; and
- *The Bonn Convention on Migratory Species (CMS)* - The CMS adopts a framework in which countries with jurisdiction over any part of the range of a particular species co-operate to prevent migratory species becoming endangered. For Australian purposes, many of the species are migratory birds.

National legislation, plans and programs
Environment Protection and Biodiversity Conservation Act 1999
The EPBC Act regulates actions that will have or are likely to have a significant impact on any matter of national environmental significance, which includes the ecological character of a Ramsar wetland (EPBC Act s16(1)). An action that will have or is likely to have a significant impact on a Ramsar wetland will require an environmental assessment and

approval under the EPBC Act. An 'action' includes a project, a development, an undertaking or an activity or series of activities (http://www.environment.gov.au/epbc/index.html).

The EPBC Act establishes a framework for managing Ramsar wetlands, through the Australian Ramsar Management Principles (EPBC Act s335), which are set out in Schedule 6 of the *Environment Protection and Biodiversity Conservation Regulations 2000*. These principles are intended to promote national standards of management, planning, environmental impact assessment, community involvement, and monitoring, for all of Australia's Ramsar wetlands in a way that is consistent with Australia's obligations under the Ramsar Convention. Some matters protected under the EPBC Act are not protected under local or state/territory legislation, and as such, many migratory birds are not specifically protected under State legislation. Species listed under international treaties JAMBA, CAMBA, ROKAMBA and CMS have been included in the List of Migratory species under the Act. Threatened species and communities listed under the EPBC Act may also occur, or have habitat in the Ramsar site; some species listed under State legislation as threatened are not listed under the EPBC Act as threatened, usually because they are not threatened at the national (often equivalent to whole-of-population) level. The Regulations also cover matters relevant to the preparation of management plans, environmental assessment of actions that may affect the site, and the community consultation process.

Native Title Act 1993
This Act provides for the recognition and protection of native title. It establishes ways in which future dealing affecting native title may proceed and sets standards for such dealing. It establishes a mechanism for determining claims to native title. It provides for, or permits, the validation of past acts, and intermediate period acts, invalidated because of the existence of native title.

Water Act 2007
This Act provides for the management of the water resources of the Murray-Darling Basin, and to make provision for other matters of national interest in relation to water and water information, and for related purposes.

The Living Murray (TLM)
TLM instigated one of Australia's most significant river restoration programs. It aims to achieve a healthy working Murray River system for the benefit of all Australians, which includes returning water to the river's environment. TLM program was established in 2002 in response to strong evidence showing the declining health of the Murray River system. It is a partnership of the Australian, NSW, Victorian, South Australian and ACT governments.

The Basin Plan
The Basin Plan, when finalised, will be a strategic plan for the integrated and sustainable management of water resources in the Murray–Darling Basin. It will provide a framework for setting environmentally sustainable limits on the amount of surface water and groundwater that can be taken from the Basin. In addition it will identify, and seek to protect and restore, key environmental assets which are essential to the life of the rivers, their surrounding landscapes and the cultural values of the communities which depend on those water resources. The Basin Plan will also take into account the impact of this protection and restoration on individual communities, industries, regions and the wider economy (http://www.mdba.gov.au/basin_plan).

NSW state legislation

The following NSW legislation applies to the NSW Central Murray Forests:

- The *Forestry Act 1916*[1] provides for the dedication, reservation, control, and use of State forests, timber reserves, and Crown lands for forestry and other purposes. The Ramsar site was entirely state forest at the time of designation. Koondrook SF, Perricoota SF and Campbells Island SF (Koondrook-Perricoota Forest Group) will

[1] As set out in the NSW *Forestry Act 2012,* in January 2013 Forests NSW became the Forestry Corporation of NSW.

continue to be harvested under the Forestry Act and the FNPE Act following changes to the tenure of the Millewa and Werai Forest Groups in 2010.

- The *National Parks and Wildlife Act 1974* (NPW Act) provides for the establishment and management of national parks, regional parks, State conservation areas and other categories of conservation reserves. The Act also provides for the protection of fauna and flora, and of Aboriginal objects and places and throughout NSW. The Act allows for some national parks to be transferred to Aboriginal ownership, and to be managed jointly with DECCW. The Act also requires the development of a plan of management for national parks and regional parks.

- The *National Park Estate (Riverina Red Gum Reservations) Act 2010* revokes State forests in the Murray, Murrumbidgee and Lachlan valleys and reserves those lands as national park, regional park and State conservation area under the NPW Act. The Millewa forests (including Millewa State Forest, Moira SF and Gulpa Island SF) are reserved as national park and regional park. The Act also revokes other State forests (including Werai State Forest and Barratta Creek State Forest) and vests those lands in the Minister for the Environment, in order to enable transfer to Aboriginal ownership and management as an Indigenous protected area (IPA). Under the Act Koondrook SF, Perricoota SF and Campbells Island SF (Koondrook-Perricoota Forest Group) will continue to be harvested and may be approved under an Integrated Forestry Operations Approval (IFOA). The Act also provides for non-commercial firewood collection in national parks and regional parks.

- The *Forestry and National Park Estate Act 1998* (FNPE Act) provides for the making of NSW Forest Agreements and for environmental assessment of forest areas prior to undertaking forestry operations..

- The *Aboriginal Land Rights Act 1983* establishes local Aboriginal land councils in New South Wales; provides for the granting of land to Aboriginal land councils; and allows land councils to acquire, manage and dispose of land for the benefit of council members. The Act also provides for the identification of “Aboriginal owners” (i.e. Aboriginal people recognised as having a connection to their traditional Country), for the purpose of transferring some national parks to Aboriginal ownership and joint management with DECCW. The Werai forests have been identified for management as an Indigenous Protected Area, which would draw on DECCW’s experience in establishing co-managed parks.

- The *Environmental Planning and Assessment Act 1979* requires the assessment of environmental impacts of activities. The Act would require the assessment of the impacts of physical works in the Murray Valley National Park and Regional Park, and of making decisions and undertaking works relating to water delivery to the Ramsar site.

- The *Threatened Species Conservation Act 1995* protects all threatened plants and animals native to NSW (with the exception of fish and marine plants) and endangered ecological communities. The red gum forests of the Ramsar site provide habitat for several threatened animals, including the superb parrot (*Polytelis swainsonii*).

- The *Fisheries Management Act 1994* provides for the protection of all threatened fish and marine vegetation native to NSW waters. More specifically, the objectives of this Act are to: conserve fish stocks and key fish habitats; conserve threatened species, populations and ecological communities of fish and marine vegetation; promote ecologically sustainable development, including the conservation of biological diversity; promote viable commercial fishing and aquaculture industries; promote quality recreational fishing opportunities; appropriately share fisheries resources between the users of those resources; and provide social and economic benefits for he wider community of NSW.

- The *Water Management Act 2000* provides for the integrated and sustainable management of the State's waters, including those provisions previously included in the *Rivers and Foreshores Improvement Act 1948*.

- The Water Sharing Plan for the New South Wales Murray and Lower Darling Regulated Rivers Water Sources (2003) made under the *Water Management Act 2000* provides water for environmental needs and ecological processes, including of the Central Murray Forests Ramsar site, and directs how the water available for extraction is to be shared. The Plan also sets rules that affect the management of access licences, water allocation accounts, the trading of or dealings in access licences and water allocations, the extraction of water, the operation of dams and the management of water flows.

- The Water Sharing Plan for the Lower Murray Groundwater Source (2006) made under the *Water Management Act 2000* sets out the rules for the management and sharing of groundwater resources in the Plan area to protect groundwater dependent ecosystems and to manage extraction for the estimated sustainable yield.

1.4 Method

The method used to develop the ecological character description for the NSW Central Murray Forests Ramsar site is based on the twelve-step approach provided in the *National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands* (DEWHA 2008a) illustrated in Figure 2. A more detailed description of each of the steps and outputs required is provided in the source document. This ECD was developed primarily through a desktop assessment and is based on existing data and information. A steering committee was formed to provide input and comment on the ECD.

1. Introduction to the description
Site details, purpose of the description, relevant legislation

2. Describe the site
Site location, climate, maps and images, tenure, criteria and wetland types

3. Identify and describe the critical components, processes, benefits and services
3.1 Identify all possible components, processes, benefits and services
3.2 Identify the critical components, processes benefits and services responsible for determining the ecological character of the site
3.3 Describe each of the critical components, processes, benefits & services

4. Develop a conceptual model of the wetland
Depict the critical components & processes of the wetland and their interactions

5. Set limits of acceptable change (LAC)
Determine LAC for critical components, processes and services

6. Identify threats to the ecological character of the site
Identify the actual or likely threats to the site

7. Describe changes to ecological character
Describe changes to the ecological character since the time of listing
Include information on the current condition of the site

8. Summarise knowledge gaps
Use information from Steps 3 - 7 to identify knowledge gaps

9. Identify site monitoring needs
Use information from Steps 3 - 8 to identify monitoring needs

10. Identify communication and education messages
Identify any communication & education messages highlighted during the development process

11. Compile the description of ecological character

12. Prepare or update the Ramsar Information Sheet
Submit as a companion document to the ecological character description

Figure 2: Twelve step process for developing an ECD (adapted from DEWHA 2008).

2. General Description of the NSW Central Murray Forests Ramsar site

2.1 Location

The NSW Central Murray Forests Ramsar site is located in the south-east of NSW, within the Murray-Darling Drainage Division (bioregion). At the time of listing, the site covered approximately 84 000 hectares and was within the Shires of Conargo, Murray, Jerilderie and Berrigan. The site is composed of three discrete but interrelated units: the Millewa Forest Group, the Werai Forest Group, and the Koondrook-Perricoota Forest Group, which lie to the north-west, south-west and south of the town of Deniliquin (population in 2006: 8500) (Figure 3).

The NSW Central Murray Forests are within the Murray-Darling Basin catchment, which covers over one million square kilometres and comprises 14 percent of the continent. Each of the forests within the Ramsar site is on the floodplain of the Murray River and its tributaries, the second largest river in Australia. At the time of listing the entire site was designated as State forest and was managed by Forests NSW. A brief introductory description of the location of each area is provided below.

2.1.1 Millewa Forest Group

The Millewa Forest Group consists of the eastern portion of the Ramsar site and is centred approximately 33 kilometres south of the town of Deniliquin. It covers an area of approximately 38 000 hectares and includes part of Murray Valley National Park and part of Murray Valley Regional Park. The main channel of the Murray River defines the southern boundary of the Millewa Forest Group and discharges water into the forest via the Edward River, Gulpa Creek, smaller channels and overbank flow.

The Barmah Forest Ramsar Wetland lies immediately to the south of the Millewa Forest Group, on the Victorian side of the border, south of the Murray River. The Barmah Forest contains river red gum (*Eucalyptus camaldulensis*) forest and other wetland communities, which are ecologically similar to those in the NSW Central Murray Forests (Parks Victoria 2006). Collectively, the Millewa Forest Group and the Barmah Forest are referred to as the Barmah-Millewa Forest. Together they were recognised by the Murray Darling Basin Commission (MDBC) as one of six significant ecological assets in the bioregion (MDBC 2005). For the purposes of Environmental Water Allocations (EWAs) the two sites are considered as a single unit (O'Connor et al. 2006) and ecologically function as such to a certain extent. However, only the northern (NSW) portion of the Barmah-Millewa Forest is within the NSW Central Murray Forests Ramsar site and considered in this description.

2.1.2 Koondrook-Perricoota Forest Group

The Koondrook-Perricoota Forest Group occurs in the western-most portion of the NSW Central Murray Forests and is located approximately 62 kilometres west-southwest of Deniliquin. It occupies an area of 34 500 hectares and includes Koondrook State Forest, Perricoota State Forest and Campbells Island State Forest. The main channel of the Murray River borders the southern boundary of the Koondrook-Perricoota Forest Group and discharges water into the forest via Swan Lagoon and from there into the Burrumbury Creek system.

The Gunbower Forest (Victoria Ramsar Wetland) lies immediately to the south of the Murray River, on the Victorian side of the border. As with the Barmah-Millewa complex, Gunbower and Koondrook-Perricoota Forest Group are ecologically similar and together form a single icon site under the Living Murray program.

2.1.3 Werai Forest Group

The Werai Forest Group consists of the northern portion of the NSW Central Murray Forests and is located approximately 46 kilometres northwest of Deniliquin. The Werai Forest Group occupies an area of 11 400 hectares and is vested in the NSW Minister for the Environment.

It occurs on the floodplain of the Edward and Niemur Rivers between Yadabal Lagoon and Morago (ANCA 1996).

The Werai Forest Group unit is hydrologically linked to the Millewa Forest Group via the Edward River. When river flow at Yarrawonga Weir is greater than 10 400 megalitres a day the flow exceeds the capacity of the main channel of the Murray River through the Barmah Choke. When this occurs substantial volumes of water are diverted down the Edward River and, ultimately, to the Werai Forest Group.

2.2 Land tenure

At the time of listing, the entire Ramsar site was gazetted as State forest and administered in accordance with the *Forestry Act 1916* and the regulations associated with that Act.

Land use within the site was based on Forest Management Zoning, a land classification system that differentiates between areas of State forests, which are specifically set aside for conservation, and those that are available for other activities, including timber harvesting. The forest management zones within the site at the time of listing are provided in Table 2 and Figure 4.

Significant changes have occurred in land tenure and land use within the site since listing, these are described in section 8.

Table 2: Forest Management Zones relevant to the NSW Central Murray Forests Ramsar site (data provided by Forests NSW).

Zone	Activities			Extent (hectares)
	Not permitted	Permitted (standard conditions)	Permitted (special conditions)	
1. Special protection	Timber harvesting	Not applicable	Construction of new roads and fire trails	2866
3(a). Harvesting exclusion	Timber harvesting	Not applicable	Road and fire trail construction	16 816
3(b). harvesting permitted with special prescription	Not applicable	Not applicable	Timber harvesting permitted with special conditions. Road and fire trail construction	5006
4. General management	Not applicable	All forest management activities.	Not applicable	59 783
5. Hardwood plantations	Not applicable	All forest management activities.	Not applicable	151
6. Softwood plantations	Not applicable	All forest management activities.	Not applicable	114
8. Areas for further assessment	Management under the same requirements as 3a (harvesting exclusion) until field investigation allows determination of final classification.			128

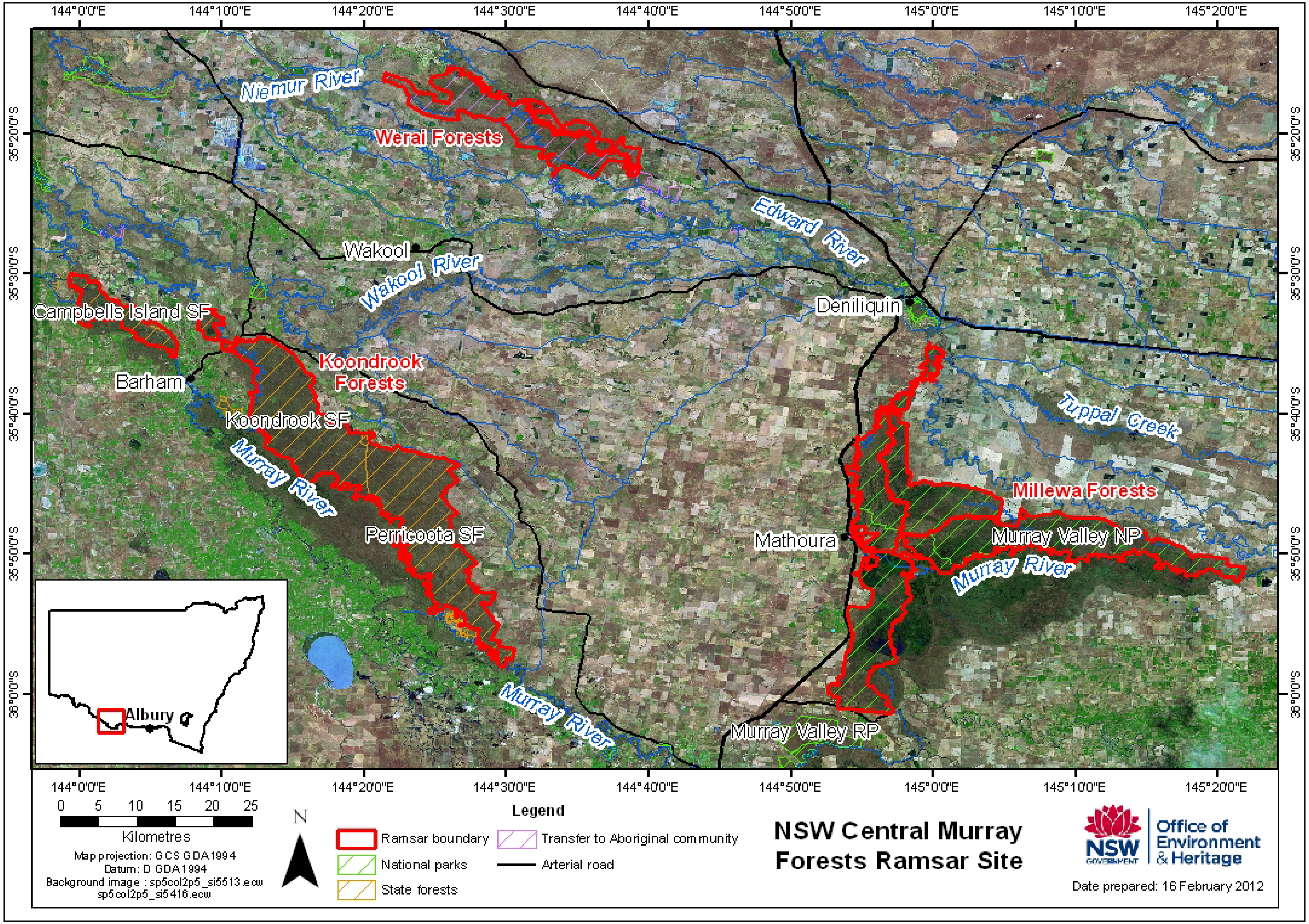

Figure 3: Site location of the NSW Central Murray Forests Ramsar site.

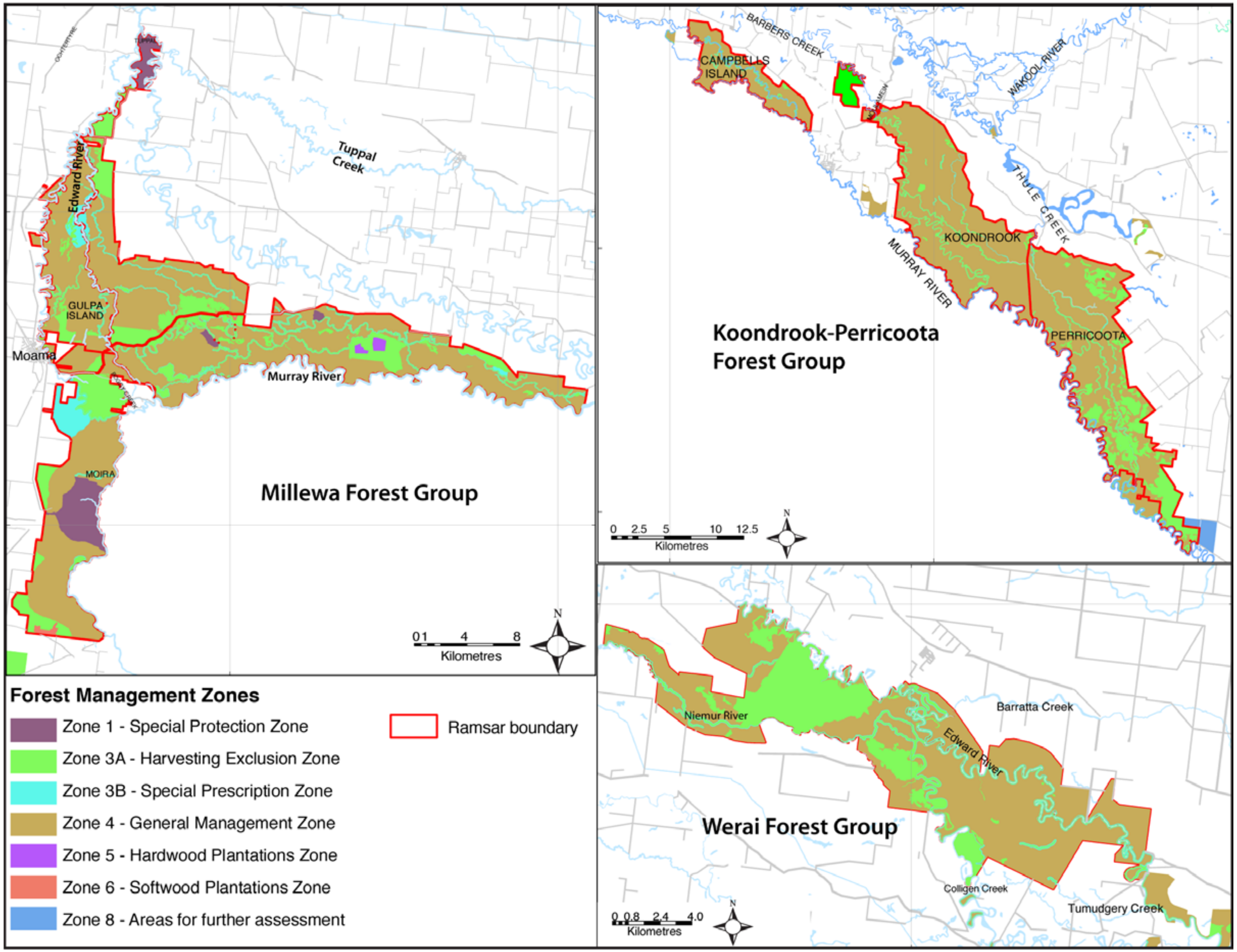

Figure 4: Forest management zones within the three sections of the NSW Central Murray Forests (data provided by Forests NSW).

2.3 Flora and fauna overview

The Central Murray Forests Ramsar site is dominated by river red gum (*Eucalyptus camaldulensis*) forest and woodland, wet grasslands and marshes located on the floodplain of the Murray River. Riparian fringes of modern river channels and lower areas of the floodplain support river red gum forest. Higher, less frequently flooded portions of the floodplain support black box (*Eucalyptus largiflorens*) woodland with an understorey of flood-tolerant grasses and saltbushes. The most frequently inundated channels; drainage depressions and oxbow lagoons support reed beds, sedgelands and wet-grasslands. There are small areas of sandy soils on higher ground such as levees, old channels, dunes and lunettes, which support white cypress-pine (*Callitris glaucohylla*) woodland.

Land surrounding the site is less influenced by floodwaters and features vegetation more typical of semi-arid zones. In many instances this is due to construction of levees on the private property/State Forest boundary. These levees were generally constructed to protect agricultural land from undesirable flooding. On the highest, rarely flooded terraces, yellow box (*Eucalyptus melliodora*) communities occur along with callitris and grey box (*Eucalyptus microcarpa*) woodlands. These grade into grassy *Eucalyptus* woodlands, saltbush (*Maireana* spp.) shrubland and native grasslands on surrounding alluvial plains. Sandy soils on levees, old channels, dunes and lunettes support white cypress-pine woodland or mallee (low, multi-stemmed *Eucalyptus* woodlands) (Benson et al. 2006; Eardley 1999). An area in east of the Perricoota State Forest (within the Koondrook-Perricoota Forest Group) supports the NSW listed endangered ecological community “inland grey box woodland”, a terrestrial vegetation community found on terraces and higher ground (GHD 2010). A list of terrestrial vascular plants known from the site is presented as Appendix B.

Wetland habitats at the site support nationally and internationally significant populations of wetland birds and fish (see Section 3). The wetlands also support at least three species of mammal, seven species of frog, three species of freshwater turtle and a number of reptile taxa closely associated with wetland and aquatic habitats (Leslie 2002). The site supports two species listed as threatened in NSW: southern myotis (*Myotis macropus*) and Sloane's froglet (*Crinia sloanei*). A list of wetland dependent fauna for the site is provided in Appendices C and D.

2.4 Wetland types

There are six Ramsar wetland types within the NSW Central Murray Forests Ramsar site. These are summarised in Table 3 and mapped in Figure 5. Extents of these wetland types were estimated using GIS interpretation of Forests NSW vegetation mapping combined with aerial photo interpretation and Murray Wetlands Working Group (MWWG) mapping of wetlands (Green and Alexander 2006). The extent of wetlands mapped as polygons (forests, woodlands and marshes) is estimated in hectares whereas the extent of linear wetlands (rivers and streams) is estimated as a length in kilometres.

Table 3: Ramsar wetland types in the NSW Central Murray Forests.

Wetland Type	Extent	Examples
M - Permanent rivers / streams / creeks.	157 kilometres	Edward River, Niemur River, Gulpa Creek
N – Seasonal / intermittent / irregular rivers / streams / creeks.	347 kilometres	Burrumbarry Creek
P – Seasonal / intermittent freshwater lakes (over eight hectares).	558 hectares	Moira Lake, Sheldrakes Lake, Swan Lagoon
Ts – Seasonal / intermittent freshwater marshes/pools on inorganic soils.	6 068 hectares	Algeboia Plain, Reed Beds, Duck Lagoon, Douglas Swamp, St Helena Swamp, Black Swamp, Pollack Swamp.
Xf - Freshwater, tree-dominated wetlands.	76 000 hectares	Majority of NSW Central Murray Forests floodplains
9 - Canals and drainage channels, ditches.	4 kilometres	Burrumbarry and Gulpa Creek inflows. Numerous secondary channels.

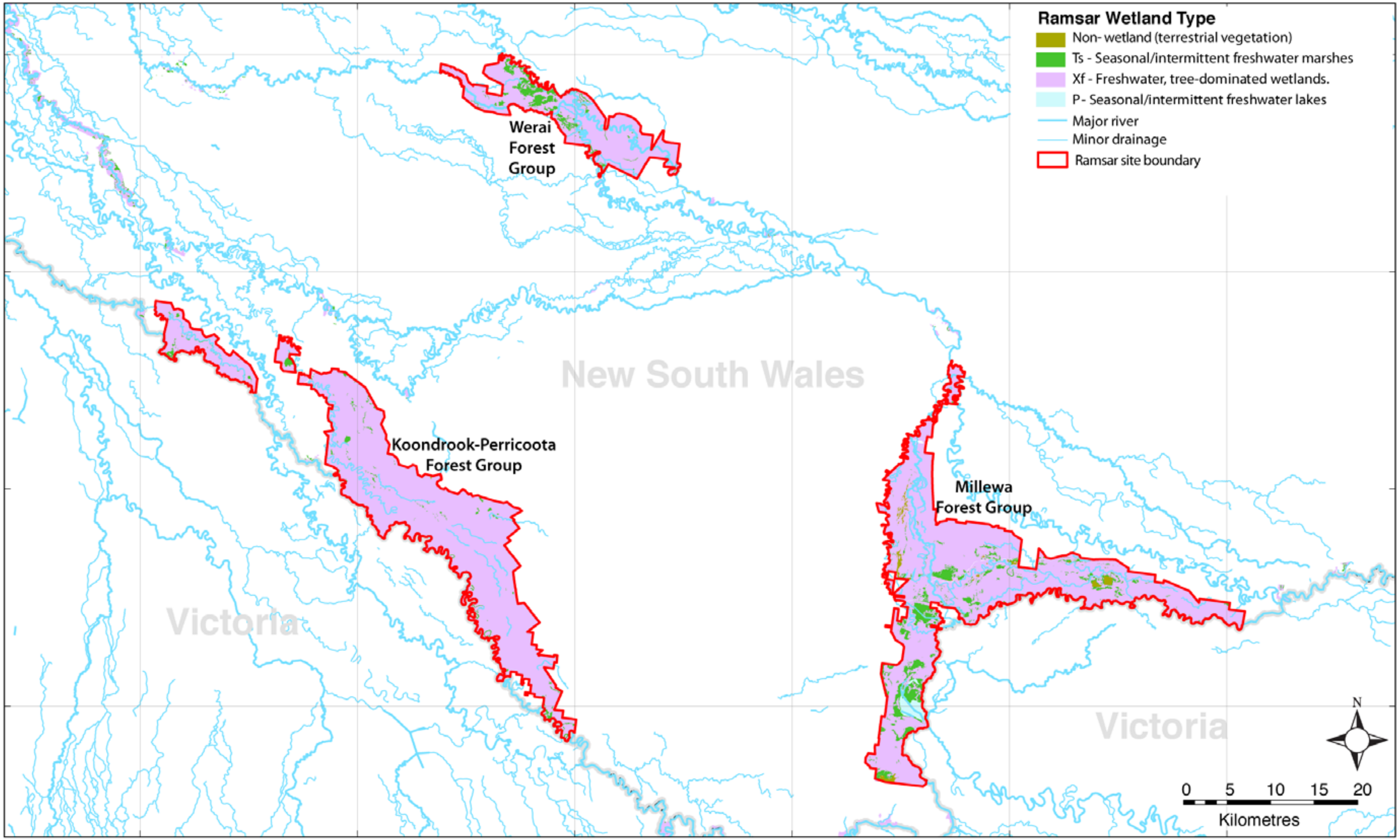

Figure 5: Ramsar wetland types within the NSW Central Murray Forests Ramsar site (prepared from vegetation data provided by Forests NSW).

The most extensive wetland type within the site is "Xf – freshwater tree dominated wetlands, which cover approximately 90 percent of the site. These are almost exclusively river red gum forest and woodland along the floodplain of the Murray River and its tributaries (Figure 6). Other examples of wetland types within the site include the large, intermittent wetland (type P) of Moira Lake in the south of the Millewa Forest Group (Figure 7) and the extensive reed and sedge swamps (type Ts) of the Millewa and Werai Forest Group (Figure 8). River, stream and drainage channels (M, N and 9) are also a common feature of the site (Figure 9).

Figure 6: River red gum forest (wetland type Xf (photo SEWPAC: photographer Kylie Wilton, 2003).

Figure 7: Moira Lake (wetland type P) in Millewa Forest Group (photo: Keith Stockweel; 2009).

Figure 8: Reed Bed Swamp (wetland type Ts) in Millewa Forest Group (photo MDBA; photographer: David Kleinert, 2009).

Figure 9: Moira Creek (wetland type N) in Millewa Forest Group (photo MDBA; photographer: Arthur Mostead, 2008).

2.5 Ramsar criteria

2.5.1 Criteria under which the site was designated

At the time that NSW Central Murray Forests were nominated as a Wetland of International Importance, there were eight criteria for identifying wetlands of international importance. The nomination documentation for the site considered that the site met five of these criteria as follows (Leslie 2002):

Criterion 1: A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.

The NSW Central Murray Forests, together with the listed Ramsar wetlands in Victoria (Barmah and Gunbower forests), form the largest complex of tree-dominated floodplain wetlands in southern Australia. The site contains wetland types that are rare within the bioregion, particularly types P (floodplain lake) and Ts (floodplain meadows and reed swamps).

The site plays a substantial role in the functioning of the Murray River, particularly in terms of hydrology (flood mitigation), water quality (sediment deposition) and river health (carbon flux and sources of invertebrate inoculum).

These wetlands provide an area of comparatively high water availability and habitat productivity in a semi-arid rainfall zone, owing to the occurrence of regular surface inundation and replenishment of groundwater systems derived from flooding of the River Murray. Their biophysical, environmental and vegetation attributes also largely define the essential character of the Riverina bioregion.

Criterion 2: A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.

The site provides a habitat network for at least eight globally threatened fauna listed by the World Conservation Union (IUCN). The Australasian bittern (*Botaurus poiciloptilus*), superb parrot (*Polytelis swainsonii*), silver perch (*Bidyanus bidyanus*) and flat-headed galaxias (*Galaxias rostrata*) are listed as ‘vulnerable’, and the regent honeyeater (*Xanthomyza phrygia*), swift parrot (*Lathamus discolor*), Murray hardyhead (*Craterocephalus fluviatilis*) and trout cod (*Maccullochella macquariensis*) are listed as ‘endangered’ on the IUCN Red List. A number of these species have also been afforded protection under the EPBC Act. Under the EPBC Act the superb parrot and the Murray hardyhead are listed as vulnerable and the swift parrot, regent honeyeater, Australasian bittern and trout cod are listed as endangered. The site is also known to contain swamp wallaby grass (*Amphibromus fluitans*), which is threatened nationally and is listed as vulnerable under the EPBC Act.

The Central Murray Forests are ecologically linked through an unbroken riparian corridor along the Murray and Edward Rivers. They are in high ecological condition and provide arboreal and wetland habitat in landscapes extensively cleared of trees and developed for agriculture. As such, the site contributes significantly to the conservation of globally and nationally threatened species. The site is immediately adjacent to other wetlands included in the Ramsar List of Wetlands of International Importance (Barmah Forest and Gunbower Forest in Victoria) and thus further enhances the viability of threatened flora and fauna species that occur at these Ramsar sites.

Criterion 4: A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.

The site provides refuge for mobile and sedentary fauna during environmentally stressful periods. It also provides sources of migrants capable of dispersing into less productive areas during favourable conditions, as it is an area of comparatively high water availability and habitat productivity in a semi-arid rainfall zone.

The site provides a habitat network for 13 species listed in migratory bird agreements between Australia, and Japan (JAMBA), China (CAMBA) and the Republic of Korea (ROKAMBA). These species are painted snipe (*Rostralula benghalensis*), great egret (*Ardea alba*), cattle egret (*Ardea ibis*), sharp-tailed sandpiper (*Calidris acuminata*), greenshank (*Tringa nebularia*), marsh sandpiper (*Tringa stagnatilis*), Latham's snipe (*Gallinago hardwickii*), white-throated needletail (*Hirundapus caudacutus*), forked-tailed swift (*Apus pacificus*), glossy ibis (*Plegadis falcinellus*), Caspian tern (*Hydropogne caspia*), red-necked stint (*Calidris ruficollis*) and white-bellied sea-eagle (*Haliaeetus leucogaster*).

Criterion 5: A wetland should be considered internationally important if it regularly supports 20 000 or more waterbirds.
The site, together with the adjacent existing Ramsar sites in Victoria (Barmah Forest and Gunbower Forest), regularly supports more than 20 000 waterbirds (Mattingley 1908, Barrett 1931, Chesterfield et al. 1984, Maher 1988). In 2000/01, there were 5508 pairs of 13 species of waterbirds recorded in Millewa Forest and greater than 10 000 pairs of ibis (two species) recorded in Barmah Forest. That is 31 000 adult birds plus at least 62 000 young (93 000 birds in total) for 2000/01. This figure does not include waterfowl or solitary nesters such as white-faced herons. The total waterbird census for 2000/01 for Barmah-Millewa would have exceeded 100 000 individuals (D. Leslie pers. comm.).

Waterbird breeding in the Barmah-Millewa Forest was recorded 32 times during 1905 to 1997, and at the 1994 level of water development is predicted to occur four times each decade on average (Leslie 2001). In 1998 and 2000 environmental flows were used to extend the duration of natural floods. The reinstatement of the natural flow regime has resulted in tremendous responses in the regeneration of vegetation and bird breeding, with some bird species coming back after a 30-year absence (Leslie and Ward 2002).

Criterion 8: A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.
The site, when inundated with floodwater, provides a cue for fish migration and enhances the ability of native fish to spawn and recruit. Tagged fish have been recorded moving large distances from the site (up to 300 kilometres upstream and 900 kilometres downstream), which is indicative of pre- and post-spawning behaviour (McKinnon 1997).

2.5.2 Assessment based on current Ramsar criteria

There have been a number of developments in the past two decades that influence the application of the Ramsar criteria to wetland sites. This includes:

- Refinements and revisions of the Ramsar criteria since 2003. A ninth criterion was added at the 9th Ramsar Conference in Uganda in 2005.
    - Criterion 9: A wetland should be considered internationally important if it regularly supports one percent of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species.
- Revision of population estimates for waterbirds (Wetlands International 2006), which influences the application of criterion six.
- A decision with respect to the appropriate bioregionalisation for aquatic systems in Australia, which for inland systems are now based on drainage divisions and for marine systems the interim marine classification and regionalisation for Australia (IMCRA). This affects the application of criteria one and three.
- Updating of threatened species listings, which affects criterion two.
- Additional information collected at the site, which affects all criteria.

An assessment of the NSW Central Murray Forests Ramsar site against the current nine Ramsar criteria has been undertaken. In deciding if the site qualifies under criteria five and six (regularly supports one percent of the individuals in a population of one species of waterbird), an approach consistent with the Ramsar Convention has been adopted (Text Box 1). This represents an assessment of the conditions at the time of listing with respect to the current criteria.

Regularly (Criteria 5 & 6) - as in supports regularly - a wetland regularly supports a population of a given size if:

i. the requisite number of birds is known to have occurred in two thirds of the seasons for which adequate data are available, the total number of seasons being not less than three; or
ii. the mean of the maxima of those seasons in which the site is internationally important, taken over at least five years, amounts to the required level (means based on three or four years may be quoted in provisional assessments only).

In establishing long-term 'use' of a site by birds, natural variability in population levels should be considered especially in relation to the ecological needs of the populations present. Thus in some situations (e.g., sites of importance as drought or cold weather refuges or temporary wetlands in semi-arid or arid areas - which may be quite variable in extent between years), the simple arithmetical average number of birds using a site over several years may not adequately reflect the true ecological importance of the site. In these instances, a site may be of crucial importance at certain times ('ecological bottlenecks'), but hold lesser numbers at other times. In such situations, there is a need for interpretation of data from an appropriate time period in order to ensure that the importance of sites is accurately assessed.

In some instances, however, for species occurring in very remote areas or which are particularly rare, or where there are particular constraints on national capacity to undertake surveys, areas may be considered suitable on the basis of fewer counts. For some countries or sites where there is very little information, single counts can help establish the relative importance of the site for a species.

The International Waterbird Census data collated by Wetlands International (2006) is the key reference source.

Text Box 1: Definition of regularly supports (Ramsar Convention 2009).

An assessment against each of the criteria for the NSW Central Murray Forests Ramsar site is provided below and summarised in Table 4.

Table 4: Criteria for Identifying Wetlands of International Importance (adopted by the 6th (1996) Meeting of the Conference of the Contracting Parties). Criteria for which the NSW Central Murray Forests Ramsar site qualified at the time of designation are highlighted in green.

Number	Basis	Description
Group A. Sites containing representative, rare or unique wetland types		
Criterion 1		A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.
Group B. Sites of international importance for conserving biological diversity		
Criterion 2	Species and ecological communities	A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.
Criterion 3	Species and ecological communities	A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.
Criterion 4	Species and ecological communities	A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.
Criterion 5	Waterbirds	A wetland should be considered internationally important if it regularly supports 20 000 or more waterbirds.
Criterion 6	Waterbirds	A wetland should be considered internationally important if it regularly supports one percent of the individuals in a population of one species or subspecies of waterbird.
Criterion 7	Fish	A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.
Criterion 8	Fish	A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.
Criterion 9	Other taxa	A wetland should be considered internationally important if it regularly supports one percent of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species.

Criterion 1: Representative, rare, or unique example of a natural or near-natural wetland

The application of this criterion must now be considered in the context of the adopted bioregionalisation for aquatic systems, which is based on drainage divisions. The site lies within the Murray Darling drainage division, which extends from Queensland, through NSW into Victoria and South Australia. There is no comprehensive inventory of Ramsar wetland types across the bioregion. However, there is strong evidence that the NSW Central Murray Forests Ramsar site contains both representative and rare wetland types in a bioregional context.

The NSW Central Murray Forests are the largest complex of tree-dominated floodplain wetlands in southern Australia. The Millewa Forest Group together with the Barmah Forest are nationally the largest continuous stand of river red gum forest (of which the Millewa Forest

Group contribute over 50 percent) (MDBC 2007a and 2007b). Overall, they are representative of the structure, species composition and ecological character of this wetland type (Keith 2004; ANCA 1996). The site contains also other wetland types that are rare within the bioregion, particularly types P (floodplain lake) and Ts (floodplain meadows and reed swamps) (Leslie 2002; ANCA 1996). Therefore, this criterion is considered to be met.

Criterion 2: Supports threatened species or threatened ecological communities.
In the Australian context, it is recommended that this criterion should only be applied with respect to nationally threatened species/communities, listed under the EPBC Act or the International Union for Conservation of Nature (IUCN) Red List. A number of threatened species listed at the national and / or international level have been recorded within the boundary of the NSW Central Murray Forests Ramsar site. However, central to the application of this criterion are the words “a wetland” and “supports”. Guidance from Ramsar (Ramsar 2005) in applying the criteria indicates that the wetland must provide habitat for the species concerned. For this reason, vagrant species and terrestrial species are not considered to contribute to the meeting of this criterion and the records of species such as plains wanderer (*Pedionomus torquatus*) and regent honeyeater (*Xanthomyza phrygia*) are not considered further. However, the superb parrot (*Polytelis swainsonii*) has been included due to its reliance on a wetland plant (river red gum) for nesting habitat.

There are seven threatened species supported by the wetlands within the Ramsar site (Table 5) that contribute to the site meeting this criterion.

Table 5: Threatened species supported by the NSW Central Murray Forests Ramsar site (E = endangered; V = vulnerable).

Species	Threatened species listing		Evidence from the site
	IUCN	EPBC	
Trout cod *Maccullochella macquariensis*	E	E	Recorded in Barmah-Millewa 2002-03 (Jones and Stuart 2004); 2003-05 (Jones 2006) and 2005-06 (King et al. 2009).
Silver Perch *Bidyanus bidyanus*	V		Present in Barmah-Millewa 2002-03 (Jones and Stuart 2004); 2003-05 (Jones 2006) and 2005-06 (King et al. 2009).
Murray cod *Maccullochella peelii peelii*		V	Present in Barmah-Millewa 2002-03 (Jones and Stuart 2004); 2003-05 (Jones 2006) and 2005-06 (King et al. 2009).
Australian painted snipe *Rostratula benghalensis*	E	V	Historical records (Leslie 2002; MDBC 2007c).
Australasian bittern *Botaurus poiciloptilus*	E	E	Recorded in Millewa Forest Group in 2001 (BA 2008) and 2005-06 (MDBC 2007c).
Superb parrot *Polytelis swainsonii*	V	V	Population of 100-200 birds present across site (Webster, 1997). Significant breeding population in Millewa Forest Group (Webster 2003).
Swamp wallaby grass *Amphibromus fluitans*		V	Present Millewa Forest Group and Koondrook-Perricoota Forest Group (MDBC 2007a; 2007b).
Murray hardyhead (*Craterocephalus fluviatilis*)		V	Recorded since 1998 (Davies et al. 2008; King et al. 2009)

Criterion 3: Supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region
Like criterion one, application of this criterion must be taken in the context of the revised bioregionalisation for aquatic systems. A lack of data across the bioregion (which spans four States) makes application of this criterion difficult. In the absence of any species unique to the Ramsar site, or evidence that this site is substantially more species rich or diverse than other comparable areas, there is little to support this criterion. Until such time that comprehensive

survey data are available across the bioregion, it is not possible to assess this criterion and as such it is not considered to be met.

Criterion 4: Supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.
The basic description of this criterion implies a number of common functions/roles that wetlands provide including supporting fauna during migration, providing drought refuge, supporting breeding and moulting in waterfowl. The NSW Central Murray Forests Ramsar site provides a number of these functions and roles as described below and clearly meets this criterion.

The critical life stage of migration
The site provides habitat for 11 species of wetland bird listed in international migratory bird agreements JAMBA, CAMBA and ROKAMBA[2]. These species are Australian painted snipe (*Rostratula benghalensis australis*), eastern great egret (*Ardea modesta*), cattle egret (*Ardea ibis*), sharp-tailed sandpiper (*Calidris acuminata*), common greenshank (*Tringa nebularia*), marsh sandpiper (*Tringa stagnatilis*), Latham's snipe (*Gallinago hardwickii*), glossy ibis (*Plegadis falcinellus*), Caspian tern (*Hydropogne caspia*), red-necked stint (*Calidris ruficollis*) and white-bellied sea-eagle (*Haliaeetus leucogaster*). Although the majority of these species are considered residents in Australia, the list includes a number of true international migrants (sharp-tailed sandpiper, common greenshank, marsh sandpiper and red-necked stint).

In addition, the NSW Central Murray Forests provide critical migration routes and spawning habitat for local populations of native fish. Native fish move into off-stream areas on rising flows and make refuge movements into deeper waters during low flow periods. During flood periods fish migrate laterally onto the floodplain in order to spawn. It also provides generally good connectivity between floodplain, anabranch and main-channel habitats which facilitates this pattern of migration (Jones 2006).

The critical life stage of breeding
Waterbird breeding in the Barmah-Millewa Forest was recorded 32 times during 1905 to 1997 (Leslie 2001). More recent successful breeding of thousands of birds were recorded in 1998, 2000 and 2005 (O'Connor et al*.* 2006). In the Koondrook-Perricoota Forest Group breeding events of hundreds of colonial nesting birds have been seen in 2000/01, 2003/4, 2004/05 and 2005/06, with over 200 chicks successfully fledged (MDBC 2007c).

The critical life stage of drought refuge
The permanent waters of streams and floodplain wetlands within the site provide refuge for mobile and sedentary fauna during environmentally stressful periods. As it is an area of comparatively high water availability and habitat productivity in a semi-arid rainfall zone, during times of drought the mosaic of aquatic, riparian and fringing river red gum forests and woodlands provide essential refuge habitat to a wide range of biota.

Criterion 5: Regularly supports 20 000 or more waterbirds
The application of this criterion to the site is problematic. The site is dominated by wetlands with a high-dense canopy cover provided by the river red gum, so aerial surveys of bird numbers are unfeasible over the majority of the site. Moreover, ground-based surveys have a lower return per unit effort than in more open habitats and so it is difficult to gauge accurately the number of water birds present at any one time. This is especially true during times of flood, when waterbird numbers are greatest but site access is most constrained.

The portions of the site along the Murray River are often surveyed in conjunction with Victorian Ramsar-listed wetlands. The original justification for this criterion utilised combined counts from both Barmah and Millewa Forests (Leslie 2002; see section 2.5.1 above). Quantitative evidence of greater than 20 000 waterbirds from within the Ramsar site alone are limited and an application of the principles of "regularly supports" are unable to be applied with current data.

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[2] Note that the original nomination included non-wetland bird species listed under international agreements (white-throated needle-tail and fork-tailed swift).

Therefore this criterion is considered not to be met.

Criterion 6: Supports one percent of the individuals in a population of one species or subspecies of waterbird

The application of this criterion suffers from the same problems as that described for criterion five above. However, while there is evidence that colonial nesting waterbirds as a group may exceed 20 000 birds in a given flood event, there is little or no evidence that the site regularly supports greater than one percent of the population of any individual species. This criterion is therefore not considered to be met by the site.

Criteria 7: Supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity

This criterion is very difficult to apply. A site can potentially qualify based on the proportion of fish species present that are endemic to the site (must be greater than 10 percent) or by having a high degree of biodisparity in the fish community. While 22 species of native fish have been recorded from within the site (approximately 50 percent of inland fish species in the bioregion), none are endemic to the site. There is no evidence that this site is more diverse with respect to fish than other wetlands in the Murray Darling Basin and all of the fish present have similar, inland water life histories. On this basis, this criterion is not considered to be met.

Criterion 8: Important source of food for fishes, spawning ground, nursery and/or migration path for fish stocks

Guidance from the Convention indicates that this criterion is about providing a network of sites that maintain fish populations as they migrate during their lifecycle. The site provides migratory routes between habitat in the Murray River, anabranches and floodplains. Native fish of the Murray River main channel utilise anabranch and flood runner channels when they are available (Thoms et al. 2000). Native fish move into off-stream areas on rising flows, and make refuge movements into deeper waters during low flow periods. Many species spawn on the floodplains (Jones 2006). Tagged fish have been recorded moving large distances from the site (up to 300 kilometres upstream and 900 kilometres downstream), which is indicative of pre- and post-spawning behaviour (McKinnon 1997). River red gum forests make a significant contribution to in stream nutrient accumulation and productivity through litterfall (Gawne et al. 2007) and provide important shelter in the form of coarse woody debris and shaded water (Jones and Stuart 2007). Therefore, this criterion was met at the time of listing and continues to be met.

Criterion 9: Supports one percent of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species

The application of this criterion relies on estimates of the total population of non-bird species. In the case of NSW Central Murray Forests this would require population estimates of frog, fish or mammal species. As there are no reliable population estimates for any of the relevant species it is not possible to determine if the site supports one percent of any population. Based on available information, this criterion is not met.

3. Components and Processes

Components (physical, chemical and biological parts) and processes (reactions and changes) are the elements of a wetland that, when considered together, form the foundation of the ecological character of a site. Wetlands are complex ecological systems and the complete list of physical, chemical and biological components and processes for even the simplest of wetlands would be extensive and difficult to conceptualise. It is not possible, or in fact desirable, to identify and characterise every organism and all the associated abiotic attributes that are affected by, or cause effect to, that organism to describe the ecological character of a system. This would result in volumes of data and theory but bring us no closer to understanding the system and how to best manage it. What is required is to identify the key components, the initial state of the systems, and the basic rules that link the key components and cause changes in state (Holland 1998). Thus, the description of components and processes provided below is focussed on characteristics that are related to the ecological character of the site. A subset of these is formally identified as “critical” components and processes in accordance with the national framework (DEWHA 2008).

Critical components and processes are those aspects of the ecology of the wetland, which, if they were to be significantly altered, would result in a significant change in the system. These are afforded special attention within an ECD and limits of acceptable change (see section 6) must be determined for all identified critical components, processes, benefits and services. The critical components and processes of a Ramsar site have been identified using the criteria specified in DEWHA (2008); i.e. “As a minimum, select for analysis and description those components, subcomponents, processes, benefits and services:

1. that are important determinants of the sites unique character;
2. that are important for supporting the Ramsar criteria under which the site was listed;
3. for which change is reasonably likely to occur over short to medium time scales (less than 100 years); and
4. that will cause significant negative consequences if change occurs.

In identifying critical components and processes, the role that components and processes play in the provision of critical ecosystem services should also be considered. To this end, the linkages between critical components, processes, benefits and services and the criteria under which the site was listed are illustrated conceptually in Figure 10. Note that cultural services such as recreation and tourism are not shown, but are underpinned by all critical components and processes and all other services. It should also be noted that the separation of components from processes is not straight forward. For example, aspects of geomorphology such as bathymetry and topography may be considered as components, while other aspects of geomorphology such as sediment transport and erosion could be considered processes. Similarly the species composition of birds at a site may be considered a component, but feeding and breeding are processes. In the context of this ECD a separation of the ecology of wetlands into components and processes is an artificial boundary and does not add clarity to the description. As such components and processes are considered together.

A summary of the components and processes in the NSW Central Murray Forests Ramsar site, highlighting critical components and processes is provided in Table 6. Each of the identified critical components and processes meet the four criteria provided by DEWHA (2008). More complete descriptions for components and process are provided below. The interactions between components and processes, the functions that they perform and the benefits and services that result are described in section 4.

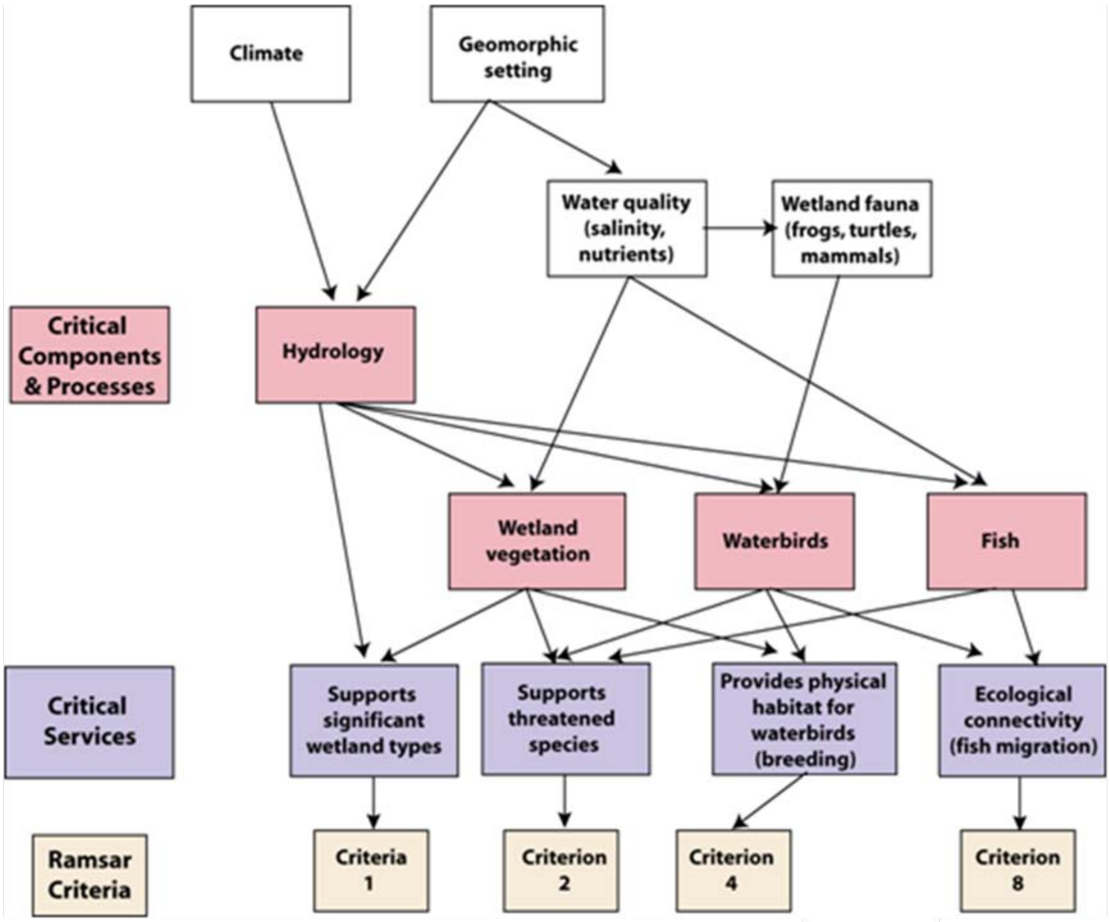

Figure 10: Simple conceptual model showing the key relationships between components and processes; benefits and services and the reasons for the site being listed as a wetland of international importance.

Table 6: Summary of components and processes within the NSW Central Murray Forests Ramsar site (Critical components and processes are shown shaded).

Component / process	Description
Climate	• Located in semi-arid climatic zone with hot dry summers and cold winters. • Rainfall occurs year round, but is higher in winter months. • On average evaporation exceeds rainfall.
Geomorphic setting	• On the floodplain of the River Murray and tributaries. • Hydrology for the Millewa and Werai Forest Group is controlled by the Barmah Choke, where the River Murray channel narrows considerably below Picnic Point and restricts and forces flows to overbank and onto the floodplain. • Soils within the site are predominantly silty-clays.
Hydrology	• Inundation of the site is driven largely by flows within the Murray River. • The hydrology of the site is highly regulated and seasonality of low and moderate flow is determined largely by irrigation needs. • Large scale floods that inundate the forests are generally the result of rainfall events. • Groundwater may be important for maintaining tree health, but remains a knowledge gap.

Component / process	Description
Water quality	• Water quality is influenced by river water quality and the length of time between floodplain inundation. • Salinity in the rivers and on the floodplain is generally low and fresh conditions prevail. • During inundation of the floodplain, nutrients are released from litter and organic debris on the forest floor. This is a natural process, but if the duration of dry periods is long, organic matter can build up and upon re-wetting result in low dissolved oxygen concentrations.
Wetland vegetation	• The two critical wetland vegetation categories are river red gum forests and floodplain marshes. • Over 90 percent of the site is covered in inundation dependent forest and woodland (river red gum and black box), which has a combined extent of over 76 000 hectares. • River red gum forest is the dominant vegetation community, comprising 65 percent of the site. • Condition at the time of listing was poor to moderate, with less than 20 percent of the river red gum forest in good condition in both Millewa and Koondrook-Perricoota Forest Group. • Floodplain marshes vary spatially and temporally within the site, both in terms of extent and community composition in response to wetting and drying. • Floodplain marshes include moira grass (*Psuedoraphis spinescens*) plains (regionally significant), giant rush (*Juncus ingens*) beds, common reed (*Phragmites australis*) beds, moist grasslands, herblands and semi-permanent marshes.
Fish	• Data deficient. • Seventeen native species of fish have been recorded from within the site. • Results from surveys indicate that abundance varies considerably and that invasive species generally comprise 10 - 30 percent of the total abundance and up to 70 percent of biomass.
Wetland birds	• Sixty-seven species of wetland bird have been recorded from the site. This includes 11 species listed under international migratory agreements and three threatened species: Australian painted snipe, (*Rostratula benghalensis australis*); superb parrot (*Polytelis swainsonii*) and Australasian bittern (*Botaurus poiciloptilus*). • Over 100 000 birds have been recorded in the site during times of flood. • The site is significant for supporting breeding of colonial nesting waterbirds and contains a significant breeding population of superb parrot.
Other wetland fauna	• Data deficient. • Three species of wetland dependant mammal: water rat (*Hydromys chrysogaster*), platypus (*Ornithorhynchus anatinus*) and southern myotis bat (*Myotis macropus)*, • Four species of wetland dependent reptile and seven species of frog have also been recorded.

3.1 Climate

NSW Central Murray Forests are situated within the semi-arid / grassland climatic zone of south-eastern Australia (Bureau of Meteorology 2010). The general climatic pattern is hot dry summers and cold winters. The three aspects of climate that most directly affect wetland ecology are rainfall (both local and in the catchment), temperature and (to a lesser extent in temperate systems) relative humidity as these all fundamentally affect wetland hydrology and the water budget. Note that the climate as described here is relevant to the time of listing, the issue of climate change is dealt with under threats (see section 7).

Rainfall, can occur year round, but is higher during winter months. Highest monthly average rainfall is in June (35 millimetres) and lowest in February (16 millimetres). There is some degree of variability in rainfall as evidenced by the 10th and 90th percentiles, which range from less than 10 millimetres per month to greater than 80 millimetres per month (Figure 11). However, this is considerably more stable than rainfall in arid and topical zones within Australia (Bureau of Meteorology 2010).

Annual average rainfall at Deniliquin is in the order of 415 millimetres per year. Once again, there is some degree of variability in annual rainfall (ranging from less than 170 millimetres to more than 800 millimetres in 50 years of records from this site) (Figure 12).

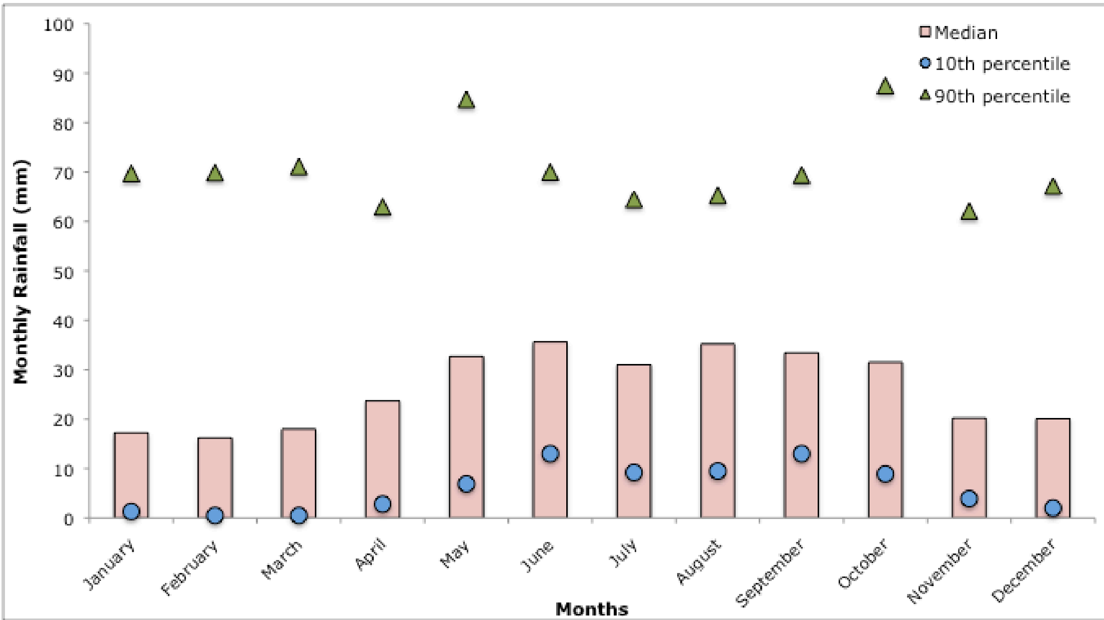

Figure 11: Median (10th and 90th percentile) monthly rainfall at Deniliquin (1856 – 2010; Bureau of Meteorology).

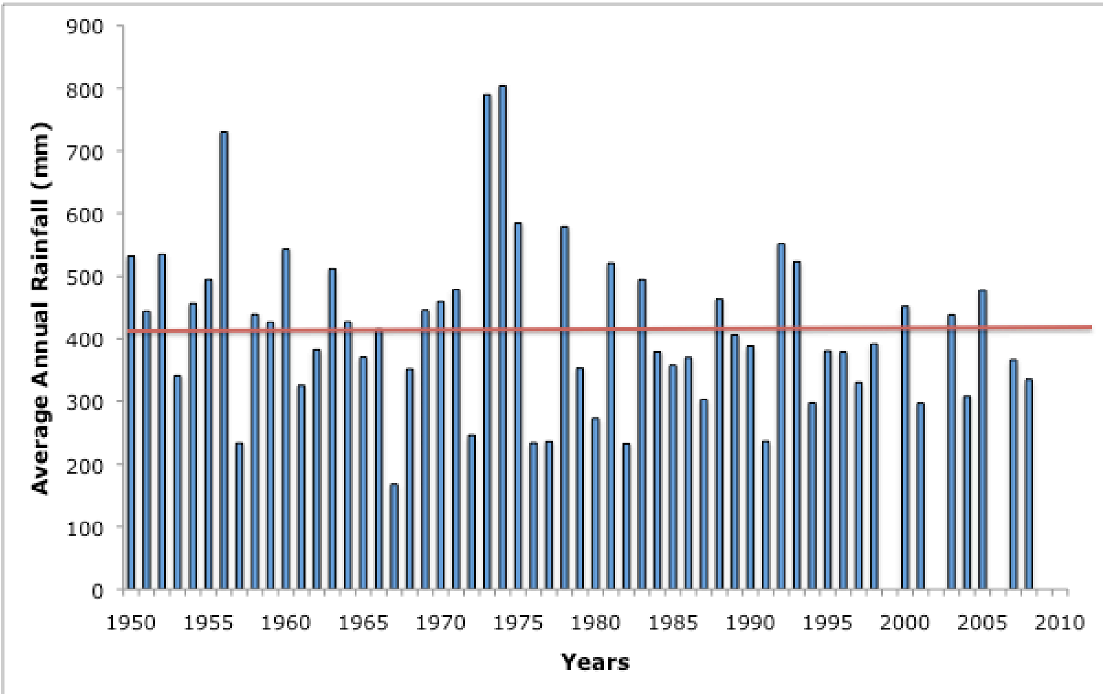

Figure 12: Average annual rainfall at Deniliquin (1950 – 2009; Bureau of Meteorology). Note horizontal line shows long term average.

Temperatures range from cool to hot (Figure 13), with average summer maximum temperatures around 32 degrees Celsius and average minimum temperatures around 15 degrees Celsius. During winter average maximum temperatures are considerably cooler (14 to 15 degrees Celsius) as are average minimum temperatures (three to four degrees Celsius). Relative humidity ranges from 50 percent during summer to 80 percent during winter months. The high temperatures, low rainfall and low humidity during summer result in evaporation exceeding rainfall year round (Figure 14).

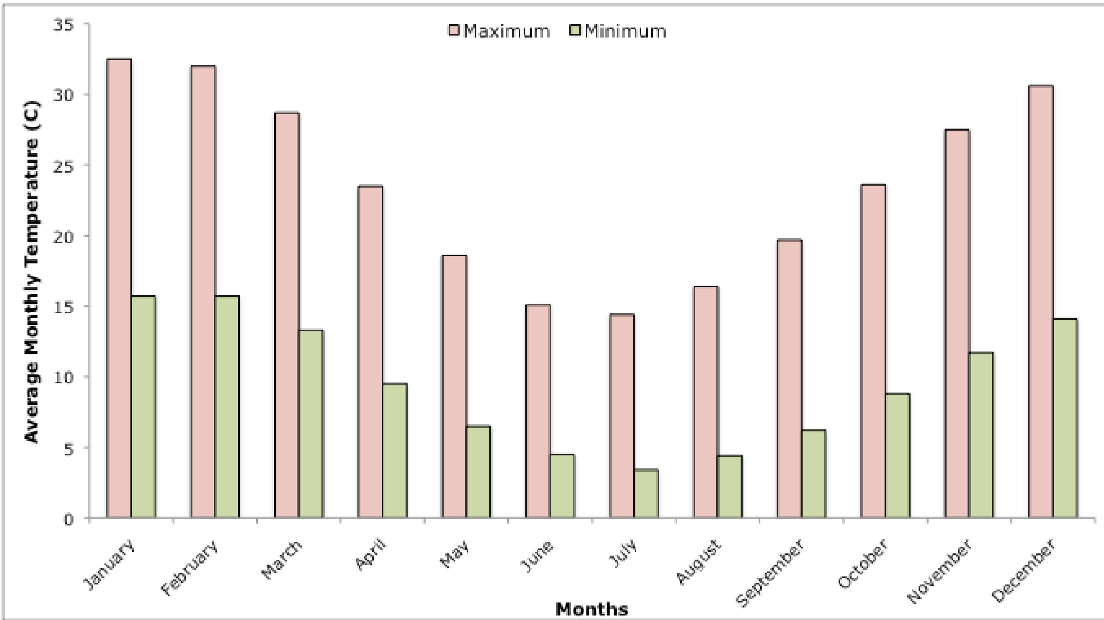

Figure 13: Average monthly maximum and minimum temperatures at Deniliquin (1967 – 2003; Bureau of Meteorology).

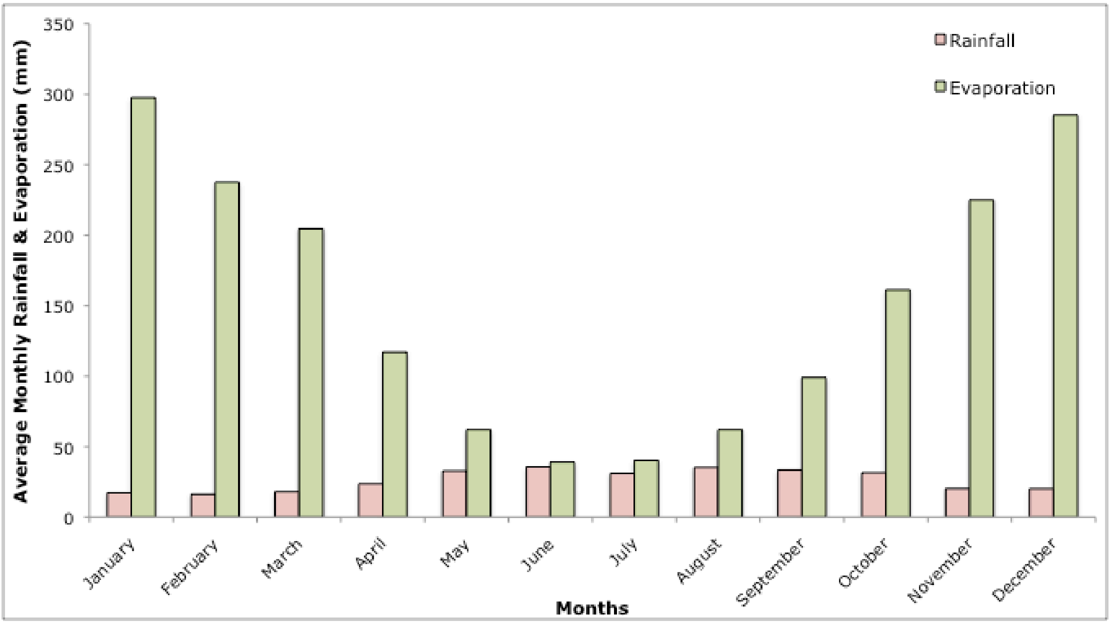

Figure 14: Average monthly rainfall and evaporation at Deniliquin (1967 – 2003; Bureau of Meteorology).

3.2 Geomorphic setting

The site is composed of Quaternary alluvial sediments on the floodplain of the Murray River and associated anabranches (Figure 15). It is made up of three main geological units:

- Floodplain clays (Qa) composed of unconsolidated grey brown micaceous silty clay, silt, sand, gravel;
- Sand dunes (Qad) composed of unconsolidated locally mobile pale orange yellow siliceous sand; local abundant micaceous and lithic grains; and
- Claypans and drainage lines (Qcp) composed of mostly clay, silt and fine sand.

Quaternary geological and geomorphological processes have fundamentally shaped the character of the NSW Central Murray Forests. These processes were responsible for the formation of extensive floodplains and ongoing patterns of wetting and drying that allow the maintenance of forests and wetlands in a semi-arid region. The general terrain of the site is extremely flat, with a regional east-west slope of some 0.2 metres per kilometre (Bacon et al. 1993). Alluvial formations are the dominant landscape features. Quaternary alluvial features include modern and ancestral river channels, floodplains, backplains, swamps, lakes and lunettes.

Historically the Murray River followed a course through what is now known as Green Gully, a depression which is approximately 20 kilometres north of Echuca. More recently, perhaps as early as approximately 550 years ago, it took a new course from Picnic Point in a southerly direction and into the ancestral course of the Goulburn River (Stone 2006). The section where the Murray cut through to the Goulburn channel is today known as the Barmah Choke because of its limited capacity to carry flows (Rutherfurd 1990). Arguably the most significant geomorphic feature of the site, the Barmah Choke has a capacity of approximately one third of the channel upstream and acts like a partial dam, forcing floodwater to frequently back up onto the floodplain, thereby inundating the forests and resulting in the triangular shape of the floodplain supporting the Barmah-Millewa Forest (MDBC 2007a).

Soils in the region have developed from Quaternary alluvial deposits and are often silty gradational loams (Land Conservation Council 1983). Soils supporting river red gum forests and woodlands are typically composed of a layer of anoxic clay overlying interleaved clay and sand strata. The overlying layer of clay may be greater than 30 metres thick (Bren 1988).

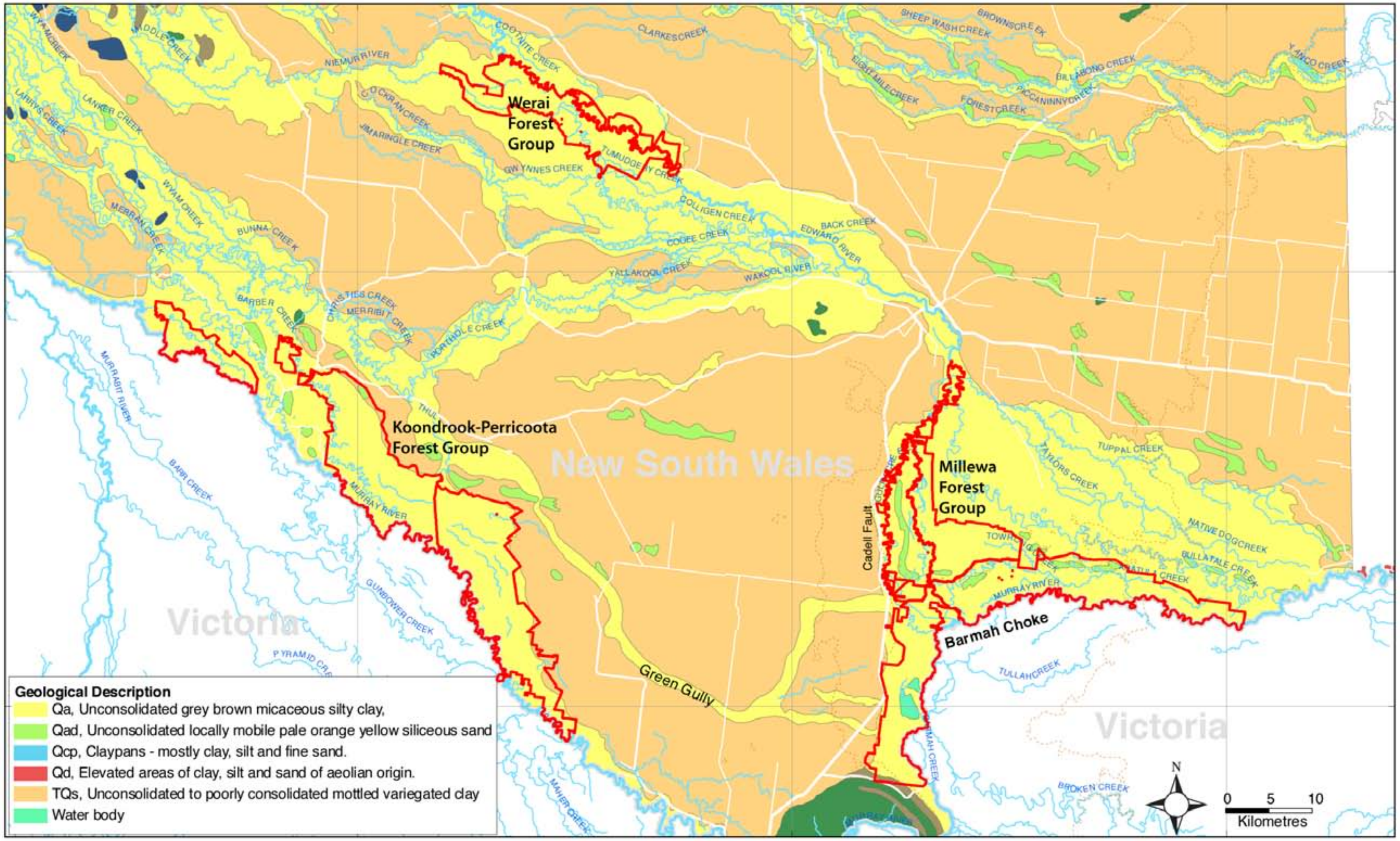

Figure 15: Geology and Geomorphology of the NSW Central Murray Forests (data from GeoScience Australia).

3.3 Hydrology

Flow in the Murray River defines the hydrology of the NSW Central Murray Forests via flow into effluent streams across the site and overbank flow onto the floodplain during flood events. The hydrology of the Murray River and its tributaries was managed for water supply, flood mitigation, navigation and hydroelectricity production long before the NSW Central Murray Forests Ramsar site was designated as a wetland of international importance in 2003. River regulation began over a century ago with a large number of dams, locks and weirs constructed between 1915 and 1974. The character of the site, at the time of listing, was strongly influenced by river regulation and the baseline for the hydrology of the site is this regulated regime. It should be noted, however, that the site was listed during a prolonged drought and there is strong evidence that hydrological regimes from 1997 to 2008 were insufficient to maintain the critical components, processes, benefits and services of the site (MDBC 2006, 2007a,b,d; Natural Resources Commission 2009). As such hydrology over longer historical timescales must be considered when setting the baseline for maintaining ecological character at this site.

Over the flat expanse of the Riverine plain, small changes in topography influence frequency distribution and depth of flooding. Water passes over the forest floor as sheet flow in large floods and 'in creek' flow during smaller flood events. Surface flooding restores soil moisture reserves necessary for tree growth and sustains large wetland habitats. Groundwater also contributes to forest water demands but these groundwater systems (underlying sandy aquifers of prior stream origin), generally only influence-localised areas, but is important to forest health where they do. Their ecological significance is secondary to overland flooding (MDBC 2007a).

Flows into the NSW Central Murray Forests occur as two main types of flow pattern:

- Channel flow, which features inundation of effluent streams, channels, depressions or leads. Occurs primarily as through-flows with limited overbank flow and ponding in depressions during moderate increases in flow; and
- Broad-area flooding, which features inundation of broad areas across the floodplain. These events occur as lateral, overbank flow from channels, which spread over broader areas and ponds in depressions or returns to channels when flow recedes (MDBC 2005; Maunsell 1992).

Although interconnected, the hydrology of each of the three forest groups within the Ramsar site is influenced by flow in different tributaries and has been characterised by numerous investigations and modelling studies in terms of the inundation of different wetland systems and vegetation communities. Critical aspects of hydrology are illustrated conceptually in Figure 16 and described for each of the three areas separately in the proceeding sections.

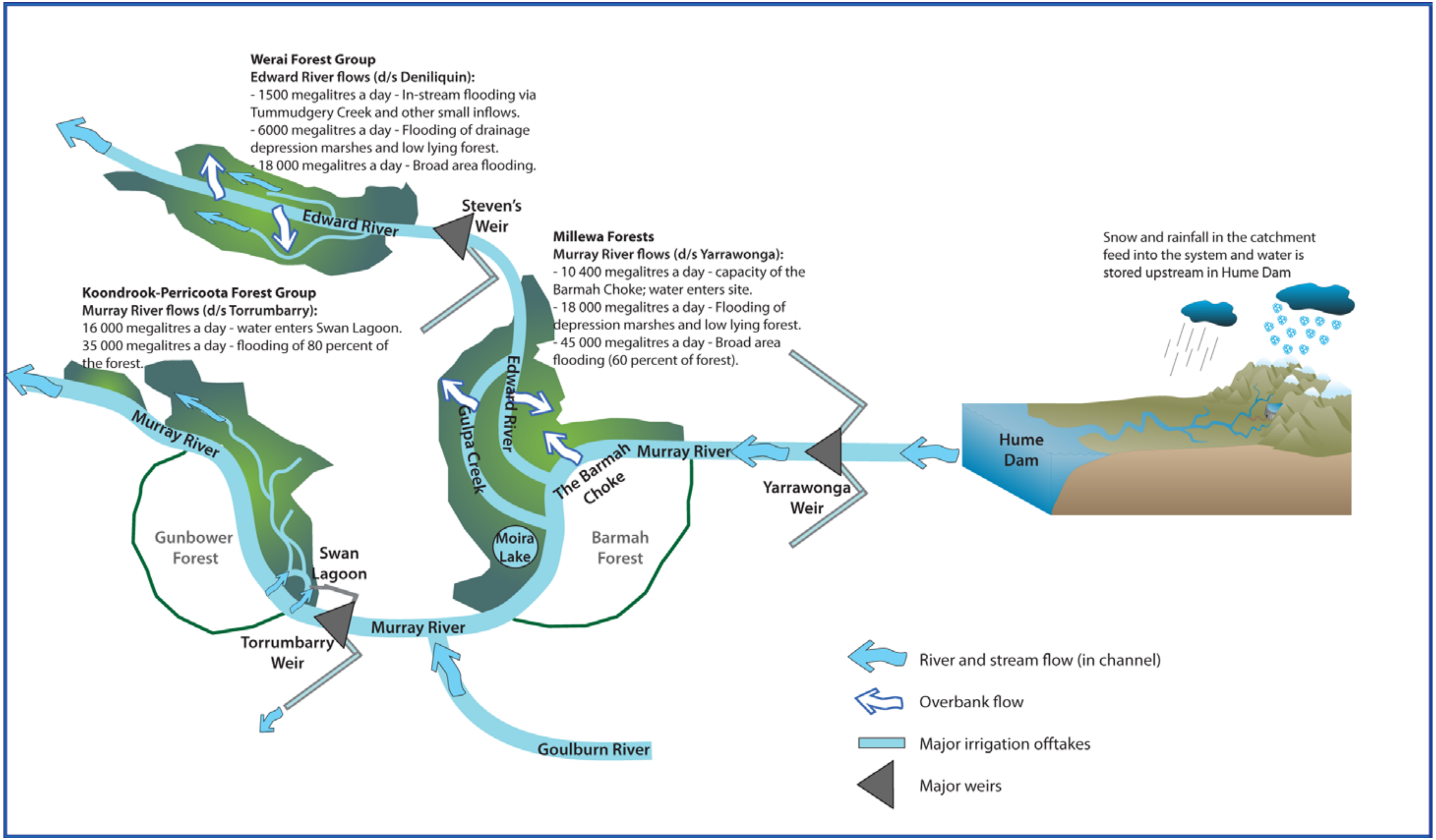

Figure 16: Conceptual diagram of the important aspects of hydrology within the NSW Central Murray Forests Ramsar site (not to scale).

3.3.1 Millewa Forest Group

Flows into the NSW Central Murray Forests are principally governed by releases from Yarrawonga Weir, some 196 kilometres upstream. Inflows into the Murray from Victorian tributaries such as the Ovens, Kiewa and King also play a significant role in flows that reach the site.

There is a large number of water regulating structures within the Millewa forest and inundation frequency, extent and duration are partially controlled by their operation. These regulators are designed to minimise unseasonal flooding of the Barmah Forest and Millewa Forest Group during the irrigation season and to allow water into the forest during the winter/spring. Under regulated conditions, all of the regulating structures are closed to maintain regulated flow within the Murray in order to pass it downstream for consumptive use.

When flows in the Murray River downstream of Yarrawonga exceed the capacity of the Barmah Choke (10 400 megalitres a day) the regulators are progressively opened to allow water to enter the forest. At flows between 10 400 and 16 000 megalitres a day, channels, swamps and other low lying areas, including about 16 percent of the forest, are inundated (Water Technology 2009). Larger floods of over 45 000 megalitres a day are required to inundate about 60 percent of the forest and it is only at flows of greater than 60 000 megalitres a day that inundation of most of the river red gum forest and substantial proportions of the black box communities occurs (Water Technology 2009).

Operation of the regulators influences the movement of water through the forest and given the number of regulators, there are many possible inundation scenarios depending on which are opened and closed and at what time. The results of modelled inundation scenarios (30 day steady inflows and all Victorian regulators open) provide an indication of flood extents in the Millewa Forest under each of the flow thresholds (Figure 17). A comparison with inundation under a similar 30 day inundation scenario, but with all the NSW regulators open (Figure 18) highlights the significant effect of regulator operation. By opening NSW regulators, the area immediately to the north of the Murray River (and site boundary) is inundated at 13 000 megalitres a day, as opposed to 25 000 megalitres a day when the NSW regulators are closed and those in Victoria are open. As flows increase, the ability to control water movement diminishes. This is illustrated by the two modelled scenarios (Figure 17 and Figure 18) which show very little difference in inundation above 35 000 megalitres a day.

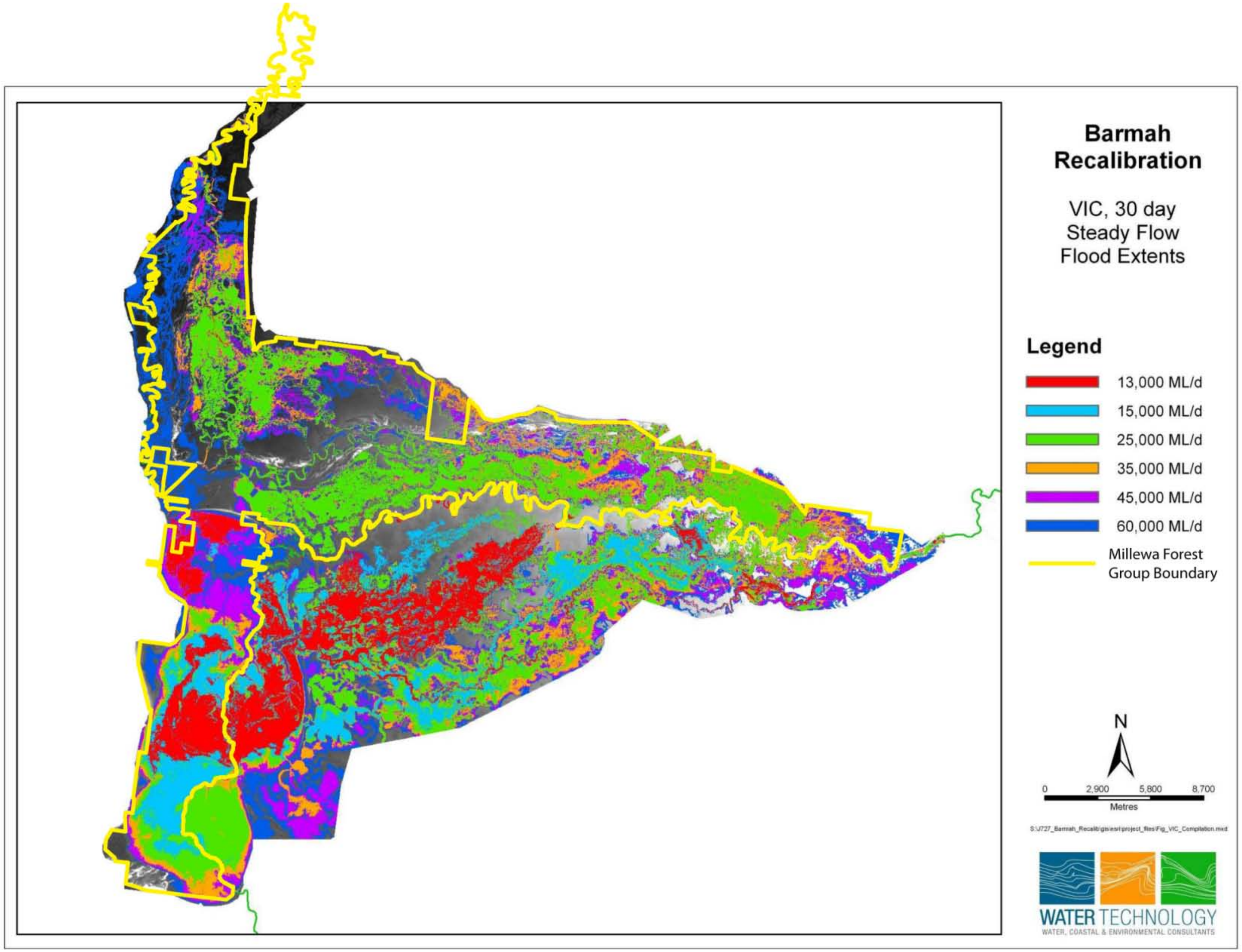

Figure 17: Inundation of Barmah Forest and Millewa Forest Group with Victorian regulators open (Water Technology 2010).

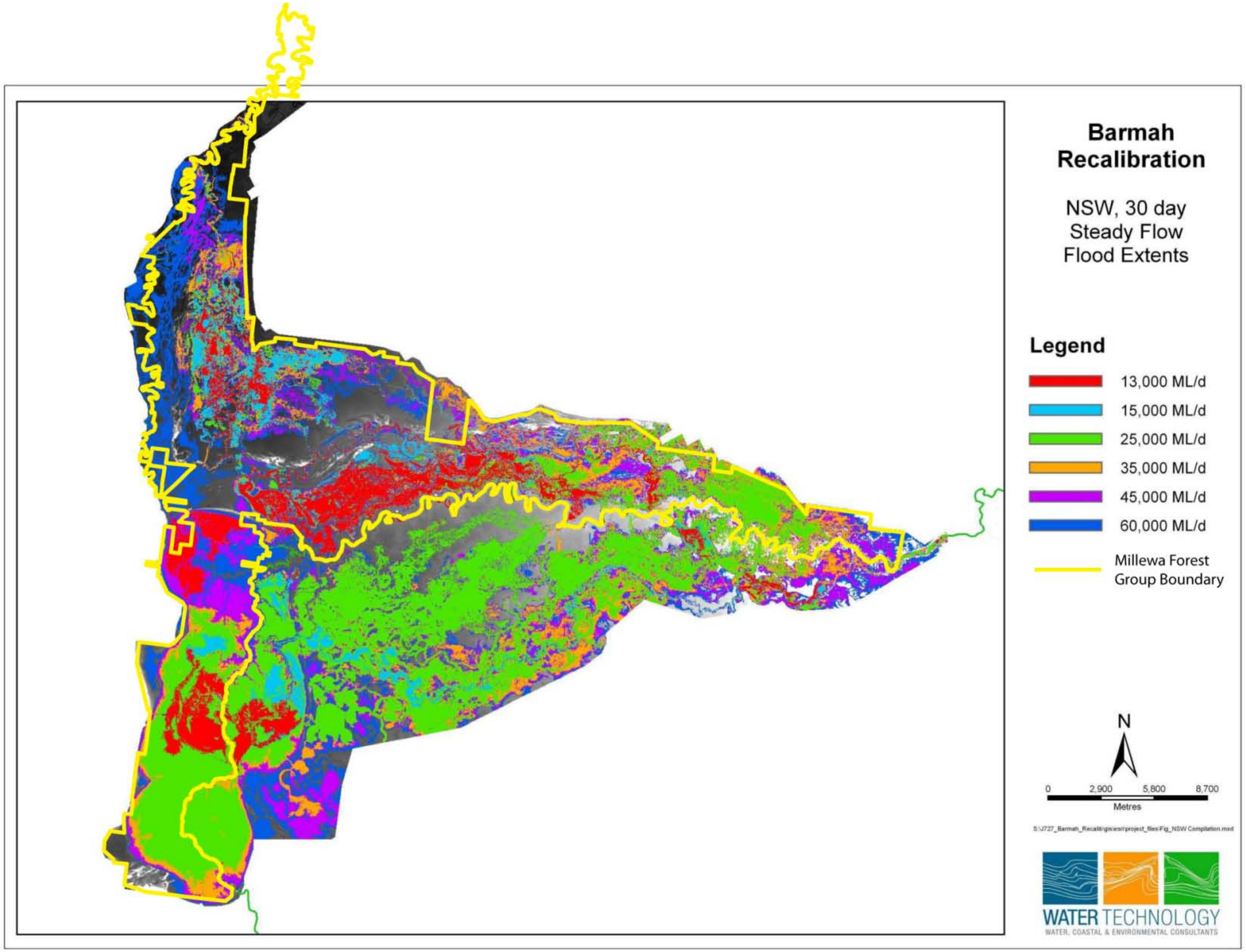

Figure 18: Inundation of Barmah Forest and Millewa Forest Group with NSW regulators open (Water Technology 2010).

Large flow events vary in frequency and duration and are largely driven by large rainfall events. Significant flood events occurred in 1973, 1974, 1975, 1981, 1991, 1992, 1993, 1996, 2000 and 2010 (Figure 19). Calculation of the average return intervals of these flood thresholds has been undertaken many times in the past decade using different hydrological models (for example CSIRO 2008; MDBC 2006; MDBC 2007a; MDBA 2010). The results of each of these are slightly different and highlight the difficulty (and uncertainty) in characterisation of flood frequency for the forests. Average recurrence intervals for large floods from the most recent modelling (MDBA 2010) are based on 114 year record and the historical climate, current development modelled hydrology is indicative of hydrological conditions at the time of listing (as there have been no significant changes in water resource use or infrastructure in the seven years since listing). The average recurrence intervals have been calculated for flow thresholds important for inundation of different vegetation communities Table 7.

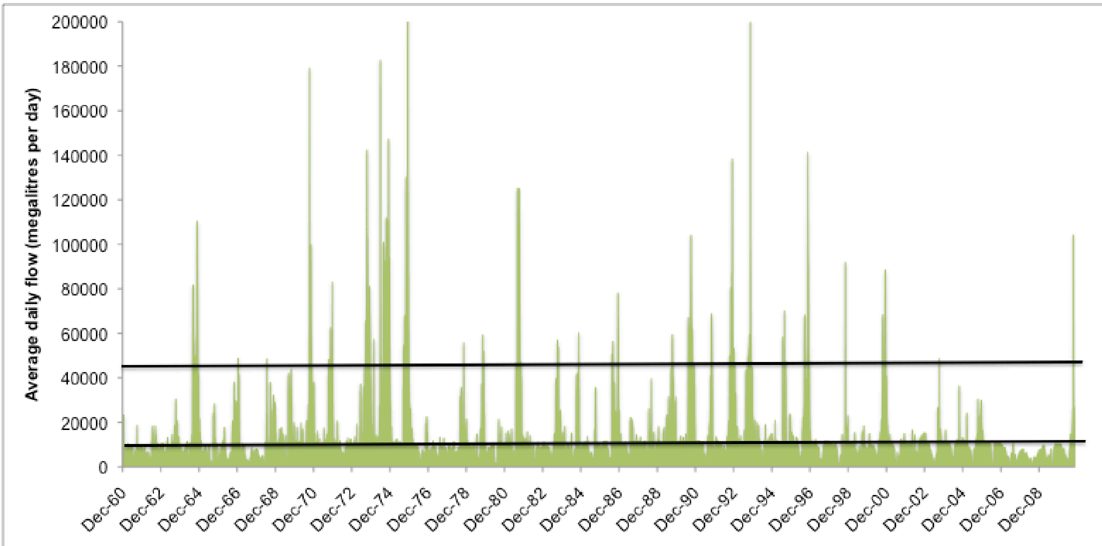

Figure 19: Average daily flow (megalitres per day) in the Murray River downstream of Yarrawonga from 1960 to 2010 (data from the Victorian Water Resources Data Waterhouse). Lines show commence to fill level (10 400 megalitres per day) and threshold for broad scale inundation (45 000 megalitres per day).

Table 7: Flood flow recurrence intervals at the Murray River downstream of Yarrawonga for specific flow events at Millewa Forest Group (MDBA 2010).

Flow (megalitres per day)	Duration (days)	Average period between events (years)	Inundation extent
12 500	70	2	All low lying areas and channels, floodplain marshes, 14 to 46 percent of the river red gum forest.
16 000[3]	98	3	Moira grass plains.
25 000	42	3.4	50 percent of river red gum forest and a small portion of river red gum and black box woodland.
35 000	30	3.8	60 percent of river red gum forest and 30 percent of river red gum woodland.
50 000	21	5.5	65 to 70 percent of the river red gum forest and 50 percent of river red gum woodland.
60 000	14	7.1	Virtually all river red gum forest, a large proportion of river red gum woodland and some inundation of black box woodland.

[3] Commence to fill threshold, up to 25 000 ML/day may be required to inundate to optimum depth, but remains a knowledge gap.

Average daily flows from around the time of listing illustrate the typical seasonality (Figure 20). The lowest flows are recorded between May and August each year. This coincides with the period when water demand from downstream users (irrigators and urban water supplies) is lowest. There is a consistent flow of water between September and January / February of each year in line with irrigation demands.

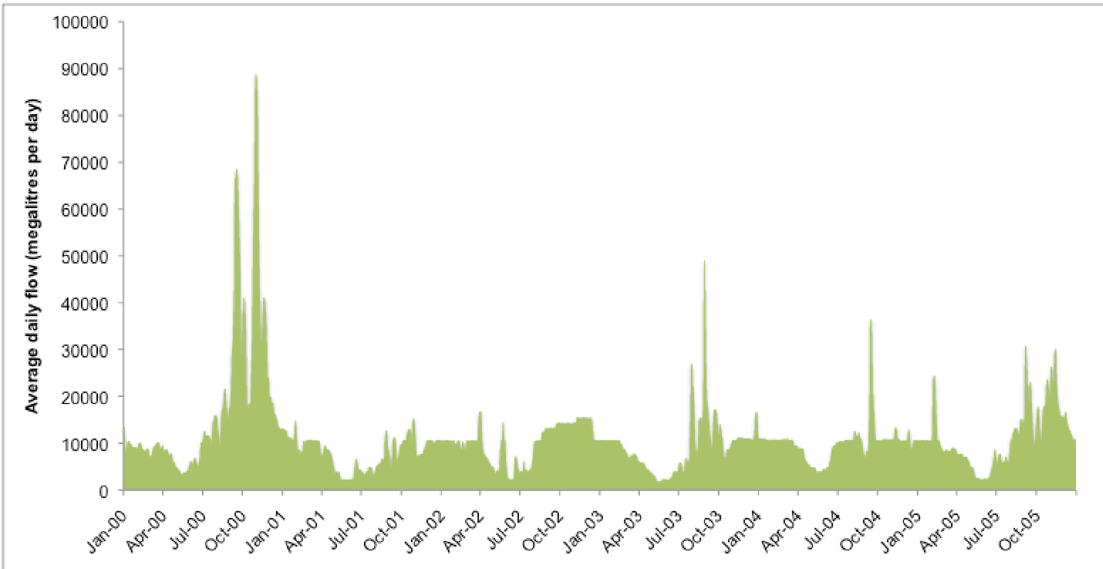

Figure 20: Average daily flow (megalitres per day) in the Murray River downstream of Yarrawonga from 2000 to 2005 (data from the Victorian Water Resources Data Waterhouse).

3.3.2 Koondrook-Perricoota Forest Group

Koondrook-Perricoota Forest Group receives water when flow in the Murray River at Torrumbarry Weir exceeds 16 000 megalitres a day. Water enters via Swan Lagoon and for the first 15 kilometres flows through the system via several deep, well-defined channels known as the Burrumbarry Creeks. These channels then break down into a myriad of smaller, interlinked runners covering an area of approximately 4500 hectares. These runners eventually coalesce into several defined streams, the largest of which is the Myloc Creek. The Myloc flows westward in conjunction with subsidiary runners, before becoming Barbers Creek, the primary drainage system for the western end of the forest. In addition to the Myloc, a second flow runs north-westerly, without a defined channel, eventually forming the secondary drain of the Cow Creek (Wyatt 1992).

Downstream of Swan Lagoon are a number of other oxbow lagoons, several of which have associated natural effluents that form secondary inflow points at very high flows in the Murray. The most significant of these are Horseshoe Lagoon and Dead River Lagoon. As river levels rise higher, an increasing number of these smaller channels begin to flow. Substantial broad area flooding occurs when the flows exceed the channel capacity of the Murray River (greater than 30 000 megalitres per day). It is estimated that at flows of 35 000 megalitres per day approximately 80 percent of the river red gum forest is inundated (MDBC 2008; Figure 22).

Similar to the Millewa Forest Group, large flow events influencing the Koondrook-Perricoota Forest Group vary in frequency and duration and are largely driven by large rainfall events. On average, hydrology at the time of listing (based on 114 year record of historical climate and current water resource development) resulted in flows exceeding the commence to fill threshold of 16 000 megalitres a day once every 2.8 years (MDBA 2010). Flow recurrence intervals for different flood events for Koondrook-Perricoota Forest Group at the time of listing are provided in Table 8 (noting that as for the Millewa Group there have been numerous modelling that have resulted in different figures for ARI; those presented represent the most recent). Of note, is the lack of flows above the broad scale flood threshold from 2001 to 2010 (Figure 21). In spring 2010, however, a “natural” flood event occurred, with broad scale flooding of up to 60 percent of the Koondrook-Perricoota Forest Group (Linda Broekman, Forests NSW personal communication).

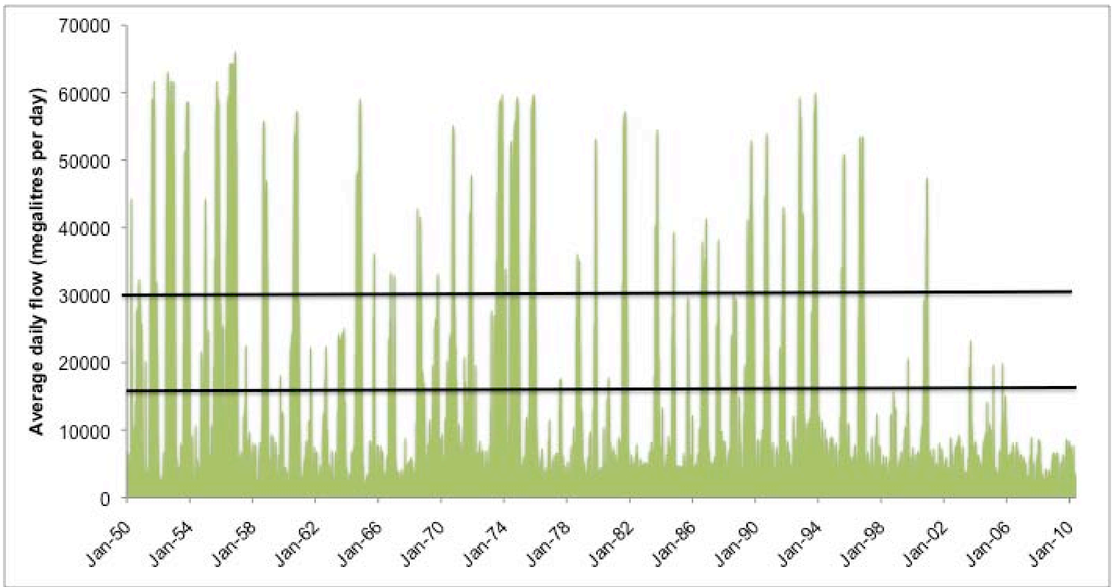

Figure 21: Average daily flow (megalitres per day) in the Murray River downstream of Torrumbarry from 1960 to 2010 (data from the Victorian Water Resources Data Waterhouse). Lines show commence to fill level (16 000 megalitres per day) and threshold for broad scale inundation (30 000 megalitres per day).

Seasonality of flows (and inundation) is similar to that in Millewa, with lowest flows occurring during April to June when irrigation demand is low; and constant flows during spring and summer when irrigation demand is at its highest.

Table 8: Flood flow recurrence intervals at the Murray River downstream of Torrumbarry for specific flow events at Koondrook-Perricoota Forest Group (MDBA 2010).

Flow (megalitres per day)	Duration (days)	Average period between events (years)	Inundation extent
16 000	90	2.8	Permanent wetlands and channels.
20 000	60	2.8	All low lying areas and channels, floodplain marshes.
30 000	60	4	70 percent of the river red gum forest and 43 percent of river red gum woodland.
40 000	60	8.3	All river red gum forest and woodland and black box woodland.

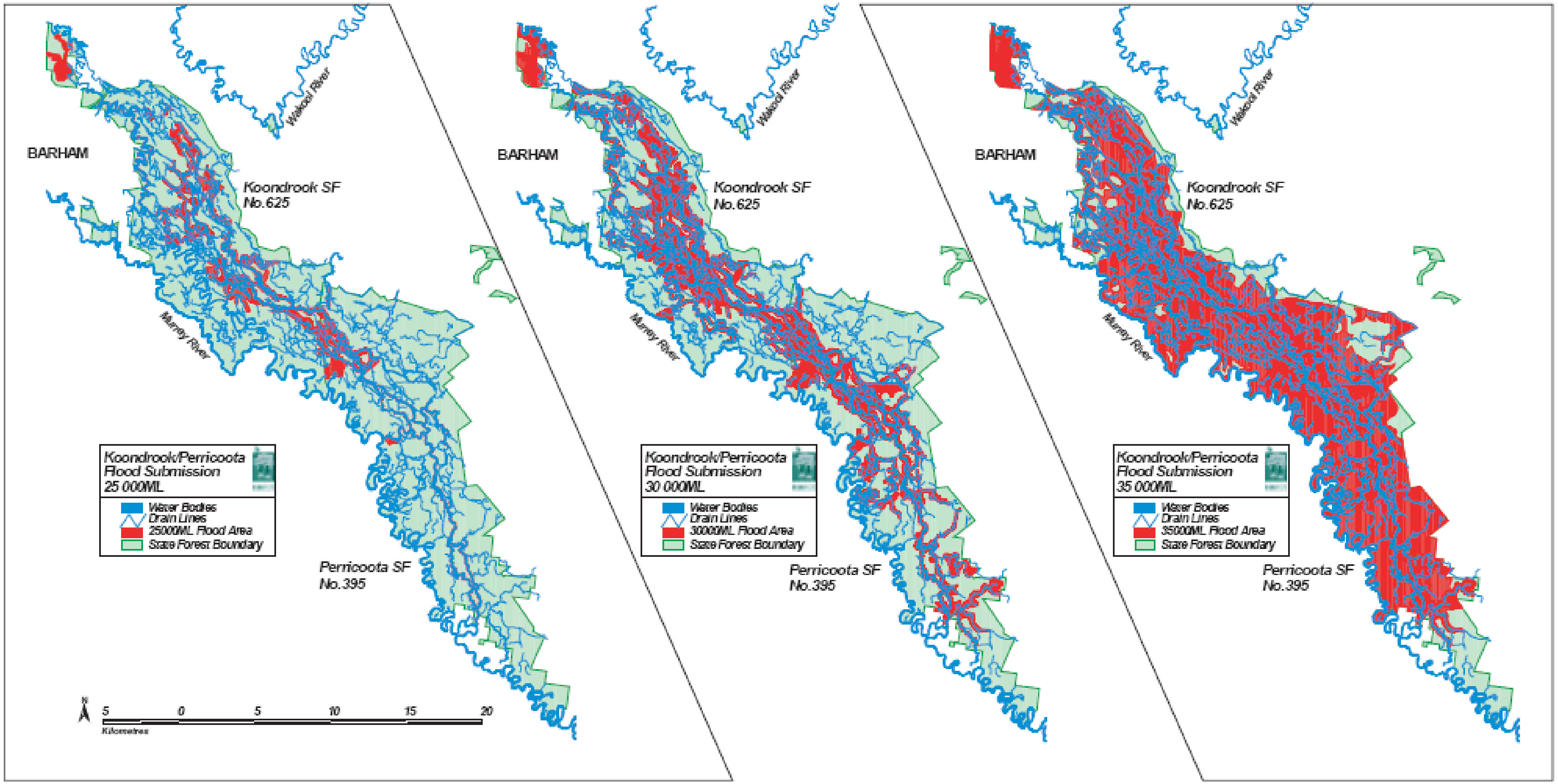

Figure 22: Inundation of Koondrook-Perricoota Forest Group (D. Leslie unpublished).

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3.3.3 Werai Forest Group

Flooding of the Werai Forest Group is determined by flows in the Edward River downstream of Stevens Weir. Floodwater enters the forest via three effluents, all of which have regulator structures, as well as overbank flow. The effluents going from east to west are Tumudgery Creek, Neimer Creek and Reed Beds Creek.

The Werai Forest Group are hydrologically linked to the Millewa Forest Group, since at high Murray River flows a significant portion of river flow passes through the Edward River system and onto the Werai Forest Group. The Bullatale Creek also brings water from central Millewa to the Edward River near Deniliquin during periods of high flow. On average the Werai Forest Group are flooded 3 to 4 days after the Millewa Forest Group are flooded (Maunsell 1992).

Water enters the site, when flows in the Edward River at Deniliquin are above 1500 megalitres a day, but at this level remain in channel. Flows of about 6000 megalitres a day result in inundation of reed beds and low lying river red gums and flows above 18 000 megalitres a day are required for broad scale flooding of the forest (Green 2001a; MDBA 2010). However, inundation mapping is not available for this portion of the Ramsar site.

The flows in the Edward River reflect seasonal water demands, with higher flows in the summer months during the irrigation season and lower flows during the winter months. Large flood events (above 18 000 megalitres a day) have occurred on a relatively frequent basis between 1952 and 1996. However, in the decade spanning the time of listing, there were no floods sufficient to inundate the forests (Figure 23). A moderate to large flood did occur in spring / summer 2010, with flows exceeding 18 000 megalitres a day in September 2010 and again in November – December 2010 with a peak of over 38 000 megalitres a day in the Edwards River at Deniliquin (NSW Water information). The average recurrence intervals for specific flow events in the Werai Forest Group based on MDBA (2010) modelling of historical climate and current development over 114 years are provided in Table 9.

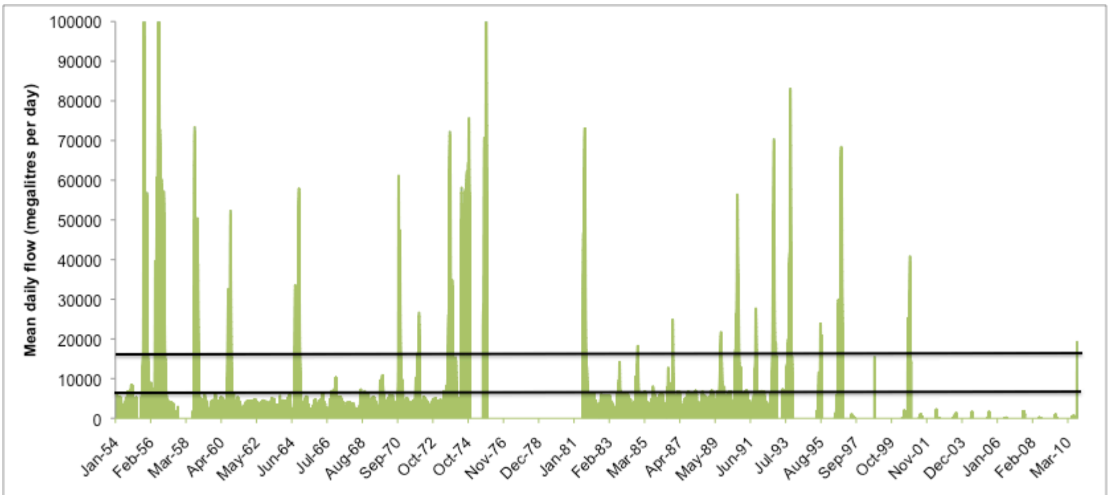


Figure 23: Average daily flow (megalitres per day) in the Edward River downstream of Deniliquin from 1954 to 2010 (data from the Victorian Water Resources Data Waterhouse). Lines show commence to fill level (6 000 megalitres per day) and threshold for broad scale inundation (18 000 megalitres per day).

Table 9: Flood flow recurrence intervals at the Edward River at Deniliquin for specific flow events at Werai Forest Group (MDBA 2010).

Flow (megalitres per day)	Duration (days)	Average period between events (years)	Inundation extent
5000	60	2.5	All low lying areas and channels, floodplain marshes.
18 000	30	6.6	Significant flooding of river red gum forests.
30 000	21	7.7	All river red gum and woodland and a portion of black box woodland.

3.3.4 Environmental watering

The hydrology of the site (as described above) was severely altered well before the time of listing and there is strong evidence to suggest that water regime at this time was insufficient to maintain the ecological character of the site (MDBC 2007a). However effective control and management of flows is now a critical component in the management of the wetlands and maintenance or improvement of their current condition. Forests NSW, the MDBC and other regulatory authorities integrate the management of environmental flows for the maintenance of natural ecosystems with consumptive water allocations.

In a heavily regulated system, access to environmental flows is critical to the ongoing health and ecological productivity of the site. Site managers may access and utilise environmental water from a range of sources. These include:

- The Living Murray program (TLM). TLM aims to recover an average of up to 500 gigalitres/year of water to improve environmental flows and achieve ecological objectives at six Icon sites along the Murray River. These include the Barmah-Millewa Forest (containing the Millewa Forest Group) and Gunbower-Koondrook-Perricoota Forest (containing the Koondrook-Perricoota Forest Group). Use of the water is governed by the Environmental Watering Group who consider a range of factors including ecological need and water availability to collectively determine where and for what purpose water should be used in any given year.

- The Barmah-Millewa Environmental Water Allocation. This allocation places up to 100 gigalitres/year from Victoria and NSW into water account for use at the site. Use of the water is governed by a steering committee comprised of land managers, water managers and environmental experts from Victoria and New South Wales in accord with a set of operational rules. In 2005/2006, the Barmah-Millewa Icon site achieved a water delivery of 513 gigalitres. This water allocation was timed with a natural peak in flows to achieve a flood event resulting in successful breeding of native fish (Jones 2006), frogs (Ward 2006) and waterbirds (O'Connor and Ward 2003).

- Murray Wetland Working Group (MWWG) Water. The MWWG is a group of people with an interest in wetland health across all land tenures along the Murray River in NSW. The group collectively assesses ecosystem requirements at a large number of wetlands and assigns water depending on need. MWWG has successfully delivered environmental water to wetlands within the Ramsar site, on numerous occasions, such as Pollacks swamp, Reed Beds swamp and Werai wetlands.

Managed flood events as a result of EWAs are now a critical component of the ecological character of the NSW Central Murray Forests.

3.3.5 Groundwater

The final component of the hydrology of the NSW Central Murray Forests is groundwater, which is believed to be of secondary importance to surface flows (MDBC 2007a; Leslie 2002). However there are a number of places where access to groundwater from prior streams is important for red gum tree health.

Surface-groundwater connectivity along the Murray River is highly variable with both losing and gaining river reaches. Variation from reach to reach is likely to be due to a combination of river regulation, floodplain groundwater flow processes and the influence of irrigation development near the river. Between Tocumwal and upstream of the Goulburn River junction, adjacent to the Millewa Forest Group, the river is ‘medium losing’. Where the Goulburn and Campaspe rivers converge with the Murray River the river is ‘low gaining’, however the river becomes ‘medium losing’ downstream of Torrumbarry Weir, adjacent to the Koondrook-Perricoota Forest Group (CSIRO 2008). The surface-groundwater interaction for the Edward River and associated effluent streams through the Werai Forest Group has not been mapped. The groundwater regime of the site and its relevance to tree health is a knowledge gap.

3.4 Water quality

Water quality within the Ramsar site is influenced both by the quality of water in river sources as well as floodplain interactions that occur during cycles of wetting and drying. Water quality in the main channel of the Murray River is generally fresh with salinity below 400 micro Siemens per centimetre from 1992 to 2008 (data from Victorian Water Resources Data Warehouse). Turbidity is moderate with a median value of 9.7 nephelometric turbidity unit (NTU) and a ninetieth percentile of 27 nephelometric turbidity unit downstream of Yarrawonga Weir (Ecos Consulting 2002).

Water quality in permanent and frequently flooded wetlands on the floodplain can vary considerably between sites and overtime. However, results of monitoring of wetlands in the Millewa Forest Group (Ward et al. 2006; Hall et al. 2006) and Koondrook-Perricoota Forest Group (Hall et al. 2006) indicate that water is generally fresh (less than 300 microSiemens per centimetre), neutral (6.5 to 7.9 pH) and of low to moderate turbidity (10 to 50 nephelometric turbidity unit).

Water quality in channels and depressional wetlands is greatly influenced by floodplain inundation. Monitoring of a managed flood event through 137 hectares of Werai Forest in 2001, showed a dramatic decline in turbidity as waters passed through the system. The turbidity of water entering the wetland was initially greater than 100 nephelometric turbidity unit, but fell to 65 nephelometric turbidity unit by the end of the inflow period. This decrease was attributed to turbid water in the Tummudgery Creek flowing into the wetlands before the arrival of less turbid water from the faster-flowing Edward River. The turbidity of water in the Last Lagoon and at the outflow of the forest was lower than the turbidity of water flowing into the wetlands (Green 2001b). This reduction in turbidity illustrates the role that floodplain depressions play in accumulating sediments and maintaining downstream water quality.

The flooding of ephemeral wetlands and floodplain surfaces may trigger black water events (Howitt et al. 2005). These are defined as flood events with elevated levels of dissolved organic carbon, sufficient to colour the water a deep brown. They are associated with reduced levels of dissolved oxygen in the water column both on the floodplain and in receiving channels and wetlands as micro organisms that consume litter on the floodplain surface upon wetting, use oxygen from the water column in the process. These events are natural and are considered important in maintaining productivity of river and floodplain environments (Junk et al. 1989). However, if there is a long period between flood events, organic matter builds up on the floodplain and dissolved oxygen concentrations can fall below the tolerances of fish and other aquatic fauna (Howitt et al. 2005).

There are recent examples of black water events from the Ramsar site, most notably in the floods of 2010, which inundated large areas of floodplain that had been dry for decades. Water discharging from the Millewa, Koondrook-Perricoota and Werai Forest Groups was very low in dissolved oxygen (less than one milligram per litre) causing decreased oxygen concentrations in the Edwards, Murray and Wakool Rivers (MDBA unpublished).

3.5 Wetland vegetation

There are 320 native species of plant that have been recorded within the Ramsar site (Appendix B). This includes a range of aquatic, floodplain and terrestrial species and the nationally threatened swamp wallaby grass (*Amphibromus fluitans*).

Vegetation mapping (undated data layer supplied by Forests NSW) of the Ramsar site (Figure 24, Figure 25 and Figure 26) shows the distribution of the two distinct types of wetland vegetation within the NSW Central Murray Forests Ramsar site that are considered critical to ecological character:

- River red gum forests and woodlands, which comprise the majority of the site and occupy the large areas of floodplain; and
- Floodplain marshes, which comprise a number of different communities all of which occur in the low lying areas of the site that are subjected to more frequent inundation.

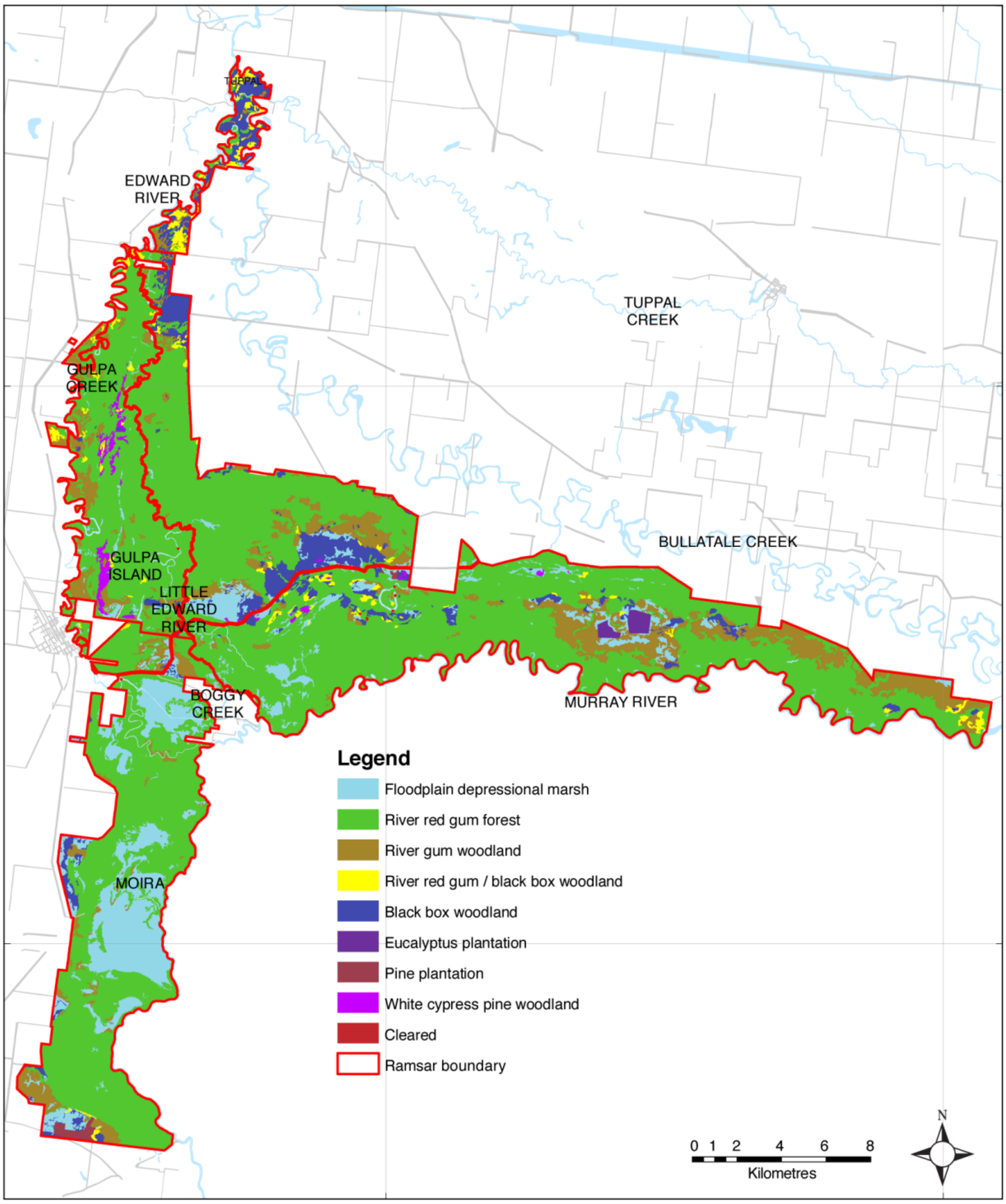


Figure 24: Millewa Forest Group vegetation associations (data from Forest NSW).

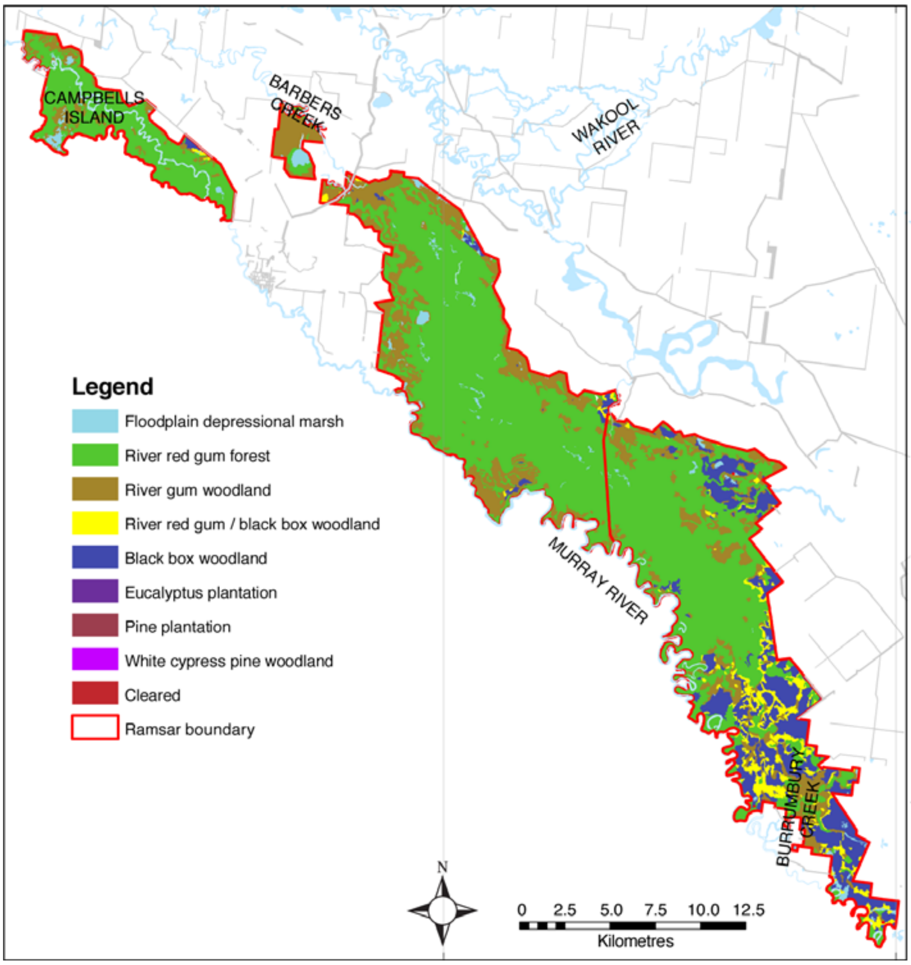


Figure 25: Koondrook-Perricoota Forest Group vegetation associations (data from Forests NSW).

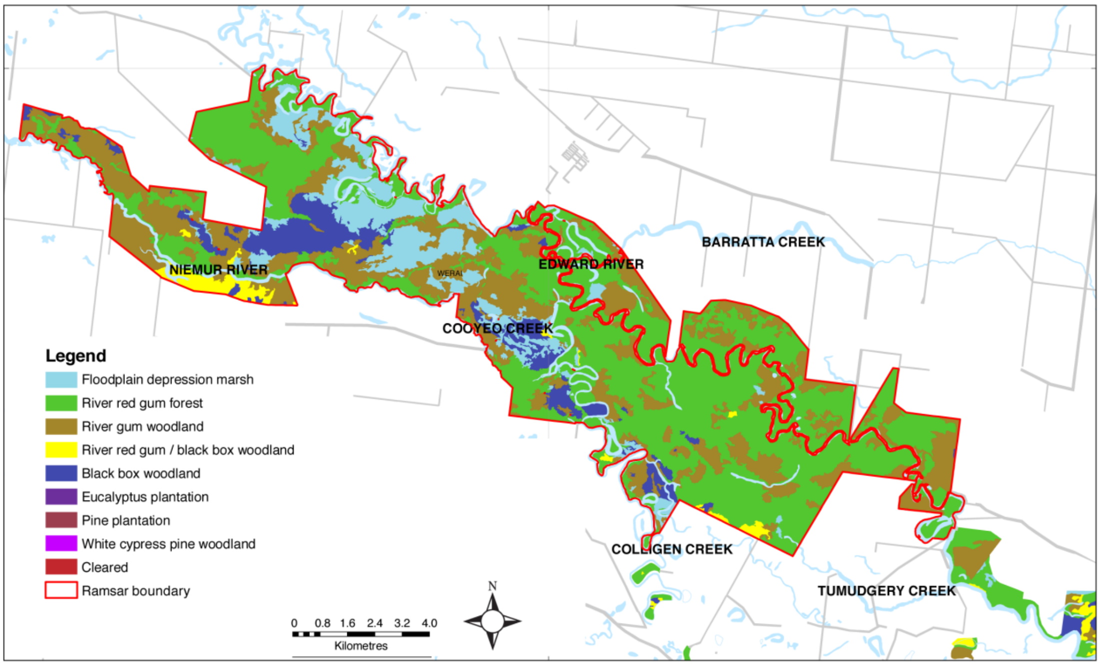


Figure 26: Werai Forest Group vegetation associations (data from Forests NSW).

3.5.1 River red gum forests and woodlands

River red gum dominated forest and woodland communities are the characteristic feature of the Ramsar site. River red gum is a fast growing, highly competitive species in areas with sufficient soil moisture. It is the canopy dominant in all vegetation associations in which it occurs, and in many areas forms monospecific communities. Co-occurring species include river cooba (*Acacia stenophylla*) as a sub-canopy species, black box and, less commonly grey box (*Eucalyptus microcarpa*), where river red gum forest intergrades with box woodland (Benson et al. 2006).

Community structure and understorey composition vary with flood regime, which in turn is a product of geomorphic setting. The driest portions of the floodplain support black box woodland which grades into a river red gum woodland at its wetter end, with a sparse, shrubby understorey and groundcover of grasses and herbs with increasing soil moisture. Better-watered locations support a taller river red gum forest with an understorey of moisture-loving grasses, herbs and sedges (Benson et al. 2006; Roberts and Marston 2000). The characteristics and community composition of each of the main communities is described in Table 10.

Table 10: Vegetation communities within the river red gum forests and woodlands in the Ramsar site (Forests NSW and Benson et al. 2006).

Vegetation community	Forests NSW description	Likely NSW Vegetation Community
River red gum forests	Better developed stands with height greater than 34 metres on frequently flooded areas or areas with shallow groundwater.	River red gum-sedge dominated tall open forest in frequently flooded sites of the semiarid warm climate zone: Very tall open forest dominated by river red gum that grow to over 30 metres high and sometimes exceed 45 metres. Shrubs are usually absent. The ground cover may be sparse and covered in litter or mid-dense to dense. It is dominated by sedges and rushes and occasional moisture tolerant grass species forbs and pond waterplants. Weed species may be common. **Canopy** *Eucalyptus camaldulensis* subsp. *camaldulensis*. **Sub-canopy** *Acacia dealbata* (sparse). **Shrub layer** absent. **Groundcover** *Eleocharis acuta-Centipeda cunninghamii-Ranunculus inundatus-Pseudoraphis spinescens*
	Intermediate levels of the floodplain. Canopy height 21 to 34 metres	River red gum herbaceous-grassy tall open forest of the inner floodplains of the lower NSW South West Slopes and Riverina: Very tall open forest dominated by River Red Gum with trees averaging about 25 metres high and a canopy cover of about 40 percent. The shrub layer is sparse or absent with Acacias sometimes present. The ground cover may be mid-dense or dense and is dominated by grasses, sedges and rushes. Weed species may be common. **Canopy** *Eucalyptus camaldulensis* subsp. *camaldulensis*. **Sub-canopy** *Acacia dealbata* and *Exocarpus strictus* (sparse). **Shrub layer** absent. **Groundcover** *Paspalidium jubiflorum, Poa labillardierei* var. *labillardierei-Carex tereticaulis- Lachnagrostis filiformis-Hemarthria uncinata* var. *uncinata*
River red gum woodland	Poor stand development. Occurs as open woodland with canopy height less than 21 metres or dense stands with lesser	River red gum - wallaby grass tall woodland on the outer river red gum zone in the semi-arid (warm) climate zone: Tall woodland to about 18 metres high dominated by river red gum. Shrub layer is generally absent. Ground cover may be mid-dense or sparse and is dominated by native grasses. Rushes and sedges also common. **Canopy** *Eucalyptus camaldulensis* subsp. *camaldulensis*. **Sub-canopy** *absent*. **Shrub layer:** *Amyema miquelii* (sparse) **Groundcover** *Paspalidium jubiflorum, Austrodanthonia*

Vegetation community	Forests NSW description	Likely NSW Vegetation Community
	canopy height.	*caespitosa - Juncus flavidus - Carex inversa*
	Red gum / box woodland	River red gum - black box woodland of the semi-arid (warm) climatic zone: Tall to mid-high woodland averaging about 18 metres high composed of a mixture of river red gum and Inland grey box and/or black box. The understorey may contain dense to very sparse stands of lignum and river coobah with the occasional *Exocarpos strictus*. The ground layer is sparse and grassy. **Canopy** *Eucalyptus camaldulensis, E. microcarpa* and *E. largiflorens* **Sub-canopy** *Acacia stenophylla* **Shrub layer** *Muehlenbeckia florulenta* **Groundcover** *Paspalidium jubiflorum, Enteropogon acicularis, Cynodon dactylon, Austrodanthonia caespitosa*
Black box woodland	Box woodland	Black box - lignum woodland of the inner floodplains in the semi-arid (warm) climate zone: Woodland, open forest or open woodland averaging about 15 m high dominated by a sparse to dense stands of *Muehlenbeckia florulenta* and *Chenopodium nitrariaceum*. The ground cover includes low shrubs such as *Sclerolaena muricata* var*. muricata, Enchylaena tomentosa, Einadia nutans* subsp. *nutans* and various saltbush species (*Atriplex* spp.). **Canopy** *Eucalyptus largiflorens* occasional *E. camaldulensis* **Sub-canopy** *Acacia stenophylla* **Shrub layer** *Muehlenbeckia florulenta - Rhagodia spinescens* **Groundcover** *Einadia nutans* subsp*. nutans Paspalidium jubiflorum - Sclerolaena muricata* var*. muricata - Austrodanthonia caespitose.*

Collectively, river red gum forests and woodlands cover over 76 000 hectares within the site, with river red gum forests comprising nearly 80 percent of the total wooded area (Table 11). There are a greater proportion of woodland areas (including black box woodland) in Koondrook-Perricoota Forest Group than the other two forest units in the Ramsar site.

Table 11: Extent (hectares) of river red gum forests and woodlands within the Ramsar site (Forests NSW unpublished).

Location	River red gum forest	River red gum woodland	Red gum / box woodland	Black box woodland
Millewa Forest Group	26 181	4002	589	2330
Koondrook-Perricoota Forest Group	22 215	6155	1201	4032
Werai Forest Group	5861	3178	210	805
Total	54 257	13 335	2000	7167

Forests NSW performed an assessment of the health of the NSW Central Murray Forests in 2005, which may be indicative of conditions at the time of listing. Most of the 1843 eucalypts assessed were severely stressed (701) or stressed (500). Only 11 percent were healthy and one percent was dead. Black box was relatively healthy compared to the river red gums.

Amongst river red gums, canopy stress appeared to increase with age class. Stress apparently increased with declining site quality, and subdominant trees appeared to be generally more stressed than dominant trees. This pattern was attributed to drought stress since both larger trees and dominant trees would have better access to groundwater. Poor health was also linked to the abundance of parasitic mistletoes and cherry ballart (E*xocarpus strictus*) (Jurskis et al. 2005). Remaining healthy river red gum forests are concentrated in low-lying portions along major drainage lines and bordering floodplain depression marshes.

This is consistent with the findings of Cunningham et al. (2009) who assessed canopy health in the Living Murray Icon sites at two points in time (2003 and 2009), which included the Millewa Forest Group and parts of the Koondrook-Perricoota Forest Group. Condition was assessed based on measures of plant area index, crown extent and percentage live basal area. The results indicated better (more healthy) canopy condition in low lying areas and along channels (Figure 27). This, in part explains the poor condition of river red gum forests and woodlands in Koondrook-Perricoota Forest Group as compared to the Millewa Forest Group. The Koondrook-Perricoota Forest Group have high commence to flow levels to achieve floodplain inundation and have experienced little or no flooding over much of the last decade (see section 3.3.2 above). There is also some evidence of decline in forest health over the last decade in both the Koondrook-Perricoota and Millewa Forest Groups (Table 12).

Unfortunately there is no similar information about trends in forest condition at Werai Forest Group as this is not part of the Living Murray Icon Sites. However an assessment in 2005 indicated that the forest was in poor condition with 92 percent of river red gum forest sampled considered highly stressed, near stressed or dead (Jurskis 2006).

Table 12: Percentage of forests in canopy condition categories in the Millewa and Koondrook-Perricoota Forest Group within the Ramsar site (Cunningham et al. 2009).

Canopy health	Millewa Forest Group		Koondrook-Perricoota Forest Group	
	2003	2009	2003	2009
Good	44	17	15	5
Moderate	52	76	80	80
Poor	3.2	5.7	5	15
Degraded	0.5	0.9	1.2	0.2
Severely degraded	0.1	0.1	0.1	0

In addition to extent and condition of the trees in the site, forest structure and structural diversity is an important characteristic (Horner et al. (2010). This includes aspects such as tree density, age classes, size ranges and the presence of features such as boughs and tree hollows. However there is little information on the forest structure of river red gum forests and woodlands from within the Ramsar site and this has been identified as a knowledge gap.

An important component of the river red gum forests and woodlands is not just the living vegetation, but also the organic matter contributed by the forest in the form of woody debris and litter. Quantitative measures of litter and woody debris are not available for the Ramsar site. However, organic matter accumulations are strongly influenced by the period between floods (Watkins et al. 2010). Litter in Tuppal and Barbers Creeks, adjacent to Koondrook Forest Group, which had been dry for the ten years 2000 to early 2010 (similar to the floodplain) had average stocks of litter of between 450 and 1270 grams (dry mass) per square metre (Watkins et al. 2010).

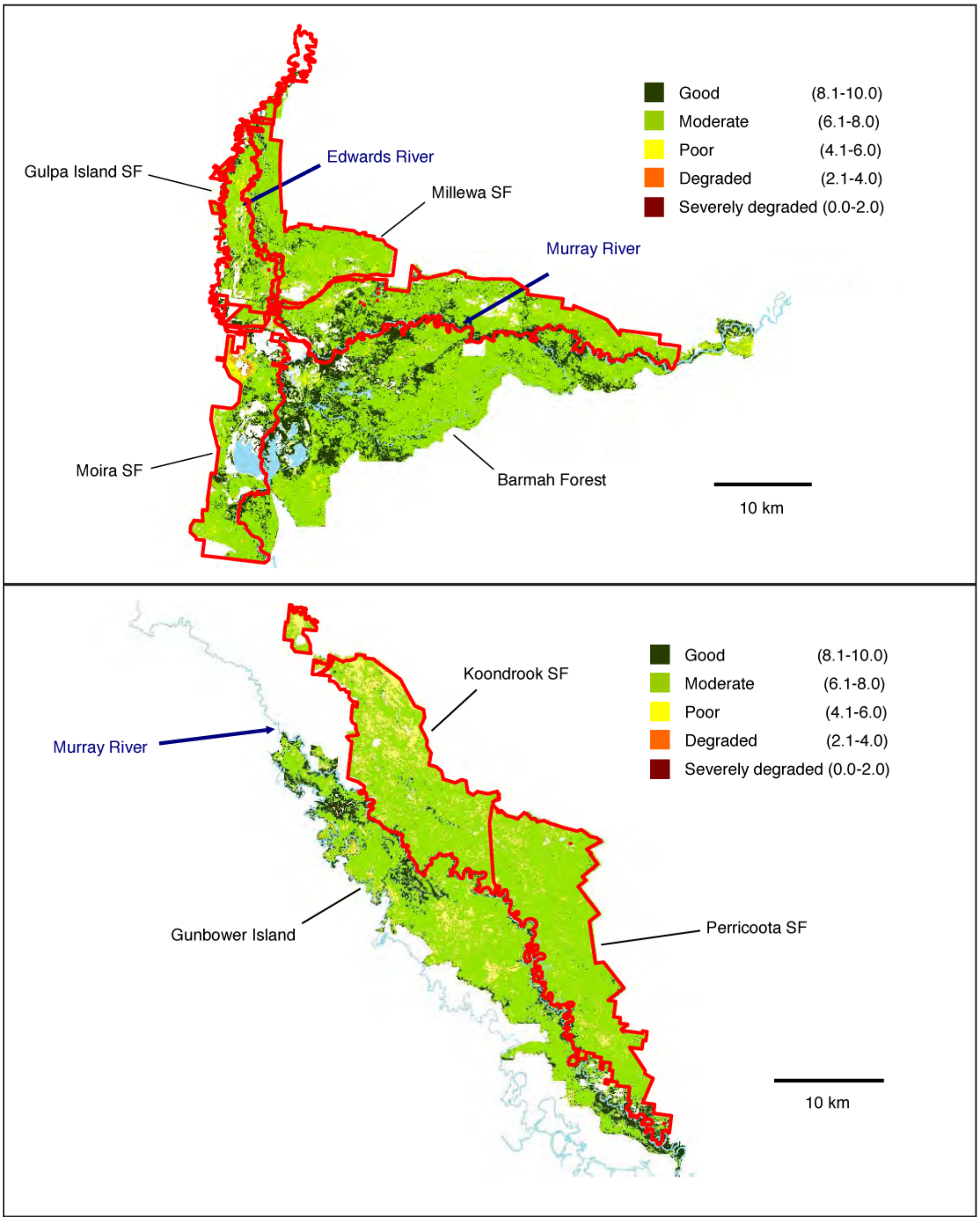
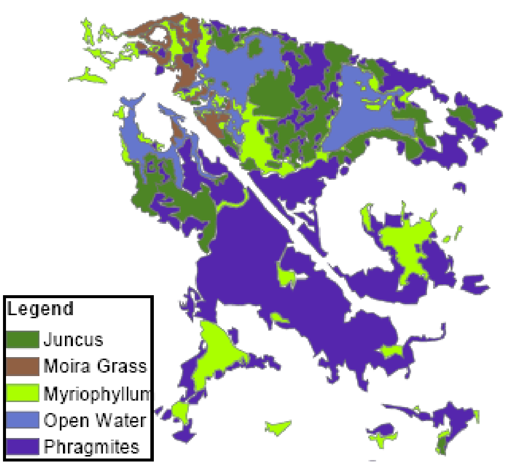


Figure 27: Canopy condition in the Millewa and Koondrook-Perricoota Forest Groups in 2009 (adapted from Cunningham et al. 2009).

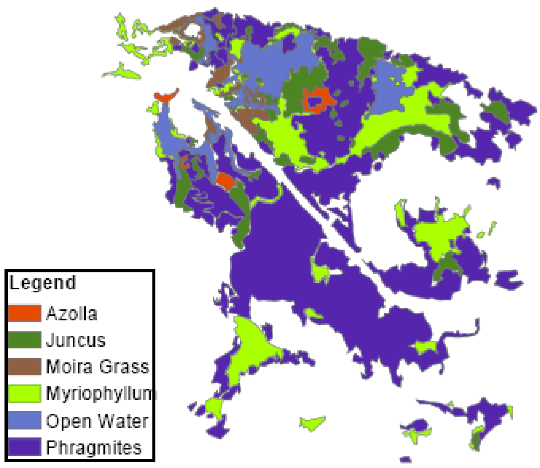
3.5.2 Floodplain marshes

Low-lying portions of the NSW Central Murray Forests feature a variety of treeless wetland types, including moira grass plains, giant rush (*Juncus ingens*) beds, common reed (*Phragmites australis*) beds, moist grasslands, herblands and semi-permanent marshes (Keith 2006). These wetlands, referred to collectively as floodplain marshes, are associated with a variety of geomorphic settings including intermittent drainage lines, flood-runners, oxbow lagoons and floodplain depressions (Green and Alexander 2006).

The extent and vegetation composition of these wetlands is dynamic, varying seasonally with flood cycles. A single wetland may support terrestrial herbs and grasses, aquatic herbs and macroalgae or reed beds over a single flood cycle. Over longer time periods prolonged wetting or drying cycles may favour the dominance of a single vegetation type, such as the formation of giant rush beds (McCarthy et al. 2006) or a shift from giant rush to *Phragmites* beds (Bowen 2005). This is illustrated by the changes in Reed Beds Swamp (Millewa Forest Group) vegetation between 2001 and 2005 (Figure 28).



Vegetation distributions throughout Reed Beds Swamp determined for 2001.



Vegetation distributions throughout Reed Beds Swamp determined for 2005.

Figure 28: Changes in vegetation distribution in Reed Beds Swamp; Millewa Forest Group 2001 to 2005 (Bowen 2005).

The general category of floodplain marshes includes the regionally significant vegetation community moira grass plains (MDBC 2007a, 2007b), which occurs in the Millewa Forest Group. They feature a moist, low mat grassland dominated by moira grass. This community occurs on elevated rises and river banks on red to brown clay or loamy soils on the floodplains (Benson et al. 2006).

The greatest extent of floodplain marshes within the NSW Central Murray Forests Ramsar site occurs within the Millewa Forest Group, which contain the large expanses of Moira Lake, Reed Beds Swamp and Duck Lagoon. The floodplain marshes of Werai Forest Group are also extensive, although this is predominantly in diffuse channel systems, including Reed Bed Creek wetlands (Green 2001a). By comparison, floodplain marshes (without treed canopy) are rarer in the Koondrook-Perricoota Forest Group, reflecting the high elevations in this unit. The major floodplain marshes within the Ramsar site are described in Table 13.

Table 13: Major floodplain marshes within the NSW Central Murray Forest Ramsar site (area from MDBA 2010; examples from Green and Alexander 2006 unless otherwise specified).

Location	Wetland area (hectares)	Examples
Millewa	3440	Horseshoe Lagoon - mainly open water.
		Reed Beds Swamp - extensive reed beds of common reed (*Phragmites australia*), *Eleaocharis* sp. and giant rush (*Juncus ingens*).
		Duck Lagoon - extensive reed beds of common reed and giant rush surrounding a large area of open-water.
		Moira Lake - open water in deepest portions surrounded by beds of giant rush then common spike rush (*Eleocharis acuta*) in shallow margins.
Koondrook	1600	Pollacks Swamp - open water and flooded grassland of swamp wallaby grass (*Amphibromus* sp.) giant rush and waterpepper.
Werai	400	Tummudgery Creek Wetlands and Reed Bed Creek Wetlands - reed beds (common reed) interspersed with moira grasslands and juvenile river red gum (Green 2001a).

The condition of floodplain marshes generally mirrors that of the river red gum forests:

- Vegetation health is generally poor and declining, particularly in the Koondrook-Perricoota Forest Group (MDBC 2007d); and
- The extent and composition of vegetation communities is changing in response to altered flood regimes (Leitch 1989; Bowen 2005).

Condition was assessed based on visual assessment of presence of above ground plant tissues. Opportunities for growth, reproduction and dispersal of flood dependent ground vegetation over 30 percent of the Koondrook forest were last achieved in 2000/01. Emergent plants (for example, *Triglochin procerum*) have not recruited throughout large tracts of the forests since 2000. The current condition of forest understorey has therefore been measured as poor and unsatisfactory (Jurskis et al. 2005).

3.6 Fish

The NSW Central Murray Forests supports a large proportion of the 35 native fish species known from the Murray Darling Basin (MDBC 2004). There are 22 species of native fish that are predicted to occur within the streams and rivers of the Ramsar site (Davies et al. 2008). However, of these only 17 native species have been recorded recently and are expected to have occurred at the site at the time of listing (Davies et al. 2008; King et al. 2007; Appendix D). Three of the native species are classified as threatened either under the EPBC Act or the IUCN Red List (see Table 5).

There is little quantitative data for fish within the NSW Central Murray Forests Ramsar site. Data exists for the Barmah-Millewa Living Murray Icon Site, which includes sampling locations in Millewa Forest Group such as Gulpa Creek and Moira Lake. However results are reported for a system as a whole and can only be considered indicative of populations in the Ramsar site.

A total of 15 native species were recorded in the Barmah-Millewa Icon Site from 2003 to 2006. This included ten native and five introduced species (Table 14). Australian smelt (*Retropinna semoni*) and carp gudgeons (*Hypseleotris* spp.) were the most abundant species, with the former accounting for between 30 and 70 percent of the total catch. Variability between years was higher for some species than others and possibly linked to temperature and inundation patterns (King et al. 2007). There was a consistently high abundance of introduced species that comprised between 10 and 36 percent of the total abundance.

Table 14: Total abundance of fish from surveys in the Barmah-Millewa Forest (King et al. 2007).

Common name	Species name	2003/4	2004/5	2005/6
Native				
Australian smelt	*Retropinna semoni*	11 348	3931	8731
Carp gudgeons	*Hypseleotris* spp.	2550	4053	3352
Flat-headed gudgeon	*Philypnodon grandiceps*	94	213	149
Unspecked hardyhead	*Craterocephalus stercusmuscarum*	322	498	378
Murray cod	*Maccullochella peelii peelii*	29	56	107
Trout cod	*Maccullochella macquariensis*	0	1	4
Golden perch	*Macquaria ambigua*	1	2	110
Silver perch	*Bidyanus bidyanus*	40	2	195
Southern pygmy perch	*Nannoperca australis*	1	17	50
Murray-Darling rainbowfish	*Melanotaenia fluviatilis*	6	1	11
Introduced				
Carp	*Cyprinus carpio*	1216	1519	1098
Goldfish	*Carassius auratus*	24	179	122
Redfin	*Perca fluviatilis*	94	157	74
Eastern gambusia	*Gambusia holbrooki*	234	2971	2512
Oriental weatherloach	*Misgurnus anguillicaudatus*	11	99	73

These results are consistent with those of the Sustainable Rivers Audit, which sampled streams and rivers both in and adjacent to the Ramsar site (Davies et al. 2008). Ten native and four introduced species were recorded in spring 2005. Australian smelt were the most abundant accounting for almost 50 percent of the catch. In total, native species represented 92 percent of total abundance, but only 23 percent of the biomass. Large bodied, alien species (such as carp), although lower in number, accounted for over 70 percent of the total biomass.

3.7 Wetland birds

A total of 67 species of wetland bird have been recorded within the site (Table 15, Appendix C). The list includes 11 species that are listed under international migratory agreements CAMBA, JAMBA and ROKAMBA, although most of these species (for example, Caspian tern, eastern great egret, and the white-bellied sea eagle) are considered resident in Australia, that is, not known to undertake international migrations (R. Jaensch personal communication). An additional 27 Australian species that are listed as migratory or marine under the EPBC Act have been recorded at the site. The list includes three species that are considered threatened nationally (Australian painted snipe and superb parrot) and internationally (Australasian bittern, *Botaurus poiciloptilus*).

The size and dynamics of the bird populations at the Ramsar site are not well documented. Attempts to quantify abundances are limited by the large size and relative inaccessibility of the wetlands (in terms of distance from large population centres, as well as difficulty of access during floods) and the dominance by heavily forested wetlands, which reduce visibility from the air. Accurate counts are perhaps most constrained by administrative arrangements that have governed the site, where jurisdictional boundaries dissect wetland ecosystems. Accordingly, no surveys have been conducted of the entire NSW Central Murray Forests Ramsar site even though some surveys have been conducted at the wetland, State Forest or Icon Site scale. Historical censuses are largely limited to the Millewa Forest Group, but are typically limited to Gulpa Creek (Barmah Millewa Forum 2001) or Moira Lake (Webster 2008) or are combined with data for the Victorian Barmah Forest wetlands (Webster 2003; MDBC 2007a, 2007c). A similar situation exists for the Koondrook-Perricoota Forest Group, where data are combined with the Victorian Gunbower Forest Wetlands and the majority of survey effort has occurred in Victoria (MDBC 2007c, 2007d). Survey effort is often determined by flood patterns with flooding often limited to Gunbower during lower, managed events. Limited information is available for the Werai Forest Group, with available surveys targeting specific, small wetlands (Green 2001b), or individual species (Webster 2003).

Table 15: Number of wetland birds recorded within the NSW Central Murray Forest Ramsar site (Leslie 2002; BA 2008). See Appendix C for full list of species.

Bird group	Typical feeding requirements	Number of species
Ducks and allies	Shallow or deeper open water foragers. Vegetarian (for example black swan) or omnivorous with diet including leaves, seeds and invertebrates.	13
Grebes	Deeper open waters feeding mainly on fish.	3
Pelicans, cormorants, darters	Deeper open waters feeding mainly on fish.	6
Heron, ibis, spoonbills	Shallow water or mudflats. Feeding mainly on animals (fish and invertebrates).	14
Hawks, eagles	Shallow or deeper open water on fish and occasionally waterbirds and carrion.	2
Cranes, crakes, rails, water hens, coots	Coots in open water; others in shallow water within cover of dense emergent vegetation such as sedge. Some species vegetarian, others mainly take invertebrates, some are omnivores.	9
Shorebirds	Shallow water, bare mud and salt marsh. Feeding mainly on animals (invertebrates and some fish).	12
Gulls, terns	Terns, over open water feeding on fish and invertebrates; gulls, opportunistic feeders over a wide range of habitats.	3
Other	Non water birds that are reliant on wetlands for breeding or feeding (for example superb parrot and Australian reed warbler).	5
Total		67

The total waterbird census for 2000/01 for Barmah-Millewa would have exceeded 100 000 individuals (D. Leslie pers. comm.). In 2005/06 a flood resulted in the successful breeding and fledging of over 52 000 colonial nesting waterbirds in the Barmah-Millewa Forest Group Icon Site; separate counts were not reported for the Millewa Forest Group (O'Connor et al. 2006). Peak abundances of wetland birds at the site include 2500 Nankeen night herons, 1414 Australian white ibis and 400 intermediate egrets at the Gulpa Creek group of wetlands in the Millewa Forest Group in 2000-01 (Barmah-Millewa Forum 2001). Peak estimates include greater than 10 000 sacred ibis (*Threskiornis molucca*) and straw-necked ibis (*Threskiornis spinicollis*) and greater than 10 000 egrets (collectively) in the Millewa Forest Group in 2000/01 and 2005/06 (O'Connor et al. 2006; MDBC 2007c, Leslie 2002).

Clear trends in the available data include population fluctuations in response to water levels, with the greatest numbers recorded during colonial nesting waterbird-breeding events. For instance the December 2001 survey of Millewa Forest Group wetlands yielded 2222 individuals of 32 species in the middle of a four-month, late spring-summer flood. Forests NSW surveys of a broader area around the wetlands recorded 5508 waterbird nests (Barmah-Millewa Forum 2001). In contrast a summer 2008 survey conducted when the same wetlands were dry yielded 85 individuals of 13 species (Webster 2008a).

About 54 waterbird species have been recorded breeding in the NSW Central Murray Forests including 25 colonial nesting species (Leslie 2001). The distribution and abundance of nesting waterbirds varies both spatially as well as temporally in response to flooding. The greatest concentration of important waterbird breeding colonies at the site are in the Millewa Forest Group associated with the Moira Lake and Gulpa Creek groups of floodplain marshes, and there are records of breeding of thousands of colonial nesting wetland birds in Millewa Forest Group during 2000/01 and 2004/05 (MDBC 2007c). However, from Koondrook-Perricoota Forest Group, there were only hundreds of birds nesting during 2000/01, 2003/4, 2004/05 and 2005/0. Large events comprising thousands of birds have not been seen in this Forest Group since a large natural flood in the mid 1970's (MDBC 2007b). In Werai, there is insufficient information to determine the significance of the area for colonial nesting waterbirds. Breeding events of hundreds of wetland birds probably occurred in 2000/01, 2004/05 and 2005/06, but there is no historical evidence of large scale breeding events.

Although there is little evidence of variability in breeding abundance over time, there is some information on breeding quality. Leslie (2001) assessed the success of breeding events at two locations in the Millewa Forest from 1979 to 1997. Breeding success was ranked as:

- 4 - Excellent: Parents induced to breed and fledge young
- 3 – Poor: Parents breed, but unable to fledge young
- 2 – Abandoned: Parents induced to breed, but abandon nests
- 1 – Nil: No nesting attempted

Results indicated that breeding was attempted at a minimum of one site within the forest in twelve out of the nineteen years. However, fledging was successful in only ten of these years. No breeding was attempted in six years (approximately one third of years assessed) and overall breeding was more successful at Reed Beds Swamp than Algebola Plains (Leslie 2001; Figure 29).

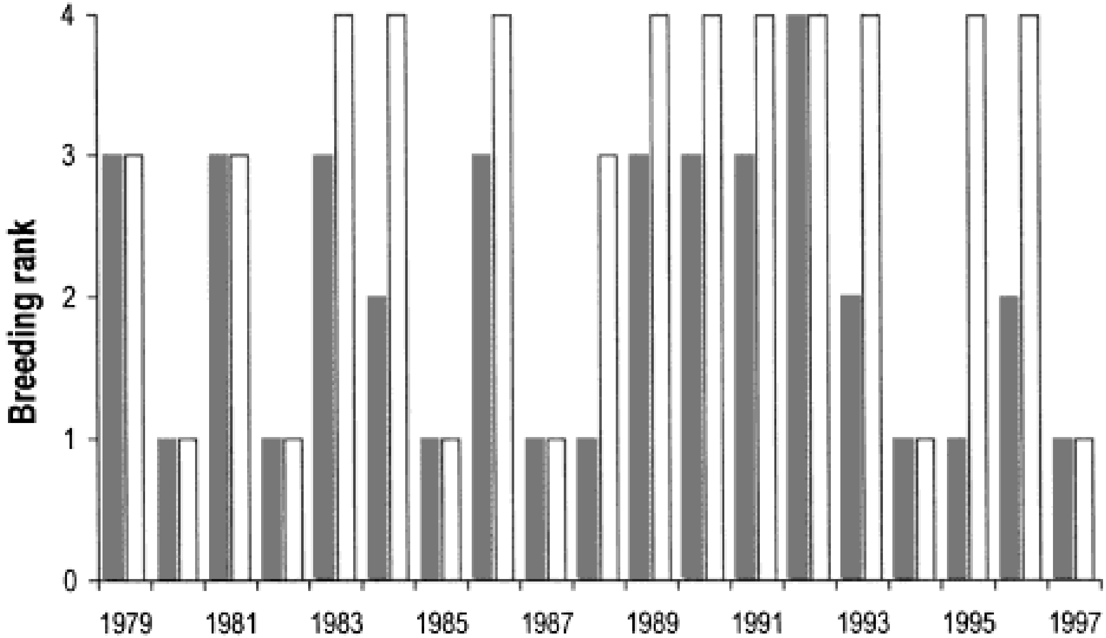


Figure 29: Breeding success of colonial nesting waterbirds at two sites in Millewa Forest Group; Algebola Plains (shaded) and Reed Beds Swamp (unshaded) from 1979 to 1997 (Leslie 2001).

The breeding population of superb parrots in the NSW Central Murray Forests is internationally significant as it is one of only three regions which support breeding populations of the species (Webster 1988). Although broadly suitable habitat for the species is present across the site the species has very specific breeding habitat requirements. The breeding population is thus confined to stretches of river red gum forest along a portion of the Murray and Edward Rivers through the Millewa Forest Group (Figure 30). Breeding and core feeding areas are not known from the Koondrook-Perricoota or Werai Forest Groups (Webster 1988, 2001, 2003; Webster R. pers. comm.).

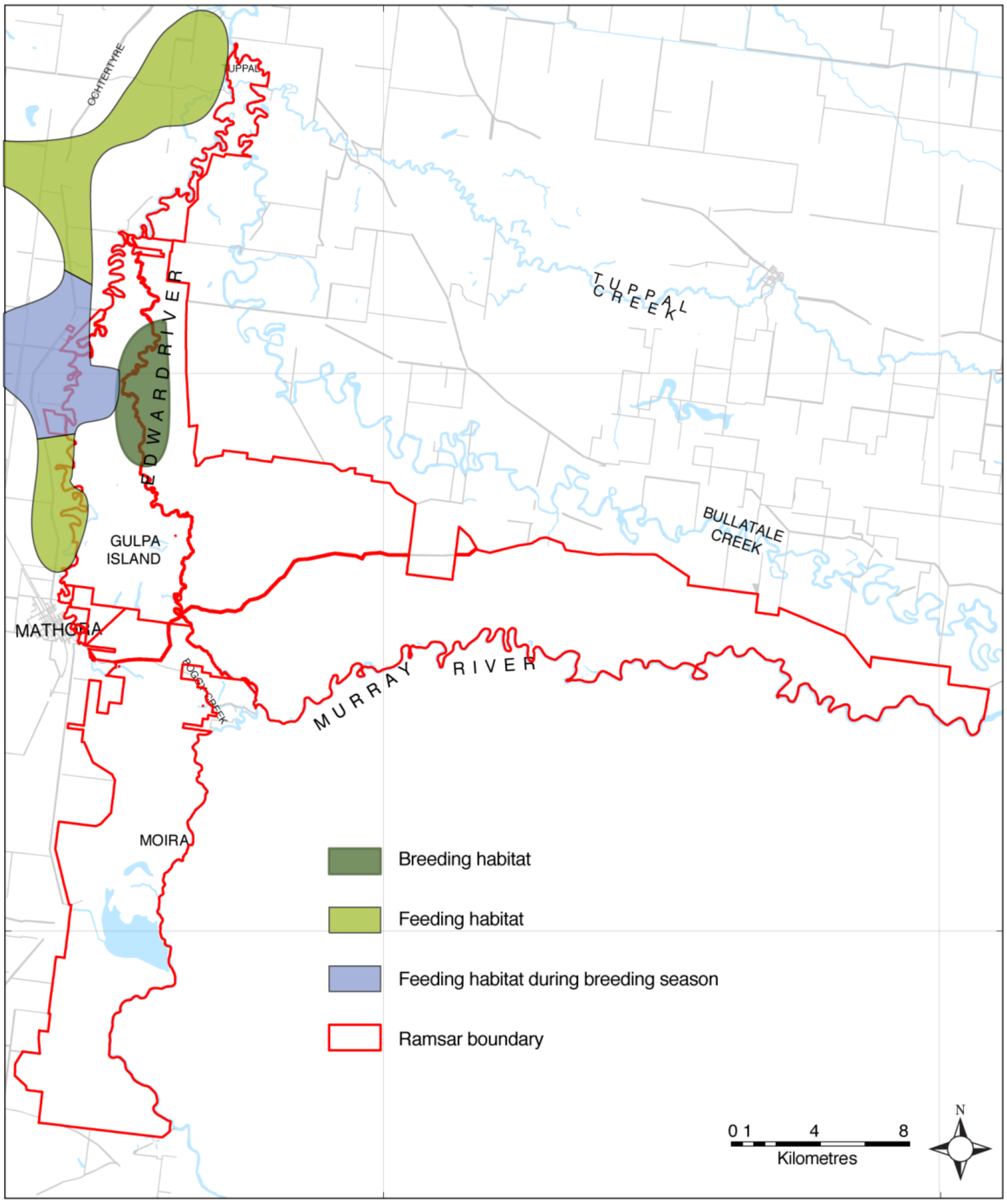


Figure 30: Superb parrot habitat within and adjacent to the Millewa Forest Group of the Ramsar site (adapted from Webster 1997).

3.8 Other wetland fauna

Three species of wetland dependant mammals have been recorded within the site:

- Water rat (*Hydromys chrysogaster*)
- Platypus (*Ornithorhynchus anatinus*)
- Southern myotis (*Myotis macropus*)

The water rat and platypus are largely restricted to the stream and channel habitat within the site, although they may extend into deeper marsh areas during floods. The southern myotis, which is listed as vulnerable in NSW, is a species of micro-bat that feeds in aquatic habitats on fish and aquatic insects and may use hollow trees within the site for roosting (Ayres et al. 1996).

Four species of wetland dependent reptile and seven species of frog have been recorded within the NSW Central Murray Forests Ramsar site (Appendix D). Although population sizes are not known, there is evidence that frogs and turtles use the shallow, well-vegetated ephemeral wetlands for breeding during flood events (GHD 2010).

4. Ecosystem Services

4.1 Overview of benefits and services

Ecosystem benefits and services are defined under the Millennium Ecosystem Assessment definition of ecosystem services as "the benefits that people receive from ecosystems (Ramsar Convention 2005, Resolution IX.1 Annex A). This includes benefits that directly affect people such as the provision of food or water resources as well as indirect ecological benefits. The Millennium Ecosystem Assessment (Millennium Ecosystem Assessment 2005) defines four main categories of ecosystem services:

1. **Provisioning services** - the products obtained from the ecosystem such as food, fuel and fresh water;
2. **Regulating services** – the benefits obtained from the regulation of ecosystem processes such as climate regulation, water regulation and natural hazard regulation;
3. **Cultural services** – the benefits people obtain through spiritual enrichment, recreation, education and aesthetics; and
4. **Supporting services** – the services necessary for the production of all other ecosystem services such as water cycling, nutrient cycling and habitat for biota. These services will generally have an indirect benefit to humans or a direct benefit over a long period of time.

The ecosystem benefits and services of the NSW Central Murray Forests Ramsar site are outlined in Table 16.

4.2 Identifying critical ecosystem services and benefits

The critical ecologically based ecosystem services and benefits of a Ramsar site have been identified using the same criteria as was used for selecting critical components and processes; i.e. “As a minimum, select for analysis and description those components , subcomponents, processes, benefits and services (DEWA 2008):

1. that are important determinants of the site’s unique character;
2. that are important for supporting the Ramsar criteria under which the site was listed;
3. for which change is reasonably likely to occur over short or medium time scales (less than 100 years); and / or
4. that will cause significant negative consequences if change occurs”.

Using these criteria it was considered that all of the supporting services (that is, those that are ecologically based) could be considered “critical”. While the site is undoubtedly beneficial in terms of timber production, cultural services and flood control; these were not considered “critical” services in that a reduction in any of these services would not necessarily indicate a change in ecological character.

Therefore the critical ecosystem benefits and services of the NSW Central Murray Forests Ramsar site are:

- supports significant wetland types;
- provides physical habitat for waterbird feeding and breeding;
- supports threatened wetland species; and
- maintains ecological connectivity for fish spawning and recruitment.

Table 16: Ecosystem services and benefits provided by the NSW Central Murray Forests Ramsar site (those considered critical are shown shaded; see section 4.2).

Category	Description
Provisioning services	
Wetland products (timber)	At the time of listing, the site comprised nine State Forests that were managed predominantly for timber production.
Wetland products (fodder)	Grazing – Forests NSW revenue from occupation permits for grazing estimated at $45 000 per annum (Shaw, S. pers. comm.).
Wetland products (honey)	Forests NSW issues licences for the keeping of hives in the forests (Forests NSW 2008).
Wetland products (firewood)	The site is locally important for firewood collection. Public access is granted for collection of fallen timber only and for personal use.
Commercial fishing	Historically the site supported a commercial fishery based around native river fish however this ceased with fisheries regulation and associated decline in fish stocks, and the impacts of river regulation on native fish populations (Leslie, 1995; Norris et al. 2001). Continues to support small-scale commercial fishing of native yabbies (*Cherax destructor*) and exotic fish, principally common carp (*Cyprinus carpio*). The carp fishery is primarily an environmental management tool however economic gains partly subsidise the service (NSW DPI, 2008).
Cultural services	
Recreation and tourism	The general public have mostly unrestricted use of the forests and rivers for recreational pursuits through a well-maintained road network to and within the forests. Common activities include recreational fishing, bird watching and bushwalking.
Spiritual and inspirational	The forested landscape in the NSW Central Murray Forests has spiritual, cultural, environmental and economic value to Aboriginal people. The Ramsar site contains a number of significant cultural heritage sites.
Science and education	The site contains interpretative ecotourism and education sites at the Gulpa Creek Wetlands. National focus of research, environmental management and education through the 'Living Murray' program (MDBC, 2006).
Regulating services	
Carbon sequestration	Although this aspect has not been quantified, the forests and their floodplain soils would comprise a significant sink of organic carbon.
Flood control	Floodplain vegetation reduces floodwater impacts by reducing velocity of peak flows and disperses flow energy across a stable, depositional environment. The floodplain and effluent streams allow for a slow recession of floodwaters which is essential for native biota but also maintains river flows at manageable levels over a longer period.
Supporting services	
Significant wetland types	The site supports the part of the largest remaining river red gum forest and provides a mosaic of vegetated wetland habitats.
Physical habitat	Central Murray Forests provides habitat for feeding and breeding of wetland birds.
Threatened species	The Ramsar site supports one plant species, three species of bird and six species of fish listed under the EPBC Act and / or the IUCN Red List.
Ecological connectivity	The site provides important migratory routes between riverine, wetland and floodplain habitats for fish spawning and recruitment.

4.3 Critical services

4.3.1 Supports significant wetland types

As described in section 2.3, the NSW Central Murray Forests Ramsar site contains a range of wetland types, some of which can be considered significant in a bioregional context. The major wetland types and associated habitats that are considered critical to the ecological character of the site are:

- Freshwater tree-dominated wetlands – river red gum forest and woodland;
- Permanent and intermittent freshwater marshes – freshwater marshes, open water; and
- Permanent and intermittent rivers and streams– permanent pools, in-stream habitats

This diversity of habitat is brought about by the interactions between geomorphology, hydrology and vegetation (Figure 31). Water regime is the single biggest determinant of wetland vegetation, with different groups of species having different morphological adaptations to patterns of inundation (Roberts and Marston 2000). Most commonly, it is a plant's ability to adapt to low oxygen in the soil following inundation that determines its optimum water regime (Brock and Cassanova 1997).

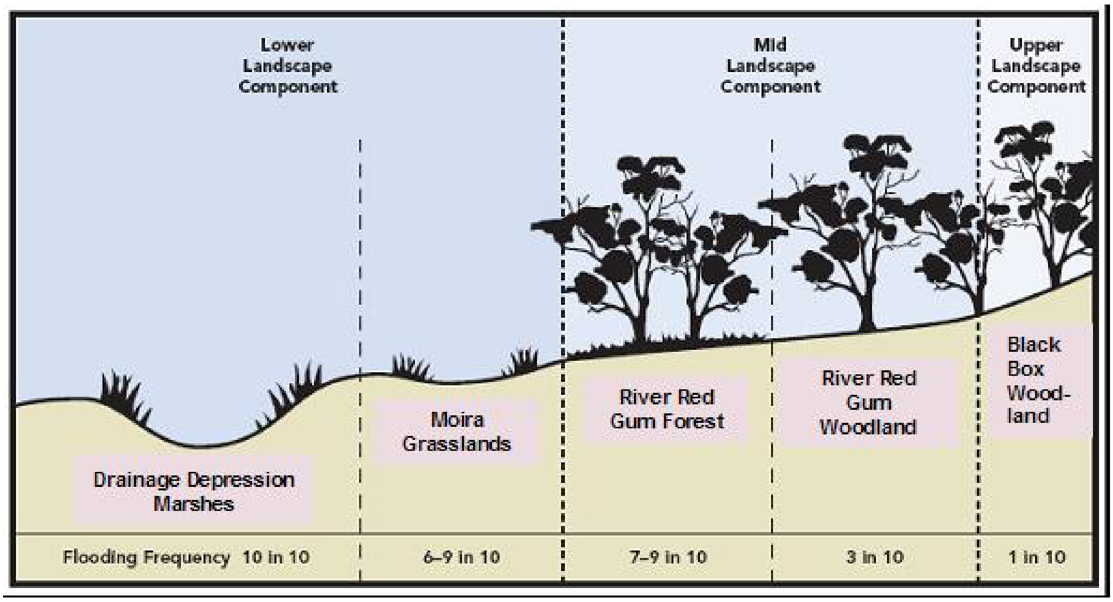


Figure 31: Vegetation associations, geomorphic setting and flood regime (adapted from MDBC 2007b).

Freshwater tree dominated wetlands

River red gum forested wetlands dominate the site and natural regeneration of river red gum is largely dependant on the natural flooding cycles of river systems, and most strongly on an intermittent late winter / early spring flooding cycle. Historically, flooding across the river red gum forests lasted approximately three months and occurred seven to eight times per decade (MDBC 2007a).

River red gum produces abundant quantities of seed, which is released mostly during spring and summer. Greater seed fall in spring may have adaptive significance as under the natural flow regime floods would usually recede during this period (Dexter 1978). Young plants appear over extensive areas after floods and can initially form dense stands of saplings, which gradually thin out as they grow. Maturing stands form forests of straight-trunked trees in areas with reliable floodwater. Prolonged inundation kills saplings, which is important for maintaining the distribution of treeless communities (marshes) at the site (CSIRO 2008; Cunningham et al. 1981).

Flood timing affects germination success. Flood recession in spring-early summer is optimal for regeneration while winter floods with winter recession are unfavourable. Spring-summer floods followed by summer recession provide suitable germination conditions but subsequent heat and water stress can cause massive seedling mortality. Germination can happen without flooding if the winter is wet. If seedlings survive frost, but conditions continue to be dry, moisture stress in the following summer is likely (Roberts and Marston 2000).

River red gum seedlings have a number of morphological adaptations that enable them to cope with inundation. However, complete immersion, unless brief, is likely to kill seedlings; lower leaves of small saplings die if submerged for long periods (Roberts and Marston 2000). Seedlings increase tolerance to flooding with age. Two-month old seedlings can survive waterlogging for one month (Roberts and Marston 2000), while seedlings 50 to 60 centimetres tall can survive extended flooding of 4-6 months and complete immersion for a few weeks by shedding leaves (Dexter 1978).

It must be noted that at the time of listing, the sites was managed as a series of State Forest. Over 70 percent of the site was managed predominantly for timber harvesting. This management includes stand thinning, select tree harvesting and (rarely) active regeneration and direct seeding (Di Stefano 2001). There is evidence from comparable forests (Barmah and Gunbower Forests) that early thinning of high density stands (greater than 1000 trees per hectare) to 600 to 800 stems per hectare, produces complexity of habitat and a larger number of hollow bearing trees, given time to develop (Horner et al. 2010). Therefore it is likely that forest management has played an important role in shaping the community composition and structure of the forests within the Ramsar site.

Permanent and intermittent freshwater marshes

In low lying areas where inundation is more frequent and flood durations are longer, water-logging of soil is too prolonged to sustain river red gum forest, and aquatic plant communities, which have greater tolerances for anoxic soils occur. Plant community composition and extent of these wetlands varies temporally and spatially in response to patterns of inundation and drying. The water regime requirements and tolerances of plants typical of these wetlands are provided in Table 17.

Permanent and intermittent rivers and streams

The NSW Central Murray Forests features an extensive and complex network of in stream habitats. They are all hydrologically connected to the Murray River and include:

- Major anabranch systems, such as Gulpa Creek and the Edward River;
- Effluent streams, such as Burrumburry Creek, Tummudgery Creek, Reed Beds Creek; and
- A network of smaller, unnamed effluent streams and flood runners.

The networks of smaller channels are important for transmitting floodwaters across the floodplain and inundating other habitat types. In-stream habitats support the aquatic and semi-aquatic plant species listed in Table 17. They play an important role maintaining propagules of these species during dry phases and then transmitting them onto the floodplain upon re-wetting.

Table 17: Preferred water regimes of plants in freshwater marshes (Benson et al. 2006; Roberts and Marston 2000 and Bren and Gibbs 1986).

Species	Vegetation association / location	Water depth	Flood frequency	Flood duration
Moira grass (*Pseudoraphis spinescens*)	Moira Grass Plains, upslope of reed beds.	More than 0.5 metres to a maximum of two metres.	75 percent of years, inter flood period not greater than two years.	Five to nine months
Giant rush (*Juncus ingens*)	Extensive, dense stands close to channels or permanent wetlands	0 to 0.5 metres	75 to 100 percent of years.	Two to 30 months
Common reed (*Phragmites australis*)	Locally abundant, dense aquatic grassland close to channels or in near-permanent wetlands	0 to 0.5 metres (not greater than 2 metres)	Can survive long droughts as rhizomes.	One to 10 months.
Cumbungi (*Typha domingensis*)	Very tall, dense rushland close to channels or in near-permanent wetlands	One to two metres	50 to 100 percent of years	Six to 12 months
Water-ribbons (*Triglochin procerum*)	Emergent aquatic in margins of channels and permanent lagoons.	0 to 1.5 metres	100 percent of years	One to eight months
Water primrose (*Ludwigia peploides*)	Amphibious in margins of channels and permanent lagoons	0 to 1 metres	100 percent of years	Eight to ten months
Water pepper (*Persicaria hydropiper*)	Amphibious in margins of channels and marshes	0 to 0.5 metres	Can survive drying of wetlands with moist soils	unknown
Ribbonweed (*Vallisneria americana*)	Submerged aquatic in channels and permanent lagoons	0 5-to 2 metres	100 percent of years	Eight to 12 months

4.3.2 Provides physical habitat for wetland bird breeding and feeding

The NSW Central Murray Forests provide a range of habitats that support wetland birds in terms of feeding and breeding. Sixty-seven species of wetland bird have been recorded at the site and this represents a wide variety of species that rely on a range of different habitats. In many instances, birds that breed within the site utilise different habitats for foraging, roosting and breeding and a network of different habitat types is required to meet all of their needs (Figure 32).

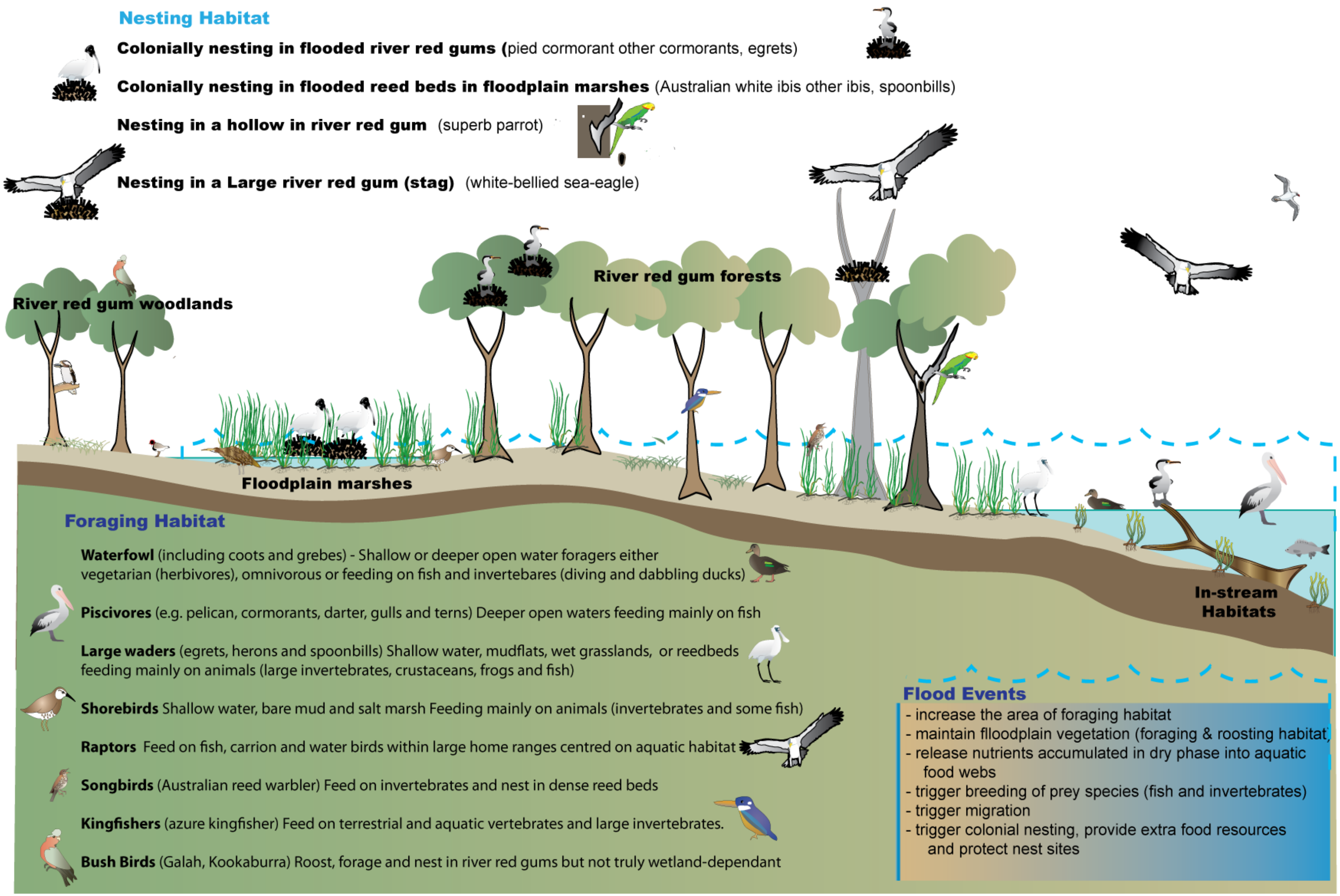


Figure 32: Conceptual diagram illustrating the variety of habitats for wetland birds within the Ramsar site.

Feeding

The service of providing habitat for wetland bird feeding is considered in terms of broad feeding / habitat guilds. Of note is the variation in feeding and foraging habitats in response to wetland inundation. This is illustrated by the proportion of total wetland bird abundance represented by each of the function feeding groups (after Kingsford and Porter 2009) in the Barmah-Millewa Icon site following floodplain inundation in 2000 and during dry conditions in 2007 and 2008 (Figure 33). When floodplains and floodplain wetlands are inundated, there is a greater diversity of wetland birds in the system (over thirty-five species recorded in 2000/2001; Barmah Millewa Forum 2001), with all functional feeding groups represented generally dominated by large wading species such as egrets and herons. During drier times, species richness is lower (between five and 14 species in 2007 and 2008; Kingsford and Porter 2009) and the site is dominated by piscivores that are located along permanent streams and waterholes, with a complete absence of herbivores.

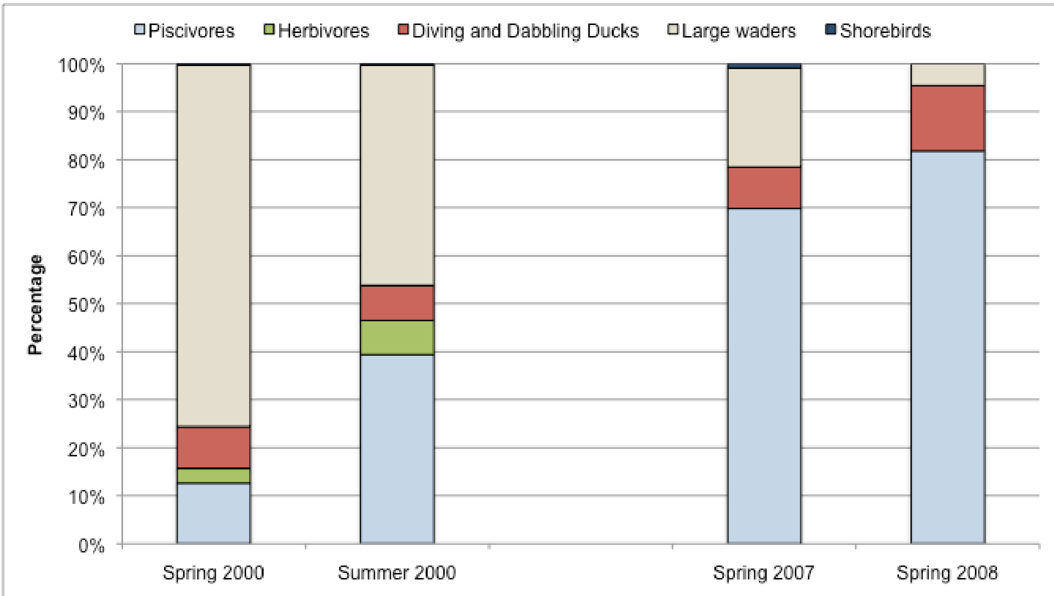


Figure 33: Proportion of birds from different feeding guilds in Barmah-Millewa Forest Group in 2000/2001 (Barmah-Millewa Forum 2001) and 2007 and 2008 (Kingsford and Porter 2009).

<u>Piscivores</u>

There are a number of wetland birds within the Ramsar site whose diet is wholly or mostly comprised of fish. This includes the terns, cormorants and darters as well as the white-bellied sea eagle. A number of these species require relatively deep water (greater than one metre) in which to feed and plunge or pursuit divers such as terns require open water expanses. Within the Ramsar site, these are limited to channels and in-stream pools as well as the larger floodplain depressions such as Moira Lake. The general habitat requirements for a number of piscivorous waterbirds that have been recorded within the Ramsar site are provided in Table 18.

Table 18: General feeding habitat requirements of a number of piscivorous wetland birds in the NSW Central Murray Forests Ramsar site (Marchant and Higgins 1990).

Species	Habitat characteristics
Caspian tern (*Hydroprogne caspia*)	• Diet consists mainly of small to medium size fish. • Feed by shallow plunging, swallowing fish in flight.
Great cormorant (*Phalacrocorax carbo*)	• Diet mainly of fish, but supplemented with crustaceans and frogs. • Feeds by capturing prey in shallow underwater dives, which often last for more than a minute.
Pied cormorant (*Phalacrocorax varius*)	• Diet consists mainly of small to medium size fish. • Feed by pursuit diving via deep underwater dives.
White-bellied sea eagle (*Haliaeetus leucogaster*)	• Feed mainly on fish, but also other birds and mammals; will also take prey from other birds and feed on carrion such as dead sheep.

Waterfowl and associated waterbirds

This group includes not just ducks, swans and geese but also grebes, coots and waterhens. There is a range of feeding strategies and foraging and roosting habitats for this group of waterbirds, some of which are described in Table 19. Under the functional feeding groups provided by Kingsford and Porter (2009) this group is divided into herbivores, which includes black swans and Eurasian coots and “ducks” which includes the diving and dabbling ducks and grebes.

Table 19: General feeding habitat requirements of selected species of waterfowl within the Ramsar site (information from Marchant and Higgins 1990).

Species	Habitat characteristics
Eurasian coot (*Fulica atra*)	Prefers vegetated lagoons and swamps. Diet – almost entirely vegetable matter (seeds and plant material). Foraging - Food is mainly obtained during underwater dives, lasting up to 15 seconds and ranging down to seven metres in depth. Birds also graze on the land and on the surface of the water.
Australasian shoveler (*Anas rhynchotis*)	Prefer deep, large permanent waterbodies. Roost on open water. Diet – plants and animals (molluscs and insect larvae). Foraging – filter feeder dabbling in mud or in surface water.
Australian shelduck (*Tadorna tadornoides*)	Wide range of habitats but prefer shallow wetlands. Diet – vegetation and invertebrates. Foraging – opportunistic grazing, dabbling, etc.
Chestnut teal (*Anas castanea*)	Prefer saline wetlands. Diet – seeds and insects. Foraging – dabbling at the water’s edge or in bottom waters.
Black swan (*Cygnus atratus*)	Inland and estuarine shallow waters where floating, submerged or emergent vegetation is plentiful. Roost – mostly over water, but occasionally on shore. Diet – herbivorous feeding on the shoots and leaves of aquatic plants including filamentous algae and seagrass. Foraging – grazers.

Waders

This group includes species in the two families, Ardeidae and Threskiornithidae, (herons, egrets, spoonbills and ibis) which are classified as “large waders” by Kingsford and Porter (2009) as well as the shorebirds. Wading species of bird feed in shallow water (usually less than 15 centimetres) and within the Ramsar site, this group is dominated by large waders, with shorebirds comprising a very small proportion of the wetland bird community. Foraging and feeding strategies of some of the wading species of birds found within the Ramsar site are provided in Table 20.

Table 20: General feeding habitat requirements of selected species of waders within the Ramsar site (information from Marchant and Higgins 1990)

Species	Habitat characteristics
Straw-necked ibis (*Threskiornis spinicollis*)	Favours inland, freshwater or brackish wetlands. Feeds mainly on terrestrial invertebrates, but also frogs, small reptiles and mammals. It forages by probing in the mud or taking prey from the surface of shallow water.
Yellow spoonbill (*Platalea flavipes*)	Prefers inland, freshwater wetlands with shallow margins. Diet – predominantly invertebrates. Foraging – in shallow mud using the vibration detectors in its bill to detect movement of prey in the mud.
White-faced heron (*Egretta novaehollandiae*)	Very diverse array of habitats from arid inland to temperate coasts. Feeds on a diversity of prey including aquatic insects, molluscs, crustaceans, frogs and fish. Foraging – variety of techniques, wading and disturbing prey, ambush hunting and probing crevices and mud.
Black-winged stilt (*Himantopus himantopus*)	Prefer inland freshwater and saline marshes. Diet – feed mainly on aquatic insects, but also crustaceans and molluscs. Foraging – wade in shallow water and seize prey at or near the surface, but occasionally taking sub-surface prey.

Breeding

The NSW Central Murray Forests Ramsar site is significant for supporting breeding of wetland birds, particularly colonial nesting waterbirds such as egrets, ibis, herons and cormorants. In order to breed, waterbirds require appropriate sites for their nests. Nesting requirements vary between groups of species. The critical habitat resources at the site include mature river red gums in the vicinity of open water and stands of *Juncus* or other emergent macrophytes in marshes (Briggs and Thornton 1995; Barmah Millewa Forum 2001). The greatest concentrations of important waterbird breeding colonies at the site are in the Millewa Forest Group associated with the Moira Lake and Gulpa Creek groups of floodplain marshes.

Waterbirds breed in response to flooding in relation to nesting habitat as well as available food resources. There is evidence to suggest that waterbird breeding occurs when food resources are at a maximum (Kingsford and Norman 2002), which depending on the season and diet of the species can lag behind the commencement of inundation for periods of four weeks to seven months. Once breeding has commenced, many Australian waterbirds require surface water to remain in and around nesting sites until offspring are independent feeders (Jaensch 2002). Drying prior to this can lead to abandonment of nests and young by parents or insufficient food resources for successful fledging. It is suggested that inundation for a minimum of four months would be required to allow for courting/mating, nest site selection and building, incubation and raising of young to independence (Jaensch 2002).

The site predominantly supports birds that nest in trees or shrubs and preferred nesting sites for most species recorded breeding in substantial numbers are similar. The habitat requirements, including length of inundation for a selection of these species are provided in Table 21.

Table 21: Nesting habitat and inundation requirements for some species of wetland bird previously recorded breeding in the Ramsar site ([1]Webster 2008; [2]Briggs 1990; [3]Jaensch 2002).

Species[1]	Stimuli for breeding[2]	Nesting Habitat[3]	Inundation requirements[3]
Great crested grebe (*Podiceps cristatus*)	Flooding	Floating mound of aquatic vegetation is placed on floating weed mat or anchored to emergent vegetation; often under cover of trees or shrubs	Minimum depth of 30 to 50 centimetres for sufficient time to prevent nest site becoming dry before nestlings leave nest and reach maturity. Four weeks incubation; one week leave nest, independent some weeks later.
Little pied cormorant (*Microcarbo melanoleucos*)	Flooding / seasonal	In forks and branches of trees (*Eucalyptus*) and tall shrubs in or over water; sometimes over dry land or on artificial structures.	Minimum depth of 30 to 50 centimetres for sufficient time to prevent nest site becoming dry before nestlings leave nest and reach maturity – three to four months.
White-necked heron (*Ardea pacifica*)	Flooding / seasonal	Low near-horizontal branch of tree in or overhanging water Trees (such as river red gum) fringing river channels, waterholes, lakes and ponds; wooded swamps (such as black box).	Minimum depth of 30 to 50 centimetres for sufficient time to prevent nest site becoming dry before nestlings leave nest and reach maturity – three months.
Great egret (*Ardea modesta*)	Flooding / seasonal	Wooded swamp (such as *Eucalyptus*); high in a tree or tall shrub standing in water, often at a higher site than associated species; on top of lignum shrub; sometimes high in trees on dry land.	Minimum depth of 30 to 50 centimetres for sufficient time to prevent nest site becoming dry before nestlings leave nest and reach maturity – three to four months.
Intermediate egret (*Ardea intermedia*)	Flooding / seasonal	Wooded swamp (such as *Eucalyptus*); high (pp to 15 metres above water) in a tree or tall shrub standing in water.	Minimum depth of 30 to 50 centimetres for sufficient time to prevent nest site becoming dry before nestlings leave nest and reach maturity – three to four months.
Nankeen night heron (*Nycticorax caledonicus*)	Flooding	Wooded swamp (such as *Eucalyptus*); in a tree or tall shrub standing in water, at variable height; often in a discrete zone (encircling a group of breeding egrets); sometimes high in trees on dry land.	Minimum depth of 30 to 50 centimetres for sufficient time to prevent nest site becoming dry before nestlings leave nest and reach maturity – two to three months.
Glossy ibis (*Plegadis falcinellus*)	Flooding	Shrubby swamp (such as. lignum), wooded swamp (such as *Eucalyptus*), and reed/cumbungi beds. In a tree or tall shrub standing in water, usually low in the tree/shrub	Minimum depth of 30 to 50 centimetres for sufficient time to prevent nest site becoming dry before nestlings leave nest and reach maturity – two to three months.
Australian white ibis (*Threskiornis molucca*)	Flooding / seasonal	Wide variety of habitats used for breeding: typically wooded swamp (such as. *Eucalyptus*), shrub swamp (such as lignum) and reed/cumbungi beds; also exotic wetland and dryland tree copses, bare islands and artificial structures.	Minimum depth of 30 to 50 centimetres for sufficient time to prevent nest site becoming dry before nestlings leave nest and reach maturity – ten weeks to three months (not relevant to nests on dry land).

4.3.3 Supports threatened species

There are eight nationally or internationally threatened species supported by the wetlands within the NSW Central Murray Forests Ramsar site; four fish, three birds and a plant. The habitat requirements of each of these are described briefly in Table 22.

Table 22: General habitat requirements of nationally threatened species within the Ramsar site.

Species	Habitat characteristics
Murray cod *Maccullochella peeli peelii*	Predate on fish, frogs and crayfish. Murray cod prefers deep holes in rivers, with instream cover such as rocks, snags and undercut banks (Lintermans 2007).
Silver perch *Bidyanus bidyanus*	Omnivorous, feeding on aquatic plants, snails, shrimps and insect larvae. Found in lowland, turbid and slow-flowing rivers (Lintermans 2007).
Trout cod *Maccullochella macquariensis*	Diet includes fish, yabbies, insect larvae, shrimps and prawns. The species is usually associated with deeper water and instream cover such as logs and boulders (Lintermans 2007).
Murray hardyhead *Craterocephalus fluviatilis*	Omnivorous, eating primarily microcrustaceans but also some aquatic insects and algae. Found around the margins of lakes, wetlands, backwaters and billabongs. Prefers open water, shallow, slow-flowing or still habitats, (Lintermans 2007).
Australasian bittern *Botaurus poiciloptilus*	Favours permanent freshwater wetlands with tall, dense vegetation, particularly bullrushes (*Typha* spp.) and spike rushes (*Elaeocharis* spp.). Hides during the day amongst dense reeds or rushes and feed mainly at night on frogs, fish, yabbies, spiders, insects and snails (Marchant and Higgins 1990).
Australian painted snipe *Rostratula benghalensis australis*	Prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber. Nests on the ground amongst tall vegetation, such as grasses, tussocks or reeds (Marchant and Higgins 1990).
Superb parrot *Polytelis swainsonii*	Generally inhabits box-gum, box-cypress-pine and boree woodlands and river red gum forest. It nests in hollows in small colonies, often with more than one nest in a single tree. It forages up to 10 km from nesting sites, primarily in grassy box woodland, feeding mainly on grass seed and herbaceous plants, fruits, berries, nectar, buds, flowers, insects and grain (DECC 2008).
Floating swamp wallaby-grass *Amphibromus fluitans*	Habitats in south-western NSW include swamp margins in mud, dam and tank beds in hard clay and in semi-dry mud of lagoons with Potamogeton and Chamaeraphis species. The species requires periodic flooding of its habitat to maintain wet conditions (OEH 2013).

4.3.4 Maintains ecological connectivity for spawning and recruitment of native fish

Understanding of native fish use of flooded wetland habitats is in its infancy in Australia and the use and significance of different habitats in the NSW Central Murray Forests Ramsar site by native fish remains a knowledge gap. However, recent investigations in comparable habitats (including Barmah Forest) have provided evidence of lateral movement of native fish during floods (Lyon et al. 2010) and the importance of floodplain wetlands for successful recruitment of many native fish species (King et al. 2009). Juvenile and larval native fish species have been recorded in wetland, lake and creek habitats within the Millewa Forest Group (King et al. 2007) and even fish that are known to spawn in river channels (such as Murray cod) are thought to utilise inundated floodplain and creek systems to feed (King et al. 2009; Lyon et al. 2010).

Native fish have been recorded moving large distances along the Murray River from the Ramsar site (up to 1000 kilometres upstream and 900 kilometres downstream), which is indicative of pre- and post-spawning behaviour (McKinnon 1997). The NSW Central Murray Forests Ramsar site provides a network of habitats for fish during these long migrations. Floodplain inundation, with its associated boom in productivity, provides both physical habitat and food resources that are important in maintaining regional native fish populations (King et al. 2009). The migration and spawning habitat requirements for some of the native fish species that are known to occur in the site are provided in Table 23.

Table 23: Migration and spawning habitats for some fish species known to occur in the Ramsar site ([1]CRCFE 2003; [2]Lintermans 2007).

Species	MFAT Habitat group[1]	Migration and spawning habitats[2]
Australian smelt (*Retropinna semoni*)	Wetland specialist (spawn and recruit in floodplain wetlands and lakes, anabranches and billabongs during in-channel flows)	Known to undertake upstream migrations in adult and juvenile stages, with fish as small as 21 millimetres recorded migrating. Spawning occurs when water temperatures reach about 11 to 15 degrees Celsius (spring and late summer in region of the Ramsar site). Juveniles may migrate out of floodplains and wetlands on receding floodwaters.
Bony herring *(Nematalosa erebi*)	Wetland specialist (spawn and recruit in floodplain wetlands and lakes, anabranches and billabongs during in-channel flows)	Daytime upstream movements have been recorded for juveniles and adults in the Murray River, and individuals as small as 22 millimetres have been recorded migrating. Males mature at one to two years and females at two years. Eggs are released in the still waters of shallow, wetlands in October-February.
Murray-Darling rainbowfish, (*Melanotaenia fluviatilisi)*	Low Flow specialist (only spawn during low flow).	Breeding is seasonal, generally spring-summer when water temperature exceeds 20 degrees Celsius, in slow moving water or wetland habitats. Individuals as small as 21 millimetres have been recorded migrating upstream, most commonly in the afternoon and dusk.
Freshwater catfish (*Tandanus tandanus*)	Freshwater catfish (spawn in coarse sediment beds (usually sand or gravel) during any flow conditions).	Spawning occurs in spring and summer when water temperatures are 20 to 24 degrees Celsius. The nest is a circular to oval depression, 0.6 to 2.0 metres in diameter, constructed from pebbles and gravel, with coarser material in the centre. While young catfish may form loose schools and undertake movements to colonise new habitats, adults tend to be solitary when they are not breeding (Cadwallader and Backhouse 1983). Adult freshwater catfish are apparently non-migratory, remaining in the same section of river for most of their lives (Davis 1977).
Golden perch (*Macquaria ambiguai)*	Flood spawners: (Spawn and recruit following flow rises. Major spawning occurs during periods of floodplain inundation).	Adult and immature fish are migratory and extensive upstream movements of more than 1000 kilometres have been recorded for some adult fish. Outside the breeding season, individuals occupy home ranges of about 100 metres for weeks or months before relocating to another site where a new home range is established. Upstream movements by both immature and adult fish are stimulated by small rises in streamflow and most movement in the Murray occurs between October and April. Some fish may move downstream to spawn.
Murray cod (*Maccullochella peeli peelii)*	Main channel specialists: (spawn and recruit under high or low flow in the main channel. Woody debris important habitat attribute).	Murray cod make an upstream migration of up to 120 kilometres to spawn in late winter/early spring when river levels are high. After spawning the fish move downstream again, returning to the same area they occupied before the migration, usually to exactly the same snag. Spawning occurs in spring and early summer when water temperatures exceed about 15 degrees Celsius. Eggs are usually deposited onto a hard surface such as logs, rocks or clay banks. The male guards the eggs during incubation and after hatching, larvae drift downstream for five to seven days, particularly by night in spring and summer

4.4 Provisioning and cultural services

4.4.1 Wetland products – timber

At the time of listing, forest management in the NSW Central Murray Forests was undertaken by Forests NSW and involved a range of activities including:

- Timber harvesting and associated silvicultural activities;
- Hydrological management, through maintenance and operation of regulators, channels and water allocations;
- Infrastructure construction and maintenance, including roads, culverts and drainage works;
- Weed and pest management;
- Fire management;
- Regulation of grazing and apiary;
- Biodiversity management, including managing flood regimes of wetlands, targeted fencing and exclusion of grazing and harvesting;
- Management of public recreation uses;
- Scientific research; and
- Public education.

These activities were regulated within a framework of management plans, licenses and authorities. At a strategic level, the planning and implementation of timber harvesting operations occurred over long cycles, based on forest growth and sustained yield in accordance with Forests NSW Riverina ESFM Plan (Forests NSW 2008a). Part of the strategic planning process involves the FMZ land classification, which differentiates between those areas of State forests that are specifically set aside for conservation and those that are available for routine management under standard conditions (see section 2.2 and Figure 4).

Prior to 2010 forest management at the site was a major factor in the social and economic profiles of the rural townships of Deniliquin (NSW), Koondrook (Victoria), Barham (NSW) and Mathoura (NSW). Social and economic benefits have been provided by timber harvesting at the site for over 100 years (well before the site was listed as a wetland of international importance). River red gum is still an important source of timber today for a wide range of uses including sawlogs, veneer, kiln dried furniture timber, piles, landscaping material, firewood and charcoal. At the time of listing, the NSW Central Murray Forests yielded tens of thousands of tonnes of timber annually (Table 24).

Table 24: Timber production in the NSW Central Murray Forests (S. Shaw, FNSW, personal communication).

Calendar Year	High Quality Logs (cubic metres)	Low Quality Logs (cubic metres	Residue (tonnes)
1997	21 316	18 644	39 873
1998	20 444	13 736	31 983
1999	16 516	11 598	35 260
2000	16 626	7208	32 872
2001	23 929	15 066	34 496
2002	21 683	12 524	33 872
2003	20 705	10 259	16 270
2004	15 797	10 396	52 168
2005	15 196	14 019	44 640
2006	21 801	20 384	35 657
2007	18 816	19 200	57 169

4.4.2 Indigenous spiritual and cultural values

The NSW *Aboriginal Land Rights Act 1983* provides the legislative basis for the Local Aboriginal Land Councils. These are the Cummergunja Local Aboriginal Land Council (covering the Millewa Forest Group and the eastern portion of the Koondrook-Perricoota Forest Group), the Moama Local Aboriginal Land Council (covering the eastern portion of the Koondrook-Perricoota Forest Group) and the Deniliquin Local Aboriginal Land Council (covering the Werai Forest Group and the western portion of the Koondrook-Perricoota Forest

Group). However Forests NSW recognises that more than one Aboriginal group may have connections and interest in a particular area. In order to facilitate their involvement, Forests NSW liaises with all relevant Aboriginal community groups in the region including local and regional Aboriginal land councils, native title claimants, knowledge holders (elders) and Aboriginal corporations (Forests NSW 2008a). Historical signs of Aboriginal occupation include scarred trees, burials, shell middens and oven mounds (Craib 1990, Lyons n.d.).

Before occupation by Europeans, people of the Baraparapa, Barkindji, Barindji, Danggali, Jeithi, Jitajita, Jotijota, Kureinji, Maljangapa, Maraura, Milpulo, Muthi Muthi, Narinari, Ngurunta, Tati Tati, Wanjiwalku, Wati Wati, Wembawemba, Wiljakali and Wiradjuri Aboriginal nations inhabited the Riverina Region. The forested landscape in the Riverina Region was an important oasis in an otherwise harsh landscape and the NSW Central Murray Forests still has spiritual, cultural, environmental and economic value to Aboriginal people today (Forests NSW 2008a; Orthia 2002).

Forests NSW maintains a regional database of all known Aboriginal sites on its estate. At the time of publication there were nearly 1000 recognised Aboriginal cultural heritage sites within the NSW Central Murray Forests. The greatest concentration is in the Werai Forest Group, which contains over 300 sites (Forests NSW 2008b). These sites are identified and avoided during forest harvesting and new sites identified during operations are managed in consultation with Aboriginal communities and DECCW. The most significant sites are fenced to protect their integrity and maintain their cultural values (Forests NSW 2008a).

The Forests NSW management plan for the site notes the following: “the spiritual connection between Aboriginal people and the natural and cultural values of the land is recognised and acknowledged in national and state government policy. The National Forest Policy Statement (NFPS) identifies Aboriginal cultural heritage as one of the many values to be conserved across the forest estate, and the NSW Government’s plan, ‘Two Ways Together’, promotes the development of partnerships with Aboriginal people. State forests offer an opportunity for local Aboriginal communities to re-establish links with the land and an avenue for Aboriginal and non- Aboriginal people to foster reconciliation” “Settlement by non-Aborigines forced Aboriginal people from their traditional areas, dismantling their social values and damaging traditional lifestyles” (Forests NSW 2008a p16).

4.4.3 Broader community values

The discovery of the Murray River near Albury in 1824 by Hume and Hovell and subsequent settlement soon lead to the growth of a unique social environment based on a number of small and sometimes isolated villages along the river. Places of European significance that illustrate the phases of pastoral settlement, timber harvesting and river navigation are located within the site. The historical value of the Riverina forests is high and is primarily related to the early use of the Murray River and the central role it played in the economic life of early communities and in the development of the forest themselves. Relics of early settlement such as the remains of barges, punts, irrigation schemes, sawmills and cemeteries can still be found on State forests (Forests NSW 2008a). These include 54 recognised heritage sites included on Forests NSW’s register of important European cultural heritage sites within the NSW Central Murray Forests (Forests NSW 2008c). The site is recognised as important for forest management as well as recreation, education, apiculture, fishing, bird watching and scientific study.

The general public have enjoyed unrestricted use of the forests and rivers for recreational pursuits through a well-maintained road network to and within the forests. Through this reliable road system successive generations from the same family come to generally the same location year after year to camp and enjoy a holiday. Water based competitive sports like water skiing and canoeing have become annual events of national prominence. Events like the Murray River Red Cross Canoe Marathon and the Southern Eighty Powerboat Ski Race are examples of these events that bring thousands of people to the forests year after year.

The aesthetic backdrop of the river red gum forests and near-natural wetlands of the site in contrast to substantial reaches of its length through degraded landscapes enhance the value of the Murray River. This is apparent in the recognition of Millewa and Koondrook-Perricoota Forest Groups as Icon Sites in the Murray Darling Basin. They have been selected for their spiritual, cultural and conservation value as best representing the values of the river system as a whole (MDBC 2004).

Recreational activities at the site are managed in accordance with Forests NSW policy and strategic framework document, “Living working, playing.... forests”, which is consistent with the strategy described in towards 2020: NSW South Wales Tourism Masterplan (Forests NSW 2008a). This strategy, when combined with powers conferred under the NSW *Forestry Act 1916* to Forests NSW authorised officers, provides the strategic framework for controlling recreation to ensure that any potential impacts arising from recreational activities are managed and mitigated. Examples of this include the provision of facilities such as the Reed Beds birdhide, which provide a controlled opportunity to visit the wetlands and view bird breeding events without impacting on the birds (G. Rodda, Forests NSW personal communication). Access tracks are also provided, maintained and signposted to ensure that vehicular impacts are minimised and controlled.

5. Conceptual models

The critical components, processes and services, which combine to form the ecological character of the NSW Central Murray Forests each, feature complex interrelationships. Cycles of wetting and drying are fundamental to these floodplain ecosystems, affecting the physical, chemical and biological processes and functions. The duration, seasonality, frequency and intensity of wetting and drying determines the type of biota that occurs on the floodplain and wetting and drying can provide important cues for flora and fauna in reproductive cycles. Simple conceptual models of wet (Figure 34) and dry phases (Figure 35) illustrate some of the interactions between critical components, processes and services that are described for each phase below.

5.1 Wet phase (filling and inundated state)

The arrival of floodwaters brings about the following physical and chemical changes within the floodplain (Boon 2006):

- Dry and aerated sediments quickly become waterlogged and devoid of oxygen;
- Mineralisation and release of nutrients and carbon from the sediments and floodplain litter;
- Depending on the water quality of source water, velocity of flooding and sediment type, the floodwaters may be highly turbid (particularly in channels where velocity is greatest) and sediments may be deposited on the low relief floodplain surface.

Biological processes that occur upon wetting include (Boulton and Brock 1999):

- Microorganisms (bacteria and algae) process mineralised nutrients and a “boom” of productivity commences;
- Egg and seed banks hatch / germinate;
- Plant propagules are brought in with the floodwaters from upstream environments;
- Fish and invertebrates arrive on the floodplain with the floodwaters;
- Stimulation of aquatic plant growth;
- Stimulation of flowering in a number of species such as Lignum (Roberts and Marston 2000);
- The release of nutrients and subsequent “boom” in productivity act as cues to initiate breeding of waterbirds, frogs, fish and turtles.

When inundated the following ecological processes can be expected (Boulton and Brock 1999):

- Productivity boom may be maintained for some time (depending on conditions of light, temperature and nutrients released into the water column;
- Submerged aquatic plants grow and flower, while amphibious aquatic plants exist in their aquatic form;
- Aquatic invertebrates occur in both larval (aquatic stages) as well as some emerging into mature aerial forms;
- Productivity boom provides important food resources for waterbirds, fish, frogs, turtles as well as insectivorous and nectivorous terrestrial species;
- Nesting of waterbirds in a variety of inundated habitats including inundated trees (e.g. egrets, ibis, cormorants); shrubs (e.g. coots, swamphens); and sedges and rushes (e.g. magpie geese; Australasian bittern);
- Frogs breeding in shallow water and inundated vegetation, tadpoles mature and grow;
- Turtles nesting on sandy island habitats, eggs hatch and juveniles feed and grow; and
- Fish breeding in inundated vegetation and woody debris; larval and juvenile forms within water column.

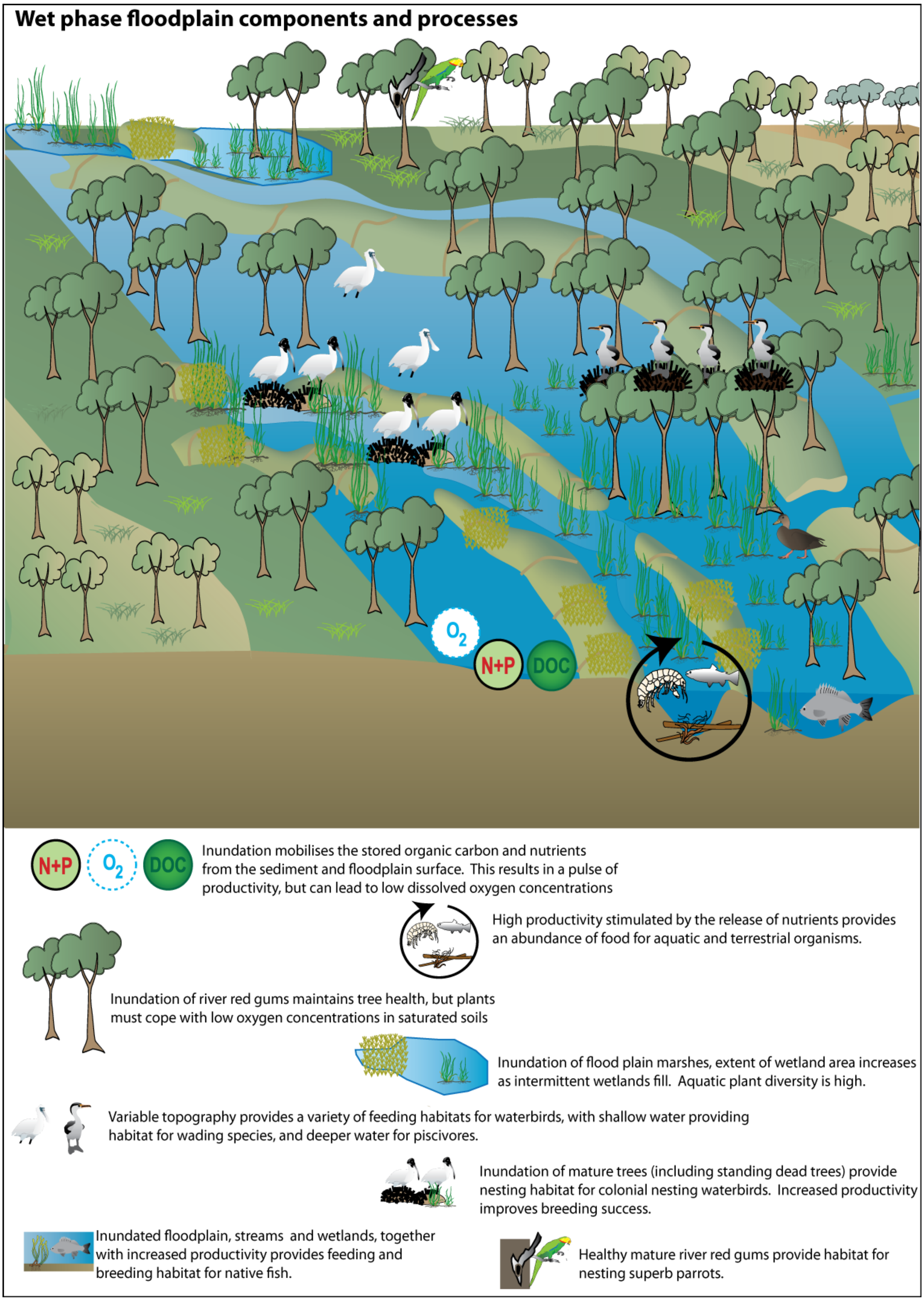


Figure 34: Simple conceptual model illustrating some of the interactions between critical components, processes and services in the NSW Central Murray Forests Ramsar site during times of floodplain inundation (wet phase).

5.2 Dry phase (drying and dry state)

The recession of floodwaters and subsequent drying of the soil results in the following ecological processes (Boulton and Brock 1999):

- As waters recede nutrients and salts become concentrated in floodplain wetlands as they dry by evaporation;
- Nutrients and organic carbon become stored in the sediment;
- Aquatic plants set seed to be stored dormant in the sediment for subsequent floods;
- Floodplain plants such as river red gum germinate and seedling emerge on the damp soil;
- Waterbirds fledge and disperse;
- Turtles migrate to nearby wet refuges, some aestivate;
- Fish return with receding waters to the river or remain in permanent channels.

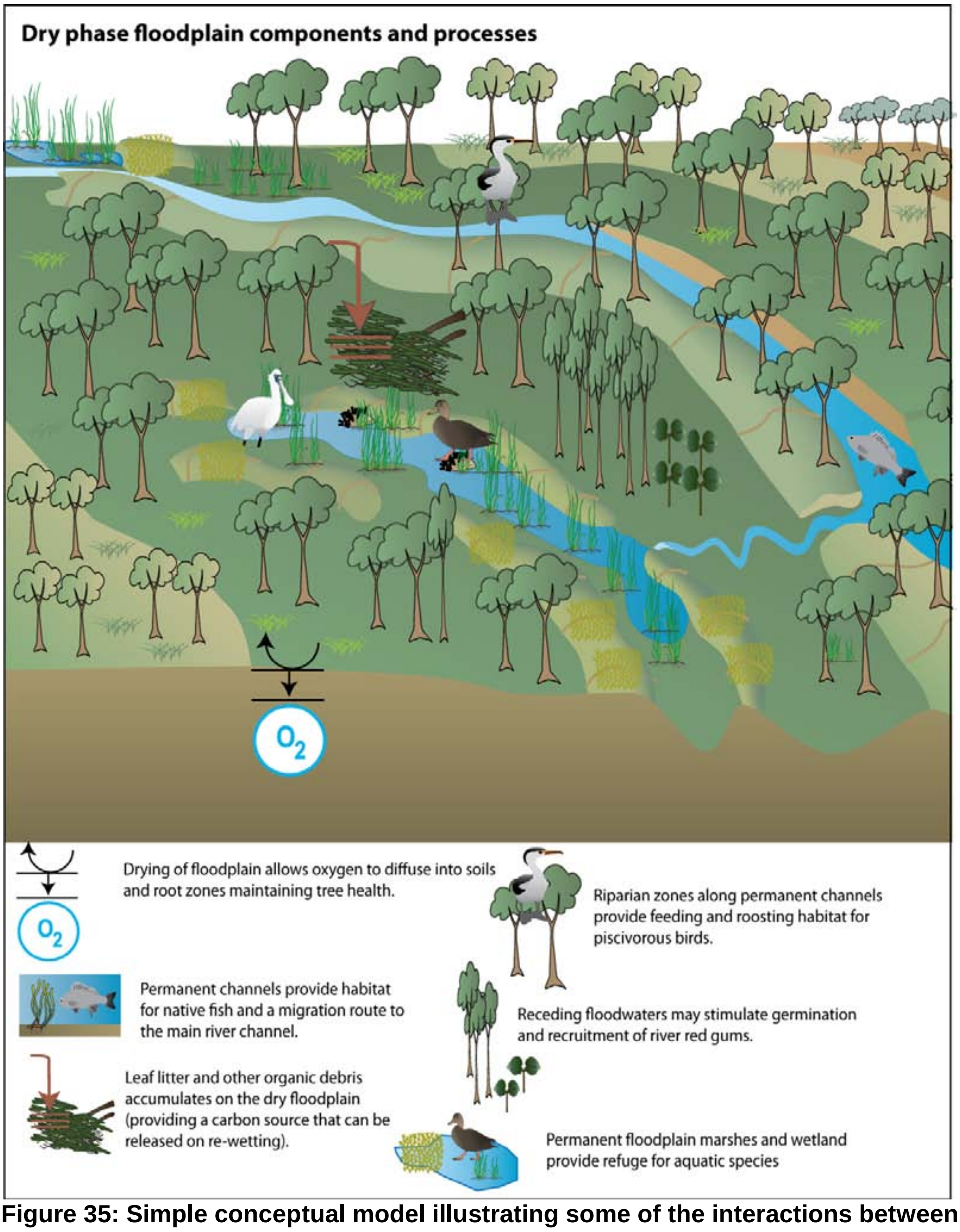


Figure 35: Simple conceptual model illustrating some of the interactions between critical components, processes and services in the NSW Central Murray Forests Ramsar site between floods (dry phase).

6. Limits of acceptable change

6.1 Process for setting Limits of Acceptable Change (LAC)

Limits of acceptable change are defined by Phillips (2006) as:

"…the variation that is considered acceptable in a particular measure or feature of the ecological character of the wetland. This may include population measures, hectares covered by a particular wetland type, the range of certain water quality parameter, etc. The inference is that if the particular measure or parameter moves outside the 'limits of acceptable change' this may indicate a change in ecological character that could lead to a reduction or loss of the values for which the site was Ramsar listed. In most cases, change is considered in a negative context, leading to a reduction in the values for which a site was listed".

LAC and the natural variability in the parameters for which limits are set are inextricably linked. Phillips (2006) suggested that LAC should be beyond the levels of natural variation. Setting limits in consideration with natural variability is an important, but complex concept. Wetlands are complex systems and there is both spatial and temporal variability associated with all components and processes. Defining this variability such that trends away from "natural" can be reliably detected is far from straight forward.

Hale and Butcher (2008) considered that it is not sufficient to simply define the extreme measures of a given parameter and to set LAC beyond those limits. What is required is a method of detecting change in pattern and setting limits that indicate a distinct shift from natural variability (be that positive or negative). This may mean accounting for changes in the frequency and magnitude of extreme events, changes in the temporal or seasonal patterns and changes in spatial variability as well as changes in the mean or median conditions.

It should be noted that LAC are not synonymous with management values or "trigger levels". The LAC described here represent what would be considered a possible change in ecological character at the site in absolute terms with no regard for detecting change prior to irrevocable changes in wetland ecology. Detecting change with sufficient time to instigate management actions to prevent an irrevocable change in ecological character is the role of wetland management and the management plan for a site should develop and implement a set of management triggers with this aim.

Additional Explanatory Notes for LAC

Limits of Acceptable Change are a tool by which ecological change can be measured. However, ECDs are not management plans and LACs do not constitute a management regime for the Ramsar site.

Exceeding or not meeting LACs does not necessarily indicate that there has been a change in ecological character within the meaning of the Ramsar Convention. However, exceeding or not meeting LACs may require investigation to determine whether there has been a change in ecological character.

In reading the ECD and the LAC, it should be recognised that the hydrology of many catchments in the Murray-Darling Basin is highly regulated, despite many of the wetlands forming under natural hydrological regimes that were more variable and less predictable. Many of the Ramsar wetlands of the Murray-Darling Basin were listed at a time when the rivers were highly regulated and water over allocated, with the character of these sites reflecting the prevailing conditions. When listed under the Ramsar Convention, many sites were already on a long-term trend of ecological decline.

While the best available information has been used to prepare this ECD and define LAC for the site, a comprehensive understanding of site character may not be possible as in many cases only limited information and data is available for these purposes. The LAC may not accurately represent the variability of the critical components, processes, benefits or services under the management regime and natural conditions that prevailed at the time the site was listed as a Ramsar wetland.

Users should exercise their own skill and care with respect to their use of the information in this ECD and carefully evaluate the suitability of the information for their own purposes.

LAC can be updated as new information becomes available to ensure they more accurately reflect the natural variability (or normal range for artificial sites) of critical components, processes, benefits or services of the Ramsar wetland.

6.2 LAC for the NSW Central Murray Forest Ramsar site

LAC have been set for the NSW Central Murray Forest Ramsar site based on conditions at the time of listing. However, it must be recognised that for some critical components and processes (particularly hydrology) long time frames need to be considered to characterise variability. The NSW Central Murray Forest Ramsar site was listed as a Wetland of International Importance in the middle of a long drought. Drought conditions were experienced during a severe and prolonged El Nino event in 1997, and although 2000 and 2001 were "wet years" drought conditions continued across southern NSW from mid 2002 until mid 2010 (DPI 2010). There is strong evidence to suggest that the hydrology of the site during the decade surrounding listing was insufficient to maintain critical components and processes such as river red gum forests and wetland bird breeding (Natural Resources Commission 2009). Therefore, consideration of long-term cycles of wetting and drying is necessary when determining LAC for this site.

Where possible, site specific information has been used to statistically determine LAC. In the absence of sufficient site specific data, LAC are based on recognised standards or information in the scientific literature that is relevant to the site. In all these cases, the source of the information upon which the LAC has been determined is provided. However, it should be noted that for many of the critical components and processes there are limited quantitative data on which to set limits. In these instances, qualitative LAC have been recommended. based on the precautionary principle. These will require careful review with increased information gained from future monitoring.

LAC are required for all identified critical components, processes, benefits and services (DEWHA 2008). However, due to the interrelated nature of components, processes and services a single LAC may in fact account for multiple components, process and services. For example, the LAC that addresses hydrology at NSW Central Murray Forests also covers the critical service of water provision and physical habitat. If hydrology were significantly altered this would lead to a loss of the services. In order to limit repetition in the LAC for NSW Central Murray Forests, a hierarchical approach has been adopted where LAC have been set for components or processes, which in this case has also covered critical services.

The columns in Table 25 contain the following information:

Critical components, processes and services	The component, processes or service that the LAC is a measure of.
Baseline / supporting evidence	Baseline information (relevant to the time of listing) and any additional supporting evidence from the scientific literature and / or local knowledge.
Limit of Acceptable Change	The LAC.
Confidence level	The degree to which the authors are confident that the LAC represents the point at which a change in character has occurred. Assigned as follows: High – Quantitative site specific data; good understanding linking the indicator to the ecological character of the site; LAC is objectively measureable. Medium – Some site specific data or strong evidence for similar systems elsewhere derived from the scientific

literature; or informed expert opinion; LAC is objectively measureable.

Low – no site specific data or reliable evidence from the scientific literature or expert opinion, LAC may not be objectively measurable and / or the importance of the indicator to the ecological character of the site is unknown.

Table 25: Limits of Acceptable Change for the NSW Central Murray Forests Ramsar site.

Critical components, processes and services	Baseline/Supporting evidence	Limit of Acceptable Change	Confidence level
Critical components and processes			
Hydrology (channels and low lying wetlands)	Average recurrence intervals (ARI) at the time of listing (based on 114 year modelled current conditions) for flow events considered important for channels and floodplain marshes for each of the forest groups are as follows (MDBA 2010): Millewa Forest Group (Murray River downstream of Yarrawonga) • 12 500 megalitres a day for 70 days (channels and wetlands) – ARI = 2 years; • 16 000 megalitres a day for 98 days (moira grasslands) – ARI = 3 years; Koondrook-Perricoota Forest Group (Murray River downstream of Torrumbarry) • 16 000 megalitres a day for 90 – ARI = 2.8 years; and Werai Forest Group (Edward River downstream of Deniliquin) • 5 000 megalitres a day for 60 days – ARI = 2.5 years. LAC have been set based on conditions at the time of listing (MDBA, 2010 e-flow model of 114 years current level of development). The LAC is assessed over a 10 year time span to account for the variability in hydrology at the site (i.e. to allow for three to five occurrences of the specified flow events within the assessment period).	*Number of events in any 10 year period (based on average recurrence intervals) for the specified flow events, not to be less than the following:* *Millewa Forest Group (Murray River flow downstream of Yarrawonga);* • *12 500 megalitres per day for 70 days – 5 events* • *16 000 megalitres a day for 98 days – 3 events* *Koondrook-Perricoota Forest Group (Murray River flow at Torrumbarry Weir);* • *16 000 megalitres per day for 90 days – 3 events* *Werai Forest Group (Edward River flow at Deniliquin);* • *5000 megalitres a day for 60 days – 4 events*	Medium

<table>
<tr><th>Critical components, processes and services</th><th>Baseline/Supporting evidence</th><th>Limit of Acceptable Change</th><th>Confidence level</th></tr>
<tr><td rowspan="2">Hydrology (moderate overbank flow)</td><td rowspan="2">Moderate overbank flow has been identified as important in terms of maintaining the ecological character of the site as the threshold at which river red gum forests and woodlands are inundated. The ARI (based on 114 year modelled current conditions) for key river flow events for each forest group are as follows (MDBA 2010):

Millewa Forest Group (Murray River downstream of Yarrawonga) – 25 000 megalitres a day (50% of river red gum forest inundated) for 60 days – ARI = 3.2 years;
Koondrook-Perricoota Forest Group (Murray River downstream of Torrumbarry) – 30 000 megalitres a day (70% of river red gum forest inundated) for 60 days – ARI = 4 years; and
Werai Forest Group (Edwards River downstream of Deniliquin) – 18 000 megalitres a day (significant proportion of river red gum forest and woodland inundated) for 30 days – ARI = 6.6 years.

As the forests are comprised of long-lived species, the maximum dry interval is also an important factor (J. Roberts pers. comm.). Maximum periods between the specified flood events specified above (based on 111 year record 1895 to 2006, current development) are 12.7 years for Millewa Forest Group and 11.8 years for Koondrook-Perricoota and 15 years for Werai Forest Group.

LAC have been set based on conditions at the time of listing (MDBA, 2010 e-flow model of 114 years current level of development) for ARI and the historical record (111 years) for maximum dry interval. The LAC is assessed over a 20 year time span to account for the variability in hydrology at the site (i.e. to allow for three to five occurrences of the specified flow events within the assessment period).</td><td>In any 20 year period the interval between the following flow events to be no more than:
• 13 years for the Millewa Forest Group (Murray River downstream of Yarrawonga) – 25 000 megalitres a day for 60 days;
• 12 years for the Koondrook-Perricoota Forest Group (Murray River downstream of Torrumbarry) – 30 000 megalitres a day for 60 days; and
• 15 years for the Werai Forest Group (Edwards River downstream of Deniliquin) – 18 000 megalitres a day for 30 days.</td><td rowspan="2">Medium</td></tr>
<tr><td>Number of events in any 20 year period (based on average recurrence intervals) for the specified flow events, not to be less than the following:

Millewa Forest Group (Murray River flow downstream of Yarrawonga);
• 25 000 megalitres per day for 60 days – 6 events
Koondrook-Perricoota Forest Group (Murray River flow at Torrumbarry Weir);
• 30 000 megalitres per day for 60 days – 5 events
Werai Forest Group (Edward River flow at Deniliquin);
• 18 000 megalitres a day for 30 days – 3 events.</td></tr>
</table>

Critical components, processes and services	Baseline/Supporting evidence	Limit of Acceptable Change	Confidence level
Hydrology (wide scale flooding)	Wide scale flooding has been identified as important in terms of maintaining the ecological character of the site as the threshold at which black box woodlands are inundated. The ARI (based on 114 year modelled current conditions) for key river flow events for each forest group are as follows (MDBA 2010): Millewa Forest Group (Murray River downstream of Yarrawonga) – 60 000 megalitres a day for 14 days – ARI = 7.1; Koondrook-Perricoota Forest Group (Murray River downstream of Torrumbarry) – 40 000 megalitres a day) for 60 days – ARI = 8.3 years; and Werai Forest Group (Edwards River downstream of Deniliquin) – 30 000 megalitres a day) for 21 days – ARI = 7.7 years. As the forests are comprised of long-lived species, the maximum dry interval is also an important factor (J. Roberts pers. comm.). Maximum periods between the specified flood events specified above (based on 111 year record 1895 to 2006, current development) are 24 years for Millewa Forest Group and 20.8 years for Koondrook-Perricoota and 23 years for Werai Forest Group. LAC have been set based on conditions at the time of listing (MDBA, 2010 e-flow model of 114 years current level of development) for ARI and the historical record (111 years) for maximum dry interval. The LAC is assessed over a 50 year time span to account for the variability in hydrology at the site (i.e. to allow for approximately five occurrences of the specified flow events within the assessment period).	*In any 50 year period the interval between the following flow events to be no more than:* • *24 years for the Millewa Forest Group (Murray River downstream of Yarrawonga) – 60 000 megalitres a day for 14 days;* • *21 years for the Koondrook-Perricoota Forest Group (Murray River downstream of Torrumbarry) – 40 000 megalitres a day for 60 days; and* • *23 years for the Werai Forest Group (Edwards River downstream of Deniliquin) – 30 000 megalitres a day for 21 days.* *Number of events in any 50 year period (based on average recurrence intervals) for the specified flow events, not to be less than the following:* *Millewa Forest Group (Murray River downstream of Yarrawonga)* • *60 000 megalitres a day for 14 days – 7 events;* *Koondrook-Perricoota Forest Group (Murray River downstream of Torrumbarry)* • *40 000 megalitres a day for 60 day – 6 events; and* *Werai (Edward River at Deniliquin)* • *30 000 megalitres a day for 21 days – 6 events.*	Medium

Critical components, processes and services	Baseline/Supporting evidence	Limit of Acceptable Change	Confidence level
Vegetation – River red gum forests and woodland	Extent of river red gum forests and woodlands in each forest group is as follows (Forests NSW unpublished): Millewa Forest Group • 26 181 hectares of river red gum forest • 4591 hectares of river red gum woodland (includes river red gum / black box woodland) Koondrook-Perricoota Forest Group • 22 215 hectares of river red gum forest; • 7356 hectares of river red gum woodland (includes river red gum / black box woodland) Werai Forest Group • 5861 hectares of river red gum forest; • 3386 hectares of river red gum woodland (includes river red gum / black box woodland) In addition, there are benchmarks for tree condition for both Millewa and Koondrook-Perricoota Forest Group (Cunningham et al. 2009) with 96% of the red gum forest and woodland at Millewa Forest Group in moderate or better condition and 95 percent at Koondrook-Perricoota at the time of listing (2003). Information on condition of forests in Werai is data deficient and a baseline must be established before a LAC can be determined. Although there is information on extent and condition for part of the Ramsar site, there is no indication of variability in either of these measures. In additional information on variability in these ecosystems from comparable sites could be sourced. As such an objective, statistically based LAC cannot be determined and a figure of 20 percent change has been selected informed by local knowledge and expert opinion of the steering committee.	*Extent of river red gum forest to be no less than:* • *20 000 hectares at Millewa Forest Group;* • *17 800 hectares at Koondrook-Perricoota Forest Group; and* • *4700 hectares at Werai Forest Group* *Extent of river red gum woodland (includes river red gum / black box woodland) to be no less than:* • *3650 hectares at Millewa Forest Group;* • *5900 hectares at Koondrook-Perricoota Forest Group; and* • *2700 hectares at Werai Forest Group* *River red gum condition to be "moderate" (according to the method of Cunningham et al. 2009) or better for at least 80 percent of forest.*	Low

Critical components, processes and services	Baseline/Supporting evidence	Limit of Acceptable Change	Confidence level
	Forest structure and structural diversity is an important characteristic of river red gum forests in terms of habitat value (Horner et al. (2010). This includes aspects such as tree density, age classes, size ranges and the presence of features such as boughs and tree hollows. However there is little information on the forest structure of river red gum forests and woodlands from within the Ramsar site and this has been identified as a knowledge gap. As such no LAC can be set at this time	*Insufficient information to develop a LAC for forest structure at this point in time.*	Not applicable
Vegetation – Floodplain marshes	Extent of floodplain marshes in each unit is (Green and Alexander 2006): • *2300 hectares at Millewa Forest Group* • *1800 hectares at Koondrook-Perricoota Forest Group* • *666 hectares at Werai Forest Group* As with the river red gum extent above, there is no indication of variability, but extent of inundation and community composition will vary considerably over wetting and drying cycles. As such an objective, statistically based LAC cannot be determined and a figure of 25 percent change has been selected informed by local knowledge and expert opinion of the steering committee. Ideally a LAC would also be set for vegetation community composition. However, there is insufficient data at this stage upon which a LAC can be based.	*Extent of floodplain marshes to be no less than:* • *1725 hectares at Millewa Forest Group;* • *1360 hectares at Koondrook-Perricoota Forest Group; and* • *500 hectares at Werai Forest Group*	Low
Native fish (species richness)	Data for native fish are limited from the Ramsar site. Quantitative data are available for the Barmah-Millewa Forest Group with an average abundance of native fish (2003 to 2006) of 12 000 ± 2700 (mean ± standard deviation; n=3; King et al. 2007). A total of 15 native fish species were recorded in 2002 – 2006 (King et al. 2007). The survey areas were however, not limited to the Ramsar site. There are no recent data from Koondrook or Werai Forest Group. There is a lack of underlying knowledge of variability in fish species richness and the relationship with ecological character. As such the LAC set for species richness has been afforded a low level of confidence and is based on 25% change from 2003 – 2006 surveys.	*A minimum of 11 native fish species in three out of five of surveys conducted in Barmah-Millewa Forest.*	Low

Critical components, processes and services	Baseline/Supporting evidence	Limit of Acceptable Change	Confidence level
Native fish (threatened species)	Three threatened native species of fish known from Millewa Forest Group (Jones 2006; King et al. 2007; Davies et al. 2008). Population size, dynamics and distribution not fully understood. Koondrook and Werai data deficient.	*Presence of Murray cod trout cod and silver perch in three out of five of surveys.*	Low
Wetland birds (abundance)	A total of 64 species of wetland bird have been recorded from within the site. However, there is no indication of the number of species that regularly utilise the habitats within the site. There is evidence that the site "regularly" supports thousands of colonial nesting waterbirds during significant flood events with successful breeding occurring on 10 occasions between 1979 and 1999 (Leslie 2001). LAC set based on the findings of Leslie (2001) and a definition of successful breeding of 80 percent of chicks fledged (Rick Webster, NPWS, personal communication).	*Successful breeding (80 percent chicks fledged) of colonial waterbirds in at least two years in ten.*	Medium
Wetland birds (threatened species)	The site supports at least three threatened species of wetland bird (Australian painted snipe, Australasian bittern and superb parrot. Of these there are regular records of Australian bittern from Millewa Forest Group (MDBC 2007c) and superb parrot from the Millewa Forest Group (Webster 2003). While there are no population estimates for the Australasian bittern, it is thought that the population of the superb parrot fluctuates between 35 and 250 individuals and conservation of known nest trees is critical (Webster 2003). Insufficient data from the Ramsar site to set a statistically based LAC.	*Presence of the Australasian bittern in Millewa Forest Group when reed beds are inundated.* *Presence of the superb parrot and evidence of nesting in Millewa Forest Group annually.*	Low Low
Critical Services			
Significant wetland types	This critical service is linked to changes in the frequency and duration of wetland wetting and drying as well as changes in extent and condition of wetland vegetation. Therefore no direct LAC has been developed and instead the critical service will be assessed indirectly through changes in the ARI and duration of specific flow events, extent and condition of river red gum forests and woodlands and extent of floodplain marshes.	*See LAC for hydrology and vegetation*	Not applicable

Critical components, processes and services	Baseline/Supporting evidence	Limit of Acceptable Change	Confidence level
Physical habitat	This critical service is linked to changes in the frequency and duration of wetland wetting and drying as well as changes in extent and condition of wetland vegetation. In addition, wetland bird abundance can be used as a surrogate measure. Therefore no direct LAC has been developed and instead the critical service will be assessed indirectly through changes in the ARI and duration of specific flow events, extent and condition of river red gum forests and woodlands, extent of floodplain marshes and abundance of wetland birds.	*See LAC for hydrology, vegetation and wetland birds.*	Not applicable
Threatened species	This critical service is indicated by the presence of threatened species at the site. Therefore no direct LAC has been developed and instead the critical service will be assessed through presence of threatened species.	*See LAC for wetland birds, fish and vegetation*	Not applicable
Ecological connectivity	The site maintains connectivity between the river and floodplain wetlands and channels for fish spawning and recruitment. This service is maintained by hydrology and can also be indicated by the species richness and abundance of native fish. Therefore no direct LAC has been developed and instead the critical service will be assessed indirectly through changes in hydrology and native fish populations.	*See LAC for hydrology and native fish.*	Not applicable

7. Threats to ecological character

7.1 Water resource use

Water resource use in the Murray Darling Basin involves large scale water interception, delivery and extraction which has resulted in major changes to the hydrology of the Murray River (Gippel and Blackham 2002; MDBC, 2008) and floodplain wetlands (MDBC, 2007d). Adverse alterations to hydrology as a result of river regulation have been identified as the most significant threat to river and floodplain health in the Murray Darling Basin (Thoms et al. 2001). The Hume Dam was constructed in 1934 and this together with other regulatory structures, water delivery and operational rules have been influencing the hydrology of the NSW Central Murray Forests for a number of decades and were in place at the time of listing as a wetland of international importance. Altered hydrology should still be considered a threat to the ecological character of the site as the negative impacts of regulation are still developing. River red gum forests are long-lived, with records of trees 500 to 1000 years of age (Jacobs 1955). As such, past water resource management could have current and future impacts on these ecosystems through time-delayed or “lag” effects acting either directly on the systems, or by reducing their resilience to other environmental factors such as drought, climate change, grazing or introduced species, or by changing the competitive interactions among different species.

The hydrology of the NSW Central Murray Forests has altered significantly over the past 100 years mostly as a result of flow regulation and water extraction (Gippel and Blackham 2002). These changes have led to a reduction in the frequency and duration of spring wetland inundation in all three forests and an alteration to the seasonality of inundation in the Millewa forest (Table 26). These are baseline conditions for ECD purposes.

Table 26: Summary of the changes to hydrology.

Variable	Change due to river regulation being experienced at the time of listing	Location
Reduced frequency of spring flooding	The frequency of floods in the range 42 000 to 78 000 megalitres a day peak magnitude has more than halved (Thoms et al. 2000). The mean length of the period between floods has increased 2.5 times, while the maximum length of the dry period has increased six-fold (Leitch 1989).	Millewa Forest Group
	Frequency of spring floods has decreased from one in three years to one in ten years (MDBC 2008).	Koondrook-Perricoota Forest Group
	Reduced magnitude of flood events, with the one in ten year floods decreasing from 15 000 megalitres a day to 3 000 megalitres a day (Gippel 1999).	Werai Forest Group
Reduced duration and extent of spring floods	The duration of floods that inundate river red gum forest have reduced from five months per year to two months per year (Leitch 1989).	Millewa Forest Group
	Duration of spring floods decreased by 50 percent from average duration of seven weeks to three weeks (URS 2001).	Koondrook-Perricoota Forest Group
	Flows between 18 and 40 000 ML/day decreased from an average of 30 days to 12 days per year (Green 2001).	Werai Forest Group
Altered flow seasonality	Unseasonal (summer and autumn) flooding of the forest due to rain rejection (Thoms et al. 2000).	Millewa Forest Group
	Lowest flows in the Murray River now occur in winter rather than summer (Thoms et al. 2000).	Millewa, Koondrook-Perricoota and Werai Forest Groups
	Increased autumn flows in the Edward River (Gippel 1999).	Werai Forest Group
Reduced variability	Under natural conditions, average monthly flows in the Murray River (between Yarrawonga and Torrumbarry Weir) vary between 100 gigalitres a month and 980 gigalitres a month, whereas under current conditions the average monthly flows vary between 110 gigalitres a month and 400 gigalitres a month (MDBMC 1995).	Millewa, Koondrook-Perricoota and Werai Forest Groups
	Flows in the Edward River at near channel capacity for eight months of the year. Coefficient of variation decreased from 0.43 to 0.19 (Gippel 1999). Large reduction in number of no and low flow events (Green 1999).	Werai Forest Group
Reduced annual volume	Annual flow volume in the Murray River downstream of Yarrawonga Weir under current conditions is 25 percent less than under natural conditions (Maheshwari et al. 1993).	Millewa, Koondrook-Perricoota and Werai Forest Groups

The potential ecological responses to altered hydrology in the River Murray were summarised by Gippel and Blackman (2002) and those considered of direct relevance to the ecological character of the NSW Central Murray Forests are reproduced in Table 33. In addition, there is specific evidence of the effects of altered hydrology on the components and processes of the Ramsar site, and although much of this evidence is from the Barmah-Millewa Forest, similar processes could be expected in comparable communities at Koondrook-Perricoota and Werai Forest Groups.

Table 27: Potential ecological responses to altered hydrological variables (Gippel and Blackham 2002).

Variable	Potential ecological response
Reduced flow magnitude	Decrease in near-channel groundwater levels and consequent reduction in the health of riparian trees.
	Reduced floodplain-channel connectivity with associated impacts to carbon cycling, primary productivity and lateral fish migration.
	Changes in river invertebrate fauna from typically lotic to more lentic species.
	Increase in the abundance of introduced fish with wide habitat tolerances.
Decreased flow variability	Decreased habitat diversity.
	Altered species composition and reduced species diversity (in-channel and in floodplain wetlands).
Altered flow seasonality	Altered in-stream primary productivity, with increased algal growth during summer flows when light and temperature are less limiting than during winter.
	Reduction in life-cycle cues and migration opportunities for native fish.
	Disruption to the breeding responses of benthic macroinvertebrates.
Reduced duration and extent of floodplain inundation	Decreased productivity on the floodplain with flow on effects to higher organisms through the food chain.
	Reduced recruitment of native fish.
	Decreased germination flowing inundation, due to lower viability of seed that has been exposed for many seasons.
	Decreased breeding opportunities for waterbirds

There is evidence that river regulation has had an impact on waterbirds within the NSW Central Murray Forests Ramsar site particularly on colonial nesting waterbirds. Flooding creates suitable nesting and feeding habitats for a range of waterbirds and acts as a stimulus for breeding. It has been estimated that a flood duration of approximately five months is required for the successful breeding of waterbirds in the Barmah-Millewa Forest (Leslie 2001). The reduced frequency, extent and duration of spring floods have resulted in a dramatic decrease in the number of species and individuals breeding in both Millewa and Koondrook (Leslie 2001; Ecological Associates 2004). The interval between breeding episodes during extended drought periods may be the most critical factor affecting colonially nesting waterbirds in the forests. Given that the average life span of a waterbird is five to seven years, the current flooding frequency may result in many waterbirds dying without breeding, thus affecting the long-term viability of populations (Leslie 2001).

River regulation and altered hydrology have also had negative effects on native fish populations as unseasonal flooding favours carp breeding (Norris et al. 2001). This is supported by the low proportion of native fish (versus introduced species) in the Murray River adjacent to the Millewa forest in comparable unregulated streams (Gerhke et al. 1995). Floodplain wetlands are important for the successful recruitment of many native fish species (King et al. 2009) and so reduced floodplain inundation and consequent reduced connectivity between wetlands and river habitats may result in decreased habitat for breeding and for juvenile native fish.

In addition, reduced frequency of inundation, coupled with unseasonal inundation (during warmer months) can increase the risk of “blackwater events”. Although floodplains are natural sources and sinks of organic matter and inundation should initiate a pulse of productivity, under certain conditions, this boom in productivity can result in low dissolved oxygen, a decrease in pH and a release of salt from the floodplain (McCarthy et al. 2006). This phenomenon is known as a ‘blackwater event’.

Breakdown of biomass during floods is an integral part of the carbon exchange mechanism on floodplains, however in certain circumstances, this can have negative effects on flora and fauna both on the floodplain and in the river channel and, in severe instances, may result in fish kills. Howitt et al. (2005) indicated that in the case of Barmah Forest this might be the result of unseasonal inundation during warmer months (summer) resulting in higher floodplain temperatures increasing primary productivity and the rate of chemical reactions. These processes and resultant impacts on water quality are likely to be similar in the NSW Central Murray Forests.

It is possible that altered hydrological regimes are also influencing salinity within the site. Depth to groundwater is not known, but there are examples of dryland salinity in nearby areas (Paul Childs, NPWS personal communication). The potential risks and impacts from this threat are a knowledge gap for the site.

7.2 Climate change

The CSIRO Murray-Darling Basin Sustainable Yields Project (CSIRO 2008; Chiew et al. 2008) has modelled the effect of climate change and related factors on the water resources in the Murray Darling Basin, including predictions for the icon sites. Models were produced for four climate scenarios: historical climate with current development, recent climate with current development, future climate with current development and future climate with future development. Under the future climate models, there was a range of potential climate estimates ranging from extreme wet to extreme dry. These different modelled scenarios resulted in a range of predictions; however, it is likely that there will be less rainfall in the Murray Catchment and increased temperatures. The median estimate is for a 10 percent decrease in average annual run-off, while extreme estimates range from a 37 percent reduction to a seven percent increase in average annual runoff (CSIRO 2008).

Almost all modelled scenarios predicted an increase in the interval between flooding of the NSW Central Murray Forests. This reduction in floodplain and wetland inundation is likely to exacerbate the effects of river regulation already observed at the sites (see Section 7.1) with an increase in stress to vegetation and fauna communities.

Climate change increases the need for active management of the site to maintain ecological character during periods of low water or moisture availability. These actions in isolation and / or combination may include:

- Construction of infrastructure that allows for the targeted watering of the site, in a water efficient manner, during periods of relatively low flow;
- Providing opportunities for the completion of critical lifecyle stages of important wetland species through managed watering events;
- Silviculturally thinning of river red gum stands that are under moisture stress to allow remaining stems to survive and become healthier; and
- Securing and applying targeted environmental water.

These actions contribute to managing drought conditions and adapting to the potential impacts of climate change in the longer term. It is noted that these adaptive measures are currently in place on the site.

7.3 Forestry activities

These ecosystems were recognised as “working forests” at the time of designation as wetlands of international importance with the ecological character at the time of listing reflecting the continuing use of these forests, including timber harvesting. Therefore authorised, sustainable timber harvesting and other forestry activities under the prevailing legislative and planning framework and International Standards of Sustainable Forest Management[4] is considered a provisioning service provided by the site refer Section 4.4.1). The qualification of benefits and services arising from forest management at the site is a

[4]Forests NSW is certified as sustainable under the Australian Forestry Standard (AS 4708-2007) an internationally recognised certification scheme under the Programme for the Endorsement of Forest Certification Schemes (PEFC).

contentious issue. It can be argued that forest management is historically essential to the establishment and maintenance of ecological character at the site since alternative land uses may have resulted in its degradation. Surrounding agricultural lands of the Riverina Plain have been substantially cleared and modified and have significantly lower conservation value than the site. Management of weeds, pests and fire regimes as part of an operating forest would also have positive effects on native biota. However “disturbance to vegetative community through cutting/clearing” is recognised as a threat to Ramsar wetlands (Wetlands International, 2008).

In NSW vegetation clearing is defined as the destruction of a sufficient proportion of one or more strata (layers) within a stand or stands of native vegetation so as to result in the loss, or long term modification, of the structure, composition and ecological function of a stand or stands (DECC 2008b). Timber harvesting at the site does not constitute vegetation clearing since it affects a small proportion of native forest in the site (<5% of a given State forest annually) and within harvest areas no vegetation strata is completely removed and understorey vegetation is disturbed as little as is practicable.

The Forests NSW (2007) *Review of Environmental Factors (REF) for the Harvesting of River Red Gum within the Central Murray Forests Area* noted that harvesting operations, in particular tree felling, may have a short term, temporary impact on the local environment. They may:

- Disturb local flora and fauna and possibly cause individual injury or mortality;
- Disturb fish habitat and obstruct fish passage;
- Alter forest structure by removing some of the overstorey and damaging the understorey;
- Increase the amount of woody and fine debris on the forest floor and increase fire risk and potential fire risk; and
- Encourage the spread of weeds and feral species.

Other short and long term impacts that may arise from forestry activities may include:

- Fragmentation of habitat and associated increased risk of mortality of animals through stress, increased energy costs of feeding and travelling, or displacement from core habitat (Bauer et al, n.d.).
- Long term changes in forest structure due to silvicultural practices designed to maximise stand condition, regeneration and the volume of merchantable timber (State Forests of NSW, 2000; Thompson, M. pers. comm.);
- Cumulative loss of important habitat resources, especially those which take a long time to develop such as large mature and/or hollow-bearing trees (Gibbons and Lindenmayer, 2002; Vesk et. al. 2008); and
- Changes to the composition of local flora and fauna populations by favouring species adapted to disturbance and/or forest structures perpetuated by silvicultural practices (Lindenmeyer et al. 2008; Smith 1985; Kavanagh et al. 1985).

The majority of these impacts are short term and confined to the immediate harvest area. Over long terms timber harvesting does not necessarily result in significant changes to ecological character since harvested areas are allowed to regenerate. These silvicultural practices are intended to maintain the character of the river red gum forests. Other critical components, processes and services, including floodplain depression marshes, fish, wetland birds and in stream habitats are intended to be protected by the Forest Management Zone classification and special prescriptions (Forests NSW 2008a).

Timber harvesting may, over time, result in the loss of important resources that take a long time to develop (Vesk et al. 2008). These include components such as large, mature or hollow-bearing trees. Timber harvesting operations conducted in Australian forests may result in the following changes to the hollow-bearing tree resource:

- An overall reduction in the number of hollow-bearing trees;
- Changes in the spatial arrangement of hollow-bearing trees, including from a random to a clumped distribution; and

- Reduced recruitment of hollow-bearing trees through high rates of attrition of retained stems under some silvicultural systems and/or rotation lengths shorter than the period required for eucalypts to develop suitable hollows (Gibbons and Lindenmayer, 2002).

Measures to perpetuate the hollow resource within the site rely on two complementary approaches:

- Exclusion of harvesting from areas that are resource-rich and/or connect significant areas of habitat across the landscape, such as riparian corridors; and
- Prescriptions within the area available for harvesting which provide for the retention of habitat trees as well as recruitment trees, which would develop into habitat trees over time (Forests NSW 2008).

Sustainable forest management is a key objective of the management of these forests (Forests NSW 2008) and forestry operations undertaken according to licences issued by DECCW under the TSC Act. A tree crown condition target of the maintenance of 65 percent of dominant and co-dominant trees is a key performance condition target of Icon Site Environmental Management Plans (MDBC 2007b) and is incorporated into the silvicultural objectives of harvesting plans to maintain forest structure. In implementing these objectives, established sustainable forestry practices could not meet the criteria as vegetation clearing or a “key threatening process” under the NSW TSC Act. Harvesting at the site would only constitute “unsustainable timber harvesting” if monitoring detected a long term modification of the structure, composition and ecological function of the river red gum forests at the site.

The effects of timber harvesting on the ecological character of the NSW Central Murray Forests Ramsar site are ameliorated by implementation of the Management Plan for the Murray Management Area, Forest Management Zoning in NSW State Forests, the Harvest Planning Manual, Riverina ESFM Plan, licence conditions issued under the Threatened Species Conservation Act 1995 and the Native Forest Silviculture Manual (MDBC 2006). Direct impacts on the majority of the critical components, processes and services described in this ECD are avoided by these measures. For instance, Forest Management Zoning precludes logging in the vicinity of floodplain marshes and in-stream habitats (drainage lines). This would avoid direct impacts on marsh-nesting wetland birds, native fish and their habitats. Further prescriptions are designed to protect specific fauna groups, such as hollow-dependant fauna, and there is some evidence they are effective. Webster (2004) found that 97 percent of nest trees for the Edward River breeding population of the superb parrot would be protected by existing prescriptions. However adequate provision of nest trees and other habitat resources is a complex issue and must consider longer time scales. Gibbons and Lindermayer (2002) suggest that the sustainable conservation of habitat trees must account for senescence, storm or bushfire damage to existing habitat trees and recruitment of future habitat trees from younger age classes.

7.4 Altered fire regimes

Fire shapes the composition and distribution of many plant and animal communities across Australia and is a vital part of many Australian ecosystems. Inappropriate fire regimes, however, can be a threat to wetland ecosystems. Destructive fires can be defined as fires occurring at frequencies, intensities, seasons, and scales that lie outside the ecological and physiological tolerances of resident plants and animals (VEAC 2008). Unfavourable fire regimes include intense, destructive wildfires but also low intensity fires if their frequency, seasonality or extent has a negative impact on biodiversity. Forests NSW does not use controlled burns as a fine fuel reduction technique. Fine fuels are instead reduced through grazing where that is consistent with the Grazing Strategy. Therefore destructive fires are most likely to arise from uncontrolled wild fires, accidental ignitions or arson.

Although mature river red gum trees can survive low intensity fires (MacNally and Parkinson 2005) saplings are fire-sensitive (Dexter 1978) with even fires of moderate intensity sufficient to damage the cambium leaving the stem susceptible to secondary attack by fungal pests. As this species lacks a lignotuber high intensity fires will generally result in significant mortality.

Historically seasonal flooding maintained grasses in a generally uncured state over the hotter summer months thereby reducing available fuels and the overall bushfire hazard.

Fire is not now considered to be a common element of these ecosystems, although historical evidence from early settlers (Curr 1883) reports a large number of fires in the area. From this it can be inferred that numbers of river red gum trees have increased markedly since European settlement. This is supported by regeneration studies, which indicate that generally riverine vegetation species do not have the morphological adaptations that are stimulated by fire. Instead, river red gum forests and their associated riverine vegetation contain species with regeneration strategies that are keyed to flooding (VEAC 2008).

High intensity fires also have the potential to remove large quantities of nutrients from the system, remove protective cover of the mineral soil, destroy living organisms, consume organic matter in surface soils, permanently change chemical properties of soil particles and impact on soil structure. Flooding after high intensity fire may cause large quantities of ash to enter the river system which may dramatically change the aquatic environments of downstream rivers (Forests NSW 2008a).

In recognition of the significant threat that destructive fires pose to the river red gum estate Forests NSW has developed a number of strategic planning and fire suppression measures to ensure fires are minimised, but when they do occur, are detected and suppressed as soon as possible.

Since river red gums are particularly sensitive to high intensity fire, fire needs to be managed to provide for low intensity and low frequency fire regimes. This may mean the management not only of fire itself but other factors that can affect the intensity and frequency of fires. For example the risk of fires from camping areas has been significantly reduced through a solid fuel ban within the Central Murray Forests Ramsar site. Preparation of access tracks and firebreaks prior to each summer ensures fire crews are able to respond quickly to outbreaks that may impact upon the site. The reduction in seasonal flooding, that historically maintained uncured grass fuels through summer, has increased fuel availability of grasses that now cure each year through the summer, significantly increasing the bushfire hazard. The targeted reduction of these fuels through grazing, in accordance with the Riverina Grazing Management Strategy, reduces the bushfire hazard and reduces bushfire potential of the Ramsar site.

In conclusion, destructive fires are viewed as a serious threat to the ecological character of the NSW Central Murray Forests. A major wild fire under extreme conditions could destroy or damage a significant proportion of the timber resource within the Koondrook-Perricoota Forest Group. It could also, in the wrong place, impact significantly on core breeding habitats of important species such as the superb parrot. Moisture deficits at very low levels, due to a changing climate (see section 7.2), increase the likelihood of destructive fire in the coming years.

7.5 Invasive species

Invasive plants and animals can be broadly defined as species that have undesirable impacts, which may be economic, environmental or social and can include native as well as exotic taxa. Within the NSW Central Murray Forests Ramsar site invasive species include:

- Weeds;
- Introduced fish (for example carp);
- Feral European honey bees; and
- Vertebrate pests (for example. rabbits, pigs, foxes, cats, dogs).

Although there has not been comprehensive vegetation mapping or weed assessments within the Ramsar site, Forests NSW has joined with local government, other agencies and stakeholders to develop regional strategies to manage weeds and other plants of concern (Forests NSW 2008a). Significant weed species that are present at the site that have been identified as requiring management as part of this process include: woody weeds (willows, sweet briar, blackberry, African boxthorn), climbers and creepers (bridal creeper, golden dodder) broad-leafed weeds (thistles, St John's wort, Noogorra burr, Bathurst burr and horehound), perennial grasses (spiny burr grass), annual grasses (quaking-grass, wild oats and *Bromus* spp.) and aquatic weeds (arrowhead and salvinia) (Thompson M. personal communication; Harrington B. personal observation.) The distribution of these weed species varies with habitat type and inundation frequency. However, the effects are similar and include displacement of native vegetation species and loss of physical habitat and food sources for animals.

Carp are indiscriminate habitat users and prolific breeders and have expanded rapidly in distribution and abundance to dominate waterways in the Murray-Darling Basin (Koehn et al. 2000). River regulation and altered hydrology are thought to have favoured the spread of carp, competitively advantaging them over native fish, particularly in areas with more permanent or unseasonal inundation (Gippel and Blackham 2002). The Barmah-Millewa forest has been identified as a potential recruitment zone for carp and they comprised 80 percent of the fish biomass in 1999 to 2001 (Stuart and Jones 2002). Carp compete with native fish and may contribute to water quality deterioration by increasing turbidity and bank erosion. Commercial harvesting of adult carp in Moira Lake has varied between 76 tonnes in 2001 to less than 20 tonnes in recent years (King 2005) and they have been utilised for fertiliser and human consumption. A National Carp Management Strategy and local carp action plans influence management.

The European honey-bee (*Apis mellifera*) was introduced to Australia in 1822 (Oldroyd et al. 1997) and although it is commercially valuable, feral populations have spread across Australia. Honeybees potentially affect native flora and fauna though: competition for tree hollows, competition for nectar and pollen, and disruption of plant-pollinator systems. Feral bees are thought to have a more significant impact on native bees than commercial honey-bees, as commercial species are typically only present when resources are high (flowering seasons) and are regulated to ameliorate impacts: Forests NSW issues Occupation Permits for Apiary at the site and regulates the numbers and locations of hives (Forests NSW 2008a). Feral honey-bees are present also when resources are low and as they are able to feed earlier in the day than native bee species, they may have an impact on native bee populations (Oldroyd et al. 1997).

Vertebrate pest animal species such as pigs (*Sus scrofa*), European rabbits (*Oryctolagus cuniculus*) and European red foxes (*Vulpes vulpes*) have all been recorded within the Ramsar site.

In accordance with the ESFM plan (Forests NSW 2008a), extensive weed and pest animal control programs are carried out on an annual basis. Control programs are developed in conjunction with local and regional weed and pest animal management agencies to complement landscape wide control programs. An annual control program is developed and implemented that targets, as a priority, blackberry, African boxthorn, St Johns wort, Noogoora burr, Bathurst burr, golden dooder, bridal creeper, horehound, willow, foxes, rabbits and carp. Control measures include biological control, spraying, creation of exclusion zones, mechanical destruction, poisoning, fishing, and baiting and harbour destruction. A biannual fox baiting program is undertaken at the site, which is a cross tenure program organised by the Rural Lands Protection Board that targets foxes on both private and public lands. The ongoing management of pests is important in maintaining the ecological character of the site.

7.6 Human disturbance (public use pressures)

Un-managed recreational activities can have a negative impact on wetland ecosystems. For example, vehicle tracks can compact the soil and impact on flora and fauna and increase access for introduced predators such as foxes. Recreational activities can also degrade habitat: e.g. digging for bardi grubs disturbs the soil, which promotes weed germination; and power boating activities can damage river bank vegetation and contribute to soil erosion and sedimentation of rivers (VEAC 2008).

A potentially significant threat to the ecological character of the Ramsar site from public use pressures is from illegal firewood collection, particularly the practice of removing fallen timber. Fallen timber is an important habitat resource for a large number of animal species within river red gum forests. MacNally et al. (2002) estimated that more than 40 tonnes of fallen timber per hectare is required to maintain the populations of some vertebrate species such as the yellow-footed antechinus (*Antechinus flavipes*). The yellow-footed antechinus is not a wetland-dependant species but is an indicator of the value of fallen timber in River red gum forests. In addition, fallen timber is important to microorganisms, invertebrates and vertebrate species and as a carbon source and shelter substrate for fish and other aquatic organisms. Removal of significant amounts of timber can have negative effects on biodiversity and species richness as well as impacts to carbon and nutrient cycling through effects on the detrital food chain.

Within the Ramsar site the cutting, obtaining or removal of timber, for use as domestic fuel, is controlled by the Forestry Act and can only be done once the appropriate licence has been issued by Forests NSW. Extensive checking of permits and licences by both Forests NSW Authorised Officers and NSW Police members ensures that the incidence of illegal removal of timber is very low (G. Rodda pers. comm.) In addition, felling and removal of dead standing trees is not permitted.

7.7 Acid sulphate soils

Acid sulphate soils (ASS) form under conditions where waterlogged sulphidic sediments provide ideal conditions for the build up of mineral iron pyrite. Left undisturbed ASS are benign, but disturbance exposes sulphidic compounds in the soil to air and results in the formation of sulphuric acid (Hicks et al. 1999). The production of acid can have a direct affect on aquatic biota, as well as resulting in altered chemical conditions that can result in deoxygenation of the water column and/ or the release of toxic metals from the sediment.

CSIRO has produced broad maps of ASS potential across the continent and these assign a low or very low probability of ASS to the majority of the NSW Central Murray Forests; the exception is in a number of depressional wetlands within the forests, such as the Moira Marshes, which are afforded a high probability of ASS. More detailed investigations (Hall et al. 2006) indicate that Horseshoe lagoon (in the Koondrook Forests) is considered to “probably” contain sulphidic sediments and Reed Bed Swamp is considered to “possibly” contain sulphidic sediments.

7.8 Summary of threats

Although a risk assessment is beyond the scope of an ECD, the DEWHA (2008) framework states that an indication of the impacts of threats to ecological character, likelihood and timing of threats should be included (Table 28).

Table 28: Summary of threats to the NSW Central Murray Forests Ramsar site.

Actual or likely threat or threatening activities	Potential impact(s) to wetland components, processes and/or service	Likelihood [1]	Timing [2]
Increased water resource development (decreased frequency and duration of inundation; altered seasonality of inundation)	Declining health and changed composition of river red gum forests. Depletion in extent and composition of floodplain marshes. Altered vegetation community composition. Decreased breeding and foraging habitat for fauna. Absence or disruption of bird, fish and frog breeding events.	Low	Current
Increased environmental watering.	Black water events	Certain	Current
Climate change (increased temperatures and decreased rainfall).	Reduction in water availability. Increased frequency and intensity of wildfire. Increased risk of blackwater.	Medium	Long-term
Forestry activities	Short term, localised mortality or displacement of flora and fauna Medium term removal of habitat resources, altered vegetation community composition and structure. Long term, potential loss of large hollow bearing trees, affecting breeding habitat.	Certain (short and medium term effects) Medium (long term effects)	Current
Altered fire regimes (increased frequency and intensity of fires)	Death of mature river red gums. Adverse changes to forest structure. Loss or degradation of habitat.	Medium	Current
Invasive species (weeds, and pests)	Predation or competition with native flora and fauna. Increased risk of destructive wildfire through increased understorey biomass.	Certain	Current
Human disturbance (recreation)	Loss or degradation of habitat through unauthorised firewood collection Soil and riparian zone degradation by off road vehicles or watercraft Increased risk of destructive wildfire	Medium	Current
Acid sulphate soils	Generation of sulphuric acid leading to mortality of flora and fauna (eg. fish kills) and degraded water quality.	Low	Long-term

[1] Where Certain is defined as known to occur at the site or has occurred in the past; Medium is defined as not known from the site but occurs at similar sites; and Low is defined as theoretically possible, but not recorded at this or similar sites.
[2] Where Current is defined as happening at the time of writing (2010); Long-term is defined as greater than 10 years.

8. Current Ecological Character and Changes Since Designation

8.1 Changes in land use

From 1 July 2010 the Millewa Forest Group component of the Ramsar site (formally State forest) has been reserved as national park (about 90 percent of the area) and regional park (about 10 percent of the area) under the NSW National Park Estate (Riverina Red Gum Reservations) Act 2010. These alterations to land tenure have resulted in major land use changes including a restriction of logging activities in the area.

Permitted activities in the national park include camping within designated areas, development/enhancement of accommodation facilities within designated areas, horse riding within designated areas, the use of motor vehicles (cars and trail bikes) within designated areas and the regulated taking of firewood for personal use (although this is likely to be phased out) (NSW DECCW unpublished data 2010). It is unclear at this stage what activities will be permitted in regional park areas other than allowing dog walking in designated areas.

Also from 1 July 2010 the Werai Forest Group is no longer gazetted State forest but has been vested in the Minister for the Environment for transfer to the Aboriginal community. Consequently, the site will no longer be managed for timber harvesting, but will be for conservation purposes. There is an assumption that permitted activities within the Millewa Forests Group component will be similar to those in Werai under changes to land tenure and management.

The land tenure of the Koondrook-Perricoota Forest Group component of the Ramsar site remains Crown Land, which is dedicated as State Forest under the *NSW Forestry Act 1916* for the purposes of timber production and other matters in the public interest. Timber harvesting will continue to be the main commercial activity occurring in this area albeit using modified techniques and operations.

The current land use within the site is presented in (Figure 36).

8.2 Changes in site management

From 1 July 2010 the NSW National Parks and Wildlife Service will be the agency responsible for land management of the Millewa Forests Group component of the Ramsar site. Longer-term arrangements will see a joint management arrangement between the NSW National Parks and Wildlife Service and the the Aboriginal community.

Also from 1 July 2010 the Werai Forest Group is no longer gazetted state forest but has been vested in the Minister for National Parks and Wildlife for transfer to traditional owners for conservation purposes. These alterations to land tenure have resulted in major land use changes including a restriction of logging activities in the area.

The Forestry Commission of New South Wales, a corporation solely constituted under the *NSW Forestry Act 1916*, trading as State Forests of New South Wales (Forests NSW) remains the land manager of the Koondrook-Perricoota Forest Group component of the Ramsar site.

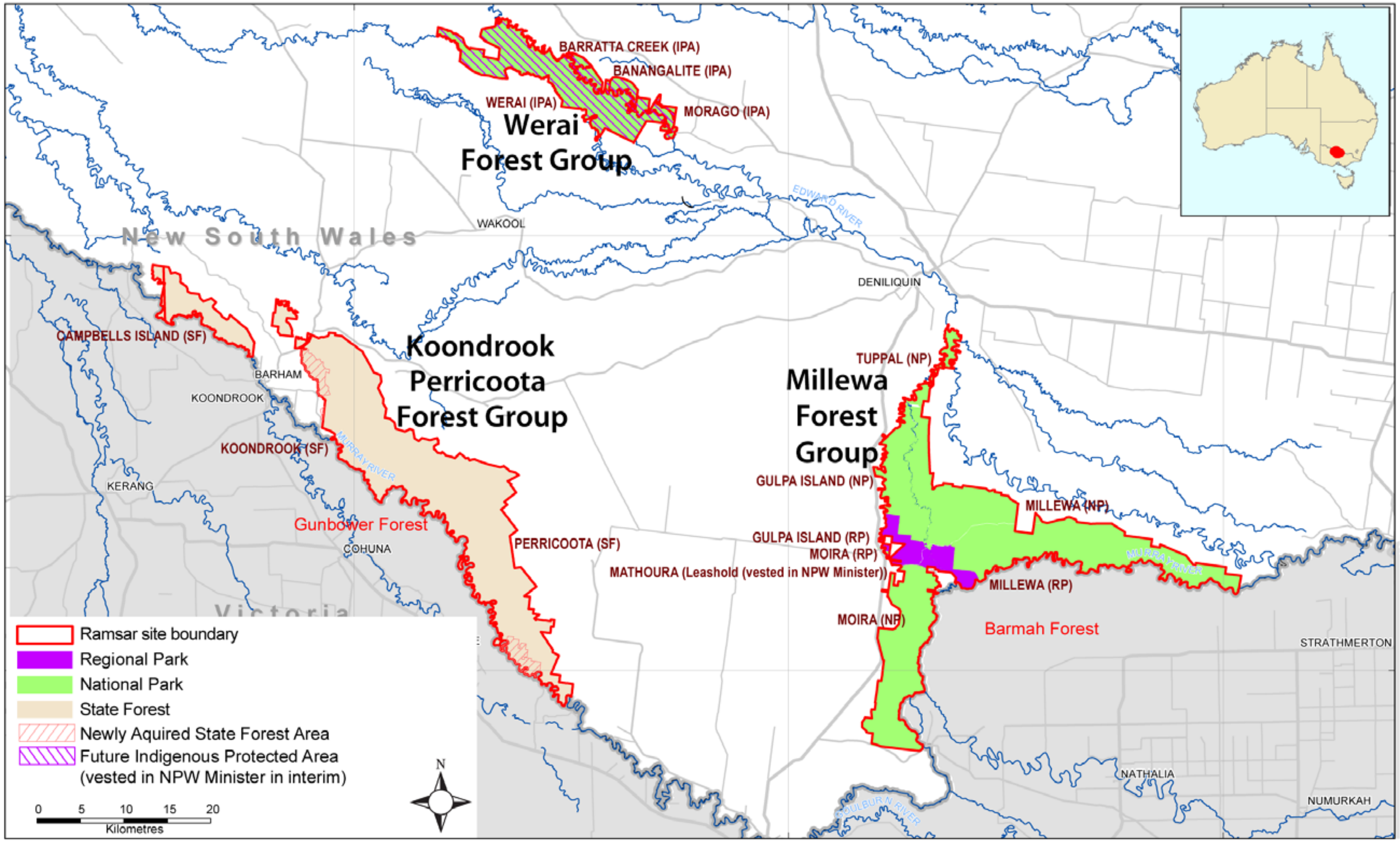


Figure 36: Land tenure within the Central Murray Forests Ramsar site.

8.3 Changes in critical components, processes and services

It has only been seven years since the designation of the Central Murray Forests Ramsar site and as such, there is little evidence of significant change to the ecological character of the site during this period. There is some evidence that tree health has declined in the forests in the period 2003 to 2010 (Cunningham et al. 2009; Table 12). However, the site was listed during a period of significant drought and it cannot be known in the short to medium term whether this decline is indicative of variability with recovery expected after significant floodplain inundation, or the beginnings of a long term decline.

There have been minor changes to geomorphology and potentially future changes to the critical component of hydrology. In 2010 construction commenced in Koondrook-Perricoota Forest Group for the “Koondrook-Perricoota Flood Enhancement Project”. The project aims to improve the condition of river red gum forest and re-establish colonial waterbird breeding by providing broad scale floodplain inundation every two to four years. The project involves the construction of (GHD 2010):

- Downstream structures to divert water into the forest from Torrumbarry Weir pool (including an inlet channel, an inlet regulator and associated infrastructure, as well as regulators at Swan Lagoon to control flows returning to the Murray River); and
- Upstream structures to control the release of water from the forest and to maximise return flows back to the river (including a levee to retain water within the forest, as well as regulators and a return channel).

Construction of works for the Koondrook-Perricoota Flood Enhancement Project is due to be completed in 2013. The works are expected to become operational once testing and commissioning have been completed.

Construction of levees and installation of regulators will have minor negative effects on the forests in comparison with positive impacts of the proposed inundation (GHD 2010) and would not be expected to result in significant negative changes to ecological character. The increased capacity to achieve floodplain inundation, however is expected to result in positive changes in floodplain condition and may require the establishment of new baselines for hydrology, vegetation and waterbirds for this portion of the Ramsar site in the future. There has been some consideration of the Koondrook-Perricoota Flood Enhancement Project when establishing LAC for hydrology.

An assessment of current conditions with respect to LAC is provided in Table 29. This indicates that a number of the LAC for hydrology have been exceeded. While there is little evidence that the site has changed in the past seven years; there is evidence that the site is on a trajectory of decline and it is thought that hydrological conditions at the time of listing were insufficient to maintain the ecological character of the site (data contained in NRC 2009; MDBA 2010).

Table 29: Assessment of current conditions against LAC for the Central Murray Forests Ramsar site.

Component / process	Limit of Acceptable Change	Current conditions	Confidence that LAC is breached or met.
Hydrology (channels and low lying wetlands)	*Number of events in any 10 year period (based on average recurrence intervals) for the specified flow events, not to be less than the following:* *Millewa Forest Group (Murray River flow downstream of Yarrawonga);* • *12 500 megalitres per day for 70 days – 5 events* • *16 000 megalitres a day for 98 days – 3 events* *Koondrook-Perricoota Forest Group (Murray River flow at Torrumbarry Weir);* • *16 000 megalitres per day for 90 days – 3 events* *Werai Forest Group (Edward River flow at Deniliquin);* • *5000 megalitres a day for 60 days – 4 events*	In the ten year period January 2001 to December 2010 the number of specified flow events for each (data from MDBA 2011): Millewa Forest Group (Murray River downstream of Yarrawonga) • Above 12 500 megalitres a day for at 70 days – 3 events • Above *16 000 megalitres a day for 98 days – 1 event* Koondrook-Perricoota Forest Group (Murray River downstream of Torrumbarry) • Above 16 000 megalitres a day for 98 days – 2 events Werai Forest Group – insufficient data available to assess. **LAC has been exceeded at both Millewa and Koondrook-Perricoota Forest Groups. The site was listed during a period of significant drought. There is little evidence to suggest there has been a change to the ecological character of the site since the time of listing. Insufficient data to assess Werai Forest Group.**	High
Hydrology (moderate overbank floods)	*In any 20 year period the interval between the following flow events to be no more than:* • *13 years for the Millewa Forest Group (Murray River downstream of Yarrawonga) – 25 000 megalitres a day for 60 days;* • *12 years for the Koondrook-Perricoota Forest Group (Murray River downstream of Torrumbarry) – 30 000 megalitres a day for 60 days; and* *15 years for the Werai Forest Group (Edwards River downstream of Deniliquin) – 18 000 megalitres a day for 30 days.*	In the 20 year period January 1991 to December 2010, the maximum period between flow thresholds for each forest group was (data from MDBA 2011): • Millewa Forest Group – November 2000 to September 2010 (10 years) • Koondrook-Perricoota Forest Group – November 2000 to September 2010 (10 years) • Werai Forest Group – insufficient data available to assess. **LAC has not been exceeded at both Millewa and Koondrook-Perricoota Forest Groups. Insufficient data to assess Werai Forest Group.**	High

Component / process	Limit of Acceptable Change	Current conditions	Confidence that LAC is breached or met.
	Number of events in any 20 year period (based on average recurrence intervals) for the specified flow events, not to be less than the following: *Millewa Forest Group (Murray River flow downstream of Yarrawonga);* • *25 000 megalitres per day for 60 days – 6 events* *Koondrook-Perricoota Forest Group (Murray River flow at Torrumbarry Weir);* • *30 000 megalitres per day for 60 days – 5 events* *Werai Forest Group (Edward River flow at Deniliquin);* • 18 000 *megalitres a day for 30 days – 3 events.*	In the 20 year period January 1991 to December 2010, the number of specified flow events for each forest group were (data from MDBA 2011): Millewa Forest Group • Above 25 000 megalitres a day for 60 days – 5 events Koondrook-Perricoota Forest Group • Above 30 000 megalitres a day for 60 days – 4 events Werai (Edward River at Deniliquin) - insufficient data available to assess **LAC has been exceeded at both Millewa and Koondrook-Perricoota Forest Groups. The site was listed during a period of significant drought. There is little evidence to suggest there has been a change to the ecological character of the site since the time of listing. Insufficient data to assess Werai Forest Group.**	High
Hydrology (wide-scale flooding)	*In any 50 year period the interval between the following flow events to be no more than:* • *24 years for the Millewa Forest Group (Murray River downstream of Yarrawonga) – 60 000 megalitres a day for 14 days;* • *21 years for the Koondrook-Perricoota Forest Group (Murray River downstream of Torrumbarry) – 40 000 megalitres a day for 60 days; and* • *23 years for the Werai Forest Group (Edwards River downstream of Deniliquin) – 30 000 megalitres a day for 21 days.*	In the 50 year period January 1951 to December 2010, the maximum period between flow thresholds for each forest group was (data from MDBA 2011): • Millewa Forest Group – November 2000 to October 2010 (10 years) • Koondrook-Perricoota Forest Group – 1990 to 2010 (21 years) • Werai Forest Group – insufficient data available to assess. **LAC has not been exceeded at both Millewa and Koondrook-Perricoota Forest Groups. Insufficient data to assess Werai Forest Group.**	

Component / process	Limit of Acceptable Change	Current conditions	Confidence that LAC is breached or met.
	Number of events in any 50 year period (based on average recurrence intervals) for the specified flow events, not to be less than the following: *Millewa Forest Group (Murray River downstream of Yarrawonga)* • *60 000 megalitres a day for 14 days – 7 events;* *Koondrook-Perricoota Forest Group (Murray River downstream of Torrumbarry)* • *40 000 megalitres a day for 60 day – 6 events; and* *Werai (Edward River at Deniliquin)* • *30 000 megalitres a day for 21 days – 6 events.*	In the 50 year period January 1951 to December 2010, the number of specified flow events for each forest group were (data from MDBA 2011): Millewa Forest Group • Above 60 000 megalitres a day for 14 days – 11 events Koondrook-Perricoota Forest Group • Above 40 000 megalitres a day for 60 days – 10 events Werai Forest Group - insufficient data available to assess. **LAC has not been exceeded at both Millewa and Koondrook-Perricoota Forest Groups. Insufficient data to assess Werai Forest Group.**	High
Vegetation	*Extent of river red gum forest to be no less than:* • *20 000 hectares at Millewa Forest Group* • *17 800 hectares at Koondrook-Perricoota Forest Group* • *4700 hectares at Werai Forest Group* *Extent of river red gum woodland (includes river red gum / black box woodland) to be no less than:* • *3650 hectares at Millewa Forest Group* • *5900 hectares at Koondrook-Perricoota Forest Group* • *2700 hectares at Werai Forest Group* *River red gum condition to be “moderate” (according to the method of Cunningham et al. 2009) or better for at least 80 percent of forest.*	No recent mapping of forest extent is available, but there is no evidence of widespread loss of long-lived trees. Cunningham et al. (2009) indicated that 93 percent of trees in the Millewa Forest Group and 85 percent of trees in the Koondrook-Perricoota Forest Group were in moderate or better condition in 2009. Pennay (2009) indicated that projected foliage cover at Werai State Forest had improved from 1988 to 2009. **LAC has not been exceeded at all forest groups.**	Medium

Component / process	Limit of Acceptable Change	Current conditions	Confidence that LAC is breached or met.
Vegetation	*Extent of floodplain marshes to be no less than:* • *1725 hectares at Millewa Forest Group* • *1360 hectares at Koondrook-Perricoota Forest Group* • *500 hectares at Werai Forest Group*	No recent assessment of extent of floodplain marshes. However, the 2010 floods are likely to have replenished the system (Rick Webster, NPWS, personal communication). **Insufficient data to assess LAC.**	Not applicable
Fish	*A minimum of 11 native fish species in three out of five of surveys conducted in Barmah-Millewa Forest.*	Total native fish in the Barmah Millewa Forest in recent surveys: 2002 = 15 (Barmah-Millewa Forum 2002) 2003 – 2005 = 11 (Jones 2006) 2003 – 2006 = 15 (King et al. 2007) 2006/7 = 11 (MDBC 2007c) 2007/8 = 5 (MDBC 2008) This equates to at least 11 native species in more than three in five surveys. **LAC has not been exceeded.**	High
	Presence of Murray cod, trout cod and silver perch in three of five surveys.	All fish surveys to date have recorded both Murray cod and silver perch in the site (Barmah-Millewa Forum 2002; Jones 2006; MDBC 2008; King et al. 2009). Trout cod have been recorded in more than three in five surveys (Barmah-Millewa Forum 2002; Jones 2006; MDBC 2008; King et al. 2007) **LAC has not been exceeded.**	High
Wetland birds	*Successful breeding (80 percent chicks fledged) of colonial waterbirds in at least two years in ten.*	In the ten period January 2000 to December 2009 successful breeding of colonial nesting waterbirds occurred twice in 2000/1 and 2005/6 (MDBC 2007c; MDBC 2008). **LAC has not been exceeded.**	High
	Presence of the Australasian bittern in Millewa Forest Group. *Presence of the superb parrot and evidence of nesting in Millewa Forest Group annually.*	The Australasian bittern has been recorded in the Millewa Forest Group in 2001 (BA 2008) and in 2006/7 (MDBC 2007a). The superb parrot has been observed breeding within the site annually in the last decade (Rick Webster personal communication). **LAC has not been exceeded.**	Medium

9. Knowledge Gaps

Throughout the Ecological Character Description for the Central Murray Forests Ramsar site, mention has been made of knowledge gaps and data deficiencies for the site. While it is tempting to produce an infinite list of research and monitoring needs for this wetland system, it is important to focus on the purpose of an ecological character description and identify and prioritise knowledge gaps that are important for describing and maintaining the ecological character of the system. As such knowledge gaps that are required to fully describe the ecological character of this site and enable rigorous and defensible limits of acceptable change to be met are relatively few and listed in Table 30.

Table 30: Knowledge gaps for the NSW Central Murray Forests Ramsar site.

Critical component, process or service	Knowledge Gap	Recommended Action
Hydrology (groundwater)	Local groundwater flow patterns (depth, flow rates, water quality, salinity). Significance to maintenance of wetland flora and fauna.	Sampling and mapping of groundwater across the site. Description of relationship between groundwater and distribution of vegetation communities and wetland types.
River red gum forest	Patterns of floodplain inundation and vegetation condition (Werai Forest Group).	Use remote sensing to classify forest condition in the Werai Forest Group (as per Cunningham et al. 2009). Relate forest types to floodplain inundation model. Develop relational database for wetland hydrological management.
	Forest structure (diversity, age classes, habitats present).	Measures of forest structure diversity including age classes, tree diameters and heights, presence/development of hollows and boughs, coarse woody debris and understorey diversity. Undertake an ecological thinning trial in Millewa Forests with independently approved experimental design and monitoring plan to measure the potential use of ecological thinning for providing structural diversity and key habitat features, enhancing ecological function, and improving canopy condition.
Floodplain marshes	Detailed mapping of vegetation community types. Baseline condition and extent.	Map vegetation community types and conditions. Moira Grass Plains are the priority due to risk of decline with changes to hydrological regime (Bren 1992) and status in Bamah-Millewa Icon Site condition benchmarks (MDBC 2007a).
Wetland birds (threatened species)	Population size, status and trends.	Perform targeted surveys for Australasian bittern and Australian painted snipe (and their habitat).
Fish	Species composition, use of off-stream habitats, variability across site.	Targeted fish surveys of Murray and Edward Rivers and selected effluent streams and marshes.

Critical component, process or service	Knowledge Gap	Recommended Action
Other wetland fauna (frogs)	Status at site.	Targeted surveys of site to obtain comprehensive species list and baseline condition. Target Sloane's froglet. Determine variability across site, relate to different hydrological and management regimes.

10. Monitoring

As a signatory to the Ramsar Convention, Australia has made a commitment to maintain ecological character of its Wetlands of International Importance. Under Part 3 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) a person must not take an action that has, will have or is likely to have a significant impact on the ecological character of a declared Ramsar wetland.

While there is no explicit requirement for monitoring the site, in order to ascertain if the ecological character of the wetland site is being maintained a monitoring program, if implemented, should provide data and information that assists in assessing changes in ecological character. The ECD provides an identification of monitoring needs to both set baselines for key components and processes and to assess against LAC.

Suggested monitoring for the Central Murray Forests Ramsar site is provided in Table 31.

Table 31: Monitoring needs for the Central Murray Forests Ramsar site.

Component/ Process	Purpose	Indicator	Locations	Frequency	Priority
Hydrology (river flows)	Assessment against LAC	River inflows (megalitres a day).	Below Yarrawonga Weir (Site); Edward River at Downstream Stevens Weir (Werai Forest Group); Downstream Torrumbarry Weir (Koondrook-Perricoota Forest Group).	Continuous	High
Hydrology (floodplain water regime)	Assessment against LAC. Verify baseline.	Extent of inundation Flood behaviour (rates of recession etc)	Minimum – colonial nesting waterbird sites. Optimum - entire site.	Flood events	High
Water quality	Assessment of threat	Salinity. Dissolved oxygen.	Key wetlands in each area.	Flood events	Medium
River red gum forests (composition)	Establishment of benchmarks and limits of change and then detection of change	Understorey species composition, distribution of threatened sub-components. Age distribution, location of important habitat trees.	Minimum – sufficient sites to further characterise Site Quality Classes. Optimum – entire site.	Continuous	Medium
River red gum forests (condition)	Establishment of benchmarks and LAC (Werai Forest Group only). Detection of change.	Minimum - Satellite multi-spectral imagery interpretation.	Entire site.	Annual	High

Component/ Process	Purpose	Indicator	Locations	Frequency	Priority
River red gum forest structure (diversity, age classes, habitats present).	Measure the potential use of ecological thinning for providing structural diversity and key habitat features, enhancing ecological function, and improving canopy condition.	Measures of forest structure diversity including age classes, tree diameters and heights, presence/development of hollows and boughs, coarse woody debris and understorey diversity.	Millewa Forests	Initially as a trial. Future use to be determined	High
Floodplain marshes (condition)	Establishment of benchmarks and LAC (Werai and Koondrook-Perricoota Forest Group). Detection of change.	API and/or satellite imagery interpretation.	Entire site	Annual	High
Floodplain marshes (composition)	Establishment of benchmarks and LAC. Detection of change.	API in combination with ground quadrat / transect surveys.	Entire site	Annual	Low
Wetland birds (colonial nesting)	Establishment of benchmarks and LAC. Detection of change.	Species, counts, breeding activity.	At identified breeding locations across entire site	Coincident with flood events	High
Wetland birds (general)	Establishment of benchmarks and LAC. Detection of change.	Species, counts, breeding activity.	At identified breeding locations across entire site	Coincident with flood events	Medium
Fish (composition)	Establishment of benchmarks and LAC (Werai and Koondrook-Perricoota Forest Group only) Detection of change (entire site)	Community composition.	Representative sample locations over entire site and adjacent Murray and Edward River Channels	Annual	Medium
Fish (abundance and spawning)	Establishment of benchmarks and LAC (Werai and Koondrook-Perricoota Forest Group only). Detection of change (entire site).	Abundance and spawning activity.	Representative sample locations over entire site and adjacent Murray and Edward River Channels	Annual	High

11. Community Education and Public Awareness Messages

Under the Ramsar Convention a Program of Communication, Education, Participation and Awareness (CEPA) was established to help raise awareness of wetland values and functions. At the Conference of Contracting Parties in Korea in 2008, a resolution was made to continue the CEPA program in its third iteration for the next two triennia (2009 – 2015).

The vision of the Ramsar Convention's CEPA Program is: "People taking action for the wise use of wetlands." To achieve this vision, three guiding principles have been developed:

a) The CEPA Program offers tools to help people understand the values of wetlands so that they are motivated to become advocates for wetland conservation and wise use and may act to become involved in relevant policy formulation, planning and management.
b) The CEPA Program fosters the production of effective CEPA tools and expertise to engage major stakeholders' participation in the wise use of wetlands and to convey appropriate messages in order to promote the wise use principle throughout society.
c) The Ramsar Convention believes that CEPA should form a central part of implementing the Convention by each Contracting Party. Investment in CEPA will increase the number of informed advocates, actors and networks involved in wetland issues and build an informed decision-making and public constituency.

The Ramsar Convention encourages that communication, education, participation and awareness are used effectively at all levels, from local to international, to promote the value of wetlands. A comprehensive CEPA program for an individual Ramsar site is beyond the scope of an ECD. The following important communication and education messages related to the NSW Central Murray Forests and are the focus of current management:

- The key role of floodplain hydrology at the site and the impacts of river regulation. The intrinsic value of the ecological character of the site and the need to maintain and conserve it. This would help promote understanding in the community of the justification for environmental water allocations that divert water resources away from irrigated agriculture and other human uses.

- The role of purposeful and adaptive management of the site. The ecological character of the site is a product of a multitude of human activities and continues to be influenced by human activities both within and outside the site. It is likely that the ecological character of the site would decline if the site was not actively managed. Most notably the hydrology of the site depends on the purposeful operation of water management infrastructure to avoid adverse effects on wetland ecosystems. Fire and weed and pest animals also require direct management to avoid negative impacts. Greater public awareness of the need to actively manage the site would help to secure funding and promote understanding of the justification for management actions.

- Identification of threatened fish species (Murray cod, trout cod, silver perch) and communication of their conservation value to recreational fishermen. This may help to minimise the number of these species taken and / or released dead and could help to improve records for these rare fish.

- The Ramsar Criteria that the site meets and how they contribute to the ecological character of the site and define its National and International value.

- The threats to the site, as outlined in Section 7 above, especially threats that may be monitored or managed through public awareness and behaviour (e.g. recreational fishing, public use pressures, destructive wild fires etc).

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Appendix A: Methods

A.1 Approach

This ECD was developed from a draft ECD prepared by GHD for Forests NSW in 2009. The tasks were designed to update the draft ECD and ensure that it met the requirements of the DEWHA (2008) framework.

Task 1: Review and compilation of available data
The consultant team undertook a thorough desktop review of existing information on the ecology of the NSW Central Murray Forests Ramsar site to identify any new or additional information that has become available since the draft was written.

Task 2: Stakeholder engagement and consultation
A Steering Committee was formed for the NSW Central Murray Forests Ramsar site ECD. This group was comprised of the following members with an interest in the ECD and management planning process:

- Susy Cenedese, OEH
- Paul Childs, National Parks and Wildlife Service (NSW)
- Alison Curtin, OEH
- John Foster, Department of Sustainability, Environment, Water, Population and Communities
- Simon Godschlax, Department of Sustainability, Environment, Water, Population and Communities
- Ross McDonnell, National Parks and Wildlife Service (NSW)
- Gary Rodda / Stephen Campbell, Forests New South Wales
- Barbara Sanders, Forests New South Wales
- Rick Webster, National Parks and Wildlife Service (NSW)

Task 3: Development of a draft ECD
Consistent with the national guidance and framework (2008) the following steps were undertaken to produce the ECD.

Steps from the national framework (DEWHA 2008)	Activities
1. Introductory details	Basic details such as location and date of listing were summarised.
2. Describe the site	Site was described in terms of: • Land tenure; • Ramsar criteria; • Wetland types (using Ramsar classification).
3. Identify and describe the critical components, processes and services	Described (quantitatively where possible) important components, services and benefits, a subset of which were identified as critical to the ecological character of the site.
4. Develop a conceptual model of the system.	Minor modifications to the conceptual models were made.
5. Set Limits of Acceptable Change	Limits of acceptable change were established for all identified critical components, processes and services.
6. Identify threats to the site	Major threats to ecological character were described.
7. Describe changes to ecological character since the time of listing	A description of changes in tenure and management as well as indications of changes in character since listing was prepared.
8. Summarise knowledge gaps	Knowledge gaps were identified not only for the ecological character description, but also for its management.
9. Identify site monitoring needs	Based on the identification of knowledge gaps and LAC, recommendations for future monitoring were described.
10. Identify communication, education and public awareness messages	A general description of the broad communication / education messages for the site have been described.

Task 4: Revision of the Ramsar Information Sheet (RIS)
The information collated during Task 1, together with the draft Ecological Character Description was used to produce a revised RIS in the standard format provided by Ramsar.

Task 5 Finalising the ECD and RIS
The draft ECD and RIS were submitted to DEWHA, and the Steering Committee for review. Comments from agencies and stakeholders were incorporated to produce revised ECD and RIS documents.

A.2 Consultant Team

Jennifer Hale (team leader)
Jennifer has over twenty years experience in the water industry having started her career with the State Water Laboratory (Rural Water Commission) in Victoria. Jennifer is an aquatic ecologist with expertise in freshwater, estuarine and near-shore marine systems. She is qualified with a Bachelor of Science (Natural Resource Management) and a Masters of Business Administration. Jennifer is an aquatic ecologist with specialist fields of expertise including phytoplankton dynamics, aquatic macrophytes, sediment water interactions and nutrient dynamics. She has a broad understanding of the ecology of aquatic macrophytes, fish, waterbirds, macroinvertebrates and floodplain vegetation as well as geomorphic processes. She has a solid knowledge of the development of ecological character descriptions and has been involved in the development of ECDs for 24 Ramsar sites. She is a member of the technical review panel for Ramsar documentation and a member of the team undertaking the Ramsar Rolling review.

Ben Harrington
Ben is an Ecologist at GHD with over seven years ecological survey experience, including five years in environmental consultancy. He has a BSc in Resource and Environmental Management, focussing on environmental management, soil science, geomorphology and ecology and a Research Masters of Science, majoring in Physical Geography at Macquarie University. Ben was the co-author on the Final Draft Ecological Character Description for the NSW Central Murray Forests on behalf of Forests NSW. Ben has recently successfully led the ecology component of the Koondrook-Perricoota Forest Flood Enhancement Project Environmental Assessment for the NSW Office of Water, which involved assessing impacts of construction of water management infrastructure and hydrological changes within the Ramsar site. He has extensive ecological survey and impact assessment experience within the Riverina, including an EIS for Forests NSW, which encompassed the Ramsar site.

Craig Wilson
Craig has over five years of professional experience in GIS based mapping with specific skills in remote sensing, spatial analysis, data capture including GPS survey, and map presentation. His work regularly supports environmental assessment, natural resource management and planning projects. Craig's understanding of natural resource management has proven to complement his professional mapping role. He has an academic background in environmental science and natural resource management with a Bachelor's degree in fisheries management and aquaculture. He has completed postgraduate studies in GIS where he discovered an interest in remote sensing technology before beginning his career in geospatial science.

Appendix B: Vascular flora species recorded at the site

Key: G, grass/sedgelands (moira grasslands and floodplain marshes); W plains woodland (river red gum woodland, black box woodland); F river red gum forest

* introduced species

Scientific Name	Common name	Habitat
PTERIDOPHYTES		
Azollaceae		
Azolla filiculoides var. rubra	Red azolla	G
Dennstaedtiaceae		
Pteridium esculentum	Common bracken	F
Marsileaceae		
Marsilea costulifera	Narrow-leaf Nardoo	F
Marsilea drummondii	Common nardoo	F
Pilularia novae-hollandiae	Austral pillwort	G
Ophiolossaceae		
Ophioglossum lusitanicum subsp. coriaceum	Adder's tongue	W
Ophioglossum lusitanicum subsp. polyphyllum	Large adder's tongue	W
Sinipteridaceae		
Cheilanthes austrotenuifolia	Rock fern	W
Cheilanthes sieberi subsp. sieberi	Mulga fern	W
GYMNOSPERMS		
Cupressaceae		
Callitris glaucophylla	White cypress pine	W
Callitris gracilis subsp. murrayensis	Murray pine	W
Pinaceae		
**Pinus canariensis*		W
**Pinus halepensis*		W
**Pinus pineata*		W
**Pinus radiata*	Radiata pine	W
ANGIOSPERMS - MONOCOTYLEDONS		
Alismataceae		
Damasonium minus	Starfruit	G
Alliaceae		
**Allium triquetrum*	Three-cornered garlic	W
Amaryllidaceae		
Calostemma purpureum	Wilcannia lily	F
Anthericaceae		
Arthropodium milleflorum	Vanilla lily	W
Arthropodium minus	Small vanilla lily	W
Dichopogon fimbriatus	Nodding chocolate-lily	W
Dichopogon strictus	Chocolate-lily	W
Tricoryne elatior	Yellow rush-lily	W
Asparagaceae		
**Asparagus officinalis*	Asparagus	F
**Myrsiphyllum asparagoides*	Bridal creeper	W
Asphodelaceae		
Bulbine bulbosa	Native leek	W
Bulbine semibarbata	Leek lily	W
Colchicaceae		
Wurmbea dioica	Early nancy	W
Cyperaceae		
Bolboschoenus fluviatilis	Marsh club-rush	G
Bolboschoenus medianus	Club-rush	G

Scientific Name	Common name	Habitat
Carex appressa	Tall sedge	G
Carex bichenoviana	A sedge	G
Carex chlorantha	A sedge	G
Carex gaudichaudiana	A sedge	G
Carex inversa	Knob sedge	G
Carex tereticaulis	Terete-culm sedge	F
Cyperus difformis	Dirty dora	G
**Cyperus eragrostis*	Umbrella sedge	G
Cyperus exaltatus	Giant sedge	G
Cyperus flaccidus	A sedge	G
Cyperus gymnocaulos	Spiny sedge	G
**Cyperus tenellus*	A sedge	G
Cyperus victoriensis	Yelka	G
Eleocharis acuta	Common spike-rush	G
Eleocharis pallens	Pale spike-rush	G
Eleocharis plana	Ribbed spike-rush	G
Eleocharis pusilla	Small spike-rush	G
Eleocharis sphacelata	Tall spike-rush	G
Fimbristylis aestivalis	Summer fringe-rush	G
Fimbristylis velata	Veiled fringe-rush	G
Isolepis hooheriana	A club-rush	G
Isolepis inundata	A club-rush	G
Isolepis victoriensis	A club-rush	G
Hydrocharitaceae		
**Egeria densa*	Leafy elodea	G
**Elodea canadenis*	Elodea	G
Ottelia ovalifolia	Swamp lily	G
Vallisneria gigantea	Ribbonweed	G
Hypoxidaceae		
Hypoxis exilis		W
Hypoxis glabella var. glabella	Tiny star	W
Iridaceae		
**Gynandriris setifolia*	Thread iris	W
**Romulea flava*	An onion grass	W
**Romulea minutiflora*	Small-flower onion grass	W
**Romulea rosea var. australis*	Onion grass	W
Juncaceae		
**Juncus acutus*	Sharp rush	G
Juncus amabilis	A rush	G
Juncus aridicola	Tussock rush	G
**Juncus bufonius*	Toad rush	G
Juncus filicaulis	A rush	W
Juncus flavidus	A rush	F
Juncus holoschoenus	Jointed-leaf rush	G
Juncus homalocaulis	Rush	W
Juncus ingens	Giant rush	G
Juncus radula	Hoary rush	G
Juncus semisolidus	A rush	G
Juncus subsecundus	Finger rush	W
Juncus usitatus	Common rush	G
Juncaginaceae		
Triglochin calcitrapum	Spurred arrowgrass	G
Triglochin dubium	Water ribbons	G
Lemnaceae		
Lemna disperma	Common duckweed	G

Scientific Name	Common name	Habitat
Spirodela punctata	Duckweed	G
Lomandraceae		
Lomandra effusa	Scented mat-rush	W
Orchidaceae		
Microtis unifolia	Common onion orchid	W
Pterostylis mutica	Midget greenhood	W
Phormiaceae		
Dianella longifolia	Blue flax-lily	W
Dianllea revoluta var. revoluta	Spreading flax-lily	W
Poaceae		
Agrostis aemula	Blowngrass	F
Agrostis avenacea var. avenacea	Blowngrass	F
**Aira caryophyllea*	Silvery hairgrass	W
**Aira cupaniana*	Silvery hairgrass	F
**Alopecurus geniculatus*	Marsh foxtail	F
Amphibromus fluitans	A swamp wallaby grass	G
Amphibromus macrorhinus	A swamp wallaby grass	F
Amphibromus nervosus	Swamp wallaby grass	G
Aristida calycina var. parealta	Branched wiregrass	W
Aristida jerichoensis var. subspinulifera	Jericho wiregrass	W
**Avena barbata*	Bearded oats	W
**Avena fatua*	Wild oats	W
Bothriochloa macra	Red-leg Grass	W
**Briza minor*	Shivery grass	W
**Bromus alopecuros*	Curly brome	W
Bromus arenarius	Sand brome	W
**Bromus carthariticus*	Prairie grass	W
**Bromus hordeaceus*	A soft brome	W
**Bromus inermis*	Awnless brome	W
**Bromus madritensis*	Madrid brome	W
**Bromus molliformis*	A soft brome	W
**Bromus diandrus*	Great brome	W
**Bromus rubens*	Red brome	W
**Bromus sterilis*	Sterile brome	W
**Bromus tectorum*	Drooping brome	W
Chloris truncata	Windmill grass	W
Cynodon dactylon	Couch grass	F
Danthonia caespitosa	White top	W
Danthonia duttoniana	Brown-black wallaby grass	W
Danthonia eriantha	Hill wallaby grass	W
Danthonia linkii	A wallaby grass	W
Danthonia setacea	Small-flowered wallaby grass	W
Danthonia tenuior	A wallaby grass	W
Deyeuxia quadriseta	Reed bent-grass	F
Dichelachne micrantha	Short-hair plume-grass	W
Digitaria ammophila	Silky umbrella grass	W
**Digitaria sanguinalis*	Summer grass	W
Diplachne fusca	Brown Beetle-grass	W
**Echinochloa crus-galli*	Barnyard grass	F
**Echinochloa microstachya*	Prickly barnyard grass	F
**Ehrharta longiflora*	Annual veldtgrass	W
Elymus scaber	Common wheatgrass	W
Enneapogon avenaceus	Common bottlewashers	W
Enneapogon nigricans	Blackheads	W
Enteropogon acicularis	Curly windmill grass	W

Scientific Name	Common name	Habitat
Eragrostis australasica	Canegrass	F
Eragrostis brownii	Brown's lovegrass	W
**Eragrostis cilianensis*	Stink grass	W
Eragrostis elongata	Clustered lovegrass	W
Eragrostis leptocarpa	Drooping lovegrass	G
Eragrostis parviflora	Weeping lovegrass	W
Eriochloa pseudoacrtricha	Early spring grass	W
Eulalia aurea	Silky browntop	W
Hemarthria uncinata	Matgrass	F
Homopholis proluta	Rigid panic	W
**Hordeum hystrix*	Mediterranean barley grass	W
**Hordeum leporinum*	Barley grass	W
**Hordeum marinum*	Sea barley	W
**Lamarckia aurea*	Golden-top	W
**Lolium loliaceum*	Stiff ryegrass	W
**Lolium perenne*	Perennial ryegrass	W
**Lolium rigidum*	Wimmera ryegrass	W
**Lolium temulentum*	Darnel	W
**Panicum coloratum*	Coolah grass	W
Panicum decompositum	Native millet	W
Panicum effusum	Hairy panic	W
Panicum subxerophilum	Cane panic	W
Paspalidium constrictum	Box grass	W
Paspalidium jubiflorum	Warrego summer-grass	F
**Paspalum dilatatum*	Paspalum	G
Paspalum distichum	Water couch	G
**Pentaschistis airoides*	False hairgrass	W
**Phalaris aquatica*	Phalaris	G
**Phalaris minor*	Lesser canary grass	F
**Phalaris paradoxa*	Paradoxa grass	F
**Phleum pratense*	Timothy grass	W
Phragmites australis	Common reed	G
**Poa annua*	Winter grass	W
Poa fordeana	Sweet swamp-grass	F
Poa labillardieri	Tussock grass	F
Poa sieberiana var. sieberiana	Fine-leaf tussock Grass	F
**Polypogon monspeliensis*	Annual beardgrass	F
Pseudoraphis spinescens	Spiny mudgrass (moira grass)	G
**Rostraria cristata*	Annual cat's tail	W
**Schismus barbatus*	Arabian grass	W
Sporobolus caroli	Fairy grass	W
Sporobolus mitchellii	Rat's-tail couch	W
Stipa aristiglumis	Plains grass	W
Stipa drummondii	A speargrass	W
Stipa nitida	A speargrass	W
Stipa nodosa	A speargrass	W
Stipa scabra	Rough speargrass	W
Themeda diandra	Kangaroo grass	W
Tripogon loliiformis	Five-minute Grass	W
**Vulpia bromoides*	Squirrel-tail Fescue	W
**Vulpia myuros*	Rat's tail fescue	W
Potamogetonaceae		
Potamogeton crispus	Curly pondweed	G
Potamogeton ochreatus	Blunt pondweed	G
Potamogeton tricarinatus	Floating pondweed	G

Scientific Name	Common name	Habitat
Typhaceae		
Typha domingensis	Narrow-leaved cumbungi	G
Typha orientalis	Broad-leaved cumbungi	G
ANGIOSPERMS - DICOTYLEDONS		
Aizoaceae		
Glinus lotoides	Hairy Carpet-weed	G
Amaranthaceae		
Alternanthera denticulata	Lesser joyweed	F
Alternanthera nana	Hairy joyweed	F
Alternanthera nodiflora	Common joyweed	F
**Alternanthera pungens*	Khaki weed	F
**Amaranthus albus*	Tumbleweed	G
Ptilotus semilanatus	Lambs tails	W
Ptilotus spathulatus	Pussy-tails	W
Anacardiaceae		
**Schinus areira*	Pepper tree	W
Apiaceae		
Daucus glochidiatus	Australian carrot	W
Eryngium plantagineum	Eryngo	W
Eryngium rostratum	Blue devil	W
Hydrocotyle laxiflora	Stinking pennywort	F
Arecaceae		
**Phoenix canariensis*	A palm	W
Asteraceae		
Actinobole uliginosum	Flannel cudweed	F
**Anthemis cotula*	Stinking mayweed	W
**Arctotheca calendula*	Capeweed	W
**Aster subulatus*	Bushy starwort	G
Brachycome basaltica var. gracilis	Swamp daisy	F
Brachycome ciliaris	Variable daisy	F
Brachycome goniocarpa	Dwarf daisy	F
Brachycome lineariloba	Hard-headed Daisy	F
Brachycome readeri	Southern daisy	F
Bracteantha bracteata	Golden everlasting	F
Calocephalus citreus	Lemon beauty-heads	W
Calocephalus sonderi	Pale beauty-heads	W
Calotis cuneifolia	Purple burr-daisy	W
Calotis erinacea	Tangled burr-daisy	W
Calotis hispidula	Bogan flea	F
Calotis scabiosifolia	Rough burr-daisy	W
Calotis scapigera	Tufted burr-daisy	W
**Carduus pycnocephalus*	Slender thistle	W
**Carduus tenuiflorus*	Winged slender thistle	W
**Carthamus lanatus*	Saffron thistle	W
Cassinia arcuata	Chinese shrub	W
**Centaurea melitensis*	Maltese cockspur	W
Centipeda cunninghamii	Common sneezeweed	F
Centipeda minima var. lanuginosa	Spreading sneezeweed	F
Centipeda minima var. minima	Spreading sneezeweed	F
**Chondrilla juncea*	Skeleton weed	W
Chrysocephalum apiculatum	Yellow buttons	W
Chthonocephalus pseudevax	Ground-heads	W
**Cichorium intybus*	Chicory	W
**Cirsium vulgare*	Spear thistle	F
**Conyza albida*	Tall fleabane	F

Scientific Name	Common name	Habitat
**Conyza bonariensis*	Flaxleaf fleabane	F
Cotula australis	Common cotula	F
**Cotula bipinnata*	Ferny cotula	F
**Cotula coronopifolia*	Water buttons	F
Craspedia variabilis	Common billy-buttons	F
Cymbonotus preissianus	Australian bears-ear	W
**Dittrichia graveolens*	Stinkwort	G
Eclipta platyglossa	Yellow twin-heads	F
**Gnaphalium coarctatum*	Spiked cudweed	F
Gnaphalium gymnocephalum	Creeping cudweed	F
Gnaphalium polycaulon	Western cudweed	F
Gnaphalium spaericum	Japanese cudweed	W
**Hedynois rhagadioloides*	Cretan weed	F
Helichrysum rutidolepis	Pale everlasting	F
**Helminthotheca echioides*	Ox-tongue	F
Hyalosperma glutinosum subsp. glutinosum	Golden sunray	F
**Hypochaeris glabra*	Smooth catsear	W
**Hypochaeris radicata*	Flatweed	W
Isoetopsis graminifolia	Grass cushion	W
Leucochrysum molle	Hoary sunray	F
**Lactuca saligna*	Wild lettuce	F
**Lactuca serriola*	Prickly lettuce	F
**Leontodon taraxacoides subsp. taraxacoides*	Lesser hawkbit	F
Leptorhynchos panaetioides	Woolly buttons	F
Leptorhynchos squamatus	Scaly buttons	F
Minuria integerrima	Smooth minuria	F
Myriocephalus rhizocephalus var. rhizocephalus	Woolly-heads	F
**Onopordum acaulon*	Stemless thistle	F
**Picris hieracioides*	Hawkweed picris	W
Picris squarrosa	A picris	F
Pseudognaphalium luteo-album	Jersey cudweed	F
Pycnosorus globosus	Drumsticks	W
Pycnosorus pleiocephalus	Soft billy-bottons	W
Rhodanthe corymbiflora	Grey sunray	F
Rhodanthe moschata	Musk sunray	W
Rhodanthe pygmaea	Pigmy sunray	F
**Schkuhira pinnata var. abrotanoides*	Dwarf marigold	W
Senecio glossanthus	Slender groundsel	F
Senecio hispidulus var. dissectus	Hill fireweed	W
Senecio lautus subsp. dissectifolius	Variable groundsel	W
Senecio quadridentatus	Cotton fireweed	F
Senecio runcinifolius	Tall groundsel	W
Sigesbeckia orientalis subsp. orientalis	Indian fireweed	F
**Silybum marianum*	Variegated thistle	F
Solenogyne bellioides	Burr-daisy	F
**Soliva stolonifera*	Jo-jo	F
**Sonchus oleraceus*	Common sowthistle	F
**Sonchus asper subsp. glaucescens*	Prickly sowthistle	F
Stuartina muelleri	Spoon cudweed	W
Tragopogon porrifolius	Salsify	W
Triptilodiscus pygmaeus	Common sunray	F
Vittadinia cuneata	Fuzzweed	W
Vittadinia dissecta	Fuzzweed	W
Vittadinia gracilis	Fuzzweed	W
**Xanthium occidentale*	Noogoora burr	F

Scientific Name	Common name	Habitat
**Xanthium spinosum*	Bathurst burr	F
Boraginaceae		
**Amsinckia intermedia*	Common fiddleneck	W
Cynoglossum suaveolens	Sweet hounds tongue	F
**Echium plantagineum*	Patterson's curse	W
Heliotropium europaeum	Common heliotrope	W
Plagiobothrys elachanthus	Hairy forget-me-not	G
Plagiobothrys plurisepaleus	White forget-me-not	G
**Phyla nodiflora*	Lippia	F
Brassicaceae		
**Capsella bursa-pastoris*	Shepherd's purse	F
**Lepidium africanum*	Peppercress	W
Lepidium fasciculanum	Bundled peppercress	W
**Rapistrum rugosum*	Turnip weed	W
Rorippa laciniata	Perennial marsh cress	G
Rorippa eustylis	River cress	F
**Rorippa palustris*	Marsh watercress	G
Sisymbrium erysimoides	Smooth mustard	W
Sisymbrium irio	London rocket	W
**Sisymbrium orientale*	Indian hedge mustard	F
**Sisymbrium officinale*	Hedge mustard	W
Callitrichaceae		
Callitriche sonderi	Starwort	G
**Callitriche stagnalis*	Common starwort	G
Campanulaceae		
Wahlenbergia communis	Tufted bluebell	W
Wahlenbergia fluminalis	River bluebell	F
Wahlenbergia gracilenta	Annual bluebell	W
Wahlenbergia gracilis	Sprawling bluebell	W
Wahlenburgia luteola	A bluebell	W
Cannabiaceae		
**Cannabis sativa*	Indian hemp	F
Caryophyllaceae		
**Cerastium glomeratum*	Mouse-ear chickweed	F
**Petrorhagia velutina*	Velvet pink	W
Scleranthus minusculus	Cushion knawel	W
**Silene gallica*	French catchfly	W
**Spergula pentandra*	Smooth cornspurry	F
**Spergularia diandra*	Lesser sandspurry	F
**Spergularia rubra*	Sandspurry	F
**Stellaria media*	Common chickweed	W
Stellaria angustifolia	Swamp starwort	F
Stellaria sp.	A starwort	G
Casuarinaceae		
Allocasuarina luehmannii	Bull oak	W
Ceratophyllaceae		
Ceratophyllum demersum	Hornwort	G
Chenopodaceae		
Atriplex nummularia	Old man saltbush	W
Atriplex leptocarpa	Slender-fruited Saltbush	W
Atriplex semibaccata	Creeping saltbush	W
Atriplex spinibractea	Spiny-fruit saltbush	W
Atriplex suberecta	Lagoon saltbush	W
**Chenopodium album*	Fat hen	W
**Chenopodium ambrosioides*	Mexican tea	W

Scientific Name	Common name	Habitat
Chenopodium desertorum subsp. microphyllum	Desert goosefoot	W
**Chenopodium murale*	Nettle-leaf goosefoot	W
Chenopodium nitrariaceum	Nitre goosefoot	F
Chenopodium pumilio	Small crumbweed	W
Dysphania glomulifera	Crumbweed	F
Dysphania littoralis	Red crumbweed	G
Einadia nutans susp. nutans	Climbing saltbush	W
Einadia hastata	Saloop	W
Enchylaena tomentosa	Ruby saltbush	W
Maireana decalvans	Black cotton bush	W
Maireana enchylaenoides	Wingless fissure weed	W
Maireana microphylla	Eastern cottonbush	W
Maireana pentagona	Slender bluebush	W
Maireana pyramidata	Black bluebush	W
Salsola kali	Buckbush	W
Scleroblitum atriplicinum	Purple goosefoot	W
Sclerolaena diacantha	Grey copperburr	W
Sclerolaena divaricata	Pale poverty-bush	W
Sclerolaena muricata	Black roly-poly	W
Sclerolaena stelligera	Star copperburr	W
Clusiaceae		
Hypericum gramineum	Small st john’s wort	W
**Hypericum perforatum*	St john’s wort	W
Convolvulaceae		
Calystegia sepium	Great bindweed	G
**Convolvulus arvensis*	Bindweed	W
Convolvulus erubescens	Australian bindweed	W
Cressa cretica	Rosinweed	W
**Cuscutta campestris*	Golden dodder	F
Crassulaceae		
Crassula colorata var. acuminata	Dense stonecrop	W
Crassula decumbens var. decumbens	Spreading stonecrop	F
Crassula helmsii	Swamp stonecrop	G
Crassula peduncularis	Purple stonecrop	F
Crassula sieberiana	Australian stonecrop	W
Cucurbitaceae		
**Citrullus lanatus var. lanatus*	Camel melon	W
**Cucumis myriocarpus*	Paddy melon	W
Elatinaceae		
Elatine gratioloides	Waterwort	G
Droceraceae		
Drosera peltata	Pale sundew	W
Euphorbiaceae		
Chamaesyce drummondii	Caustic weed	F
**Euphorbia peplus*	Petty spurge	W
Fabaceae - Caesalpinioideae		
Senna artemisioides subsp. filifolia	Punty bush	W
Fabaceae - Faboideae		
Cullen tenax	Emu-foot	F
Dillwynia sericea	Showy parrot pea	F
Eutaxia diffusa	A bush-pea	W
Eutaxia microphylla	Mallee Bush-pea	W
**Genista monspessulana*	Cape broom	W
Glycine clandestina	Twining glycine	W
Glycine tabacina	Variable glycine	F

Scientific Name	Common name	Habitat
Glycyrrhiza acanthocarpa	Native liquorice	F
Lotus australis	Australian trefoil	W
Lotus cruentus	Red-flowered lotus	W
**Medicago minima*	Small Woolly burr-medic	W
**Medicago polymorpha*	Burr medic	W
**Medicago praecox*	Small-leaf burr medic	W
**Melilotus indicus*	Hexham scent	F
Swainsona phacoides	Lilac darling pea	W
Swainsona procumbens	Broughton pea	W
**Trifolium angustifolium*	Narrow-leaved clover	F
**Trifolium arvense*	Haresfoot clover	W
**Trifolium campestre*	Hop clover	W
**Trifolium cernuum*	Nodding clover	G
**Trifolium dubium*	Yellow-suckling clover	W
**Trifolium glomeratum*	Clustered clover	F
**Trifolium repens*	White clover	F
**Trifolium striatum*	Knotted clover	W
**Trifolium subterraneum*	Subterranean clover	F
**Trifolium tomentosum*	Woolly clover	W
**Vicia hirsuta*	Hairy vetch	F
**Vicia monantha subsp. triflora*	Square-stemmed vetch	W
**Vicia sativa subsp. augustifolia*	Narrow-leaved vetch	W
**Vicia sativa subsp. sativa*	Common vetch	W
Fabaceae - Mimisoideae		
Acacia acinacea	Gold-dust wattle	W
+Acacia baileyana	Cootamundra wattle	W
Acacia brachybotrya	Grey wattle	W
Acacia dealbata	Silver wattle	F
Acacia hakeoides	Western black wattle	W
Acacia implexa	Hickory wattle	W
Acacia montana	Mallee wattle	W
Acacia pendula	Boree	W
Acacia pyncantha	Golden wattle	W
Acacia salicina	Cooba	W
Fumariaceae		
**Fumaria bastardii*	Bastards fumitory	W
**Fumaria muralis*	Wall fumitory	W
Gentianaceae		
**Centaurium spicatum*	Spike centaury	W
**Cicendia quadrangularis*	Square cicendia	W
Sebaea ovata	Yellow centaury	W
Geraniaceae		
**Erodium botrys*	Long storksbill	W
**Erodium cicutarium*	Common crowfoot	W
Erodium crinitum	Blue crowfoot	W
**Erodium moschatum*	Musky crowsfoot	W
Geranium retrorsum	Common cranesbill	W
Geranium solanderi var. solanderi	Australian geranium	W
Goodenaceae		
Goodenia fascicularis	Silky goodenia	W
Goodenia glauca	Pale goodenia	F
Goodenia gracilis	Slender goodenia	F
Goodenia heteromera	Spreading goodenia	F
Goodenia pinnatifida	Scrambled eggs	W
Goodenia pusilliflora	Small-flowered Goodenia	W

Scientific Name	Common name	Habitat
Haloragaceae		
Haloragis aspera	Rough raspwort	F
Haloragis glauca	Grey raspwort	F
Haloragis heterophylla	Variable raspwort	G
Myriophyllum crispatum	Common water-milfoil	G
Myriophyllum verrucosum	Red water-milfoil	G
Lamiaceae		
Ajuga australis	Austral bugle	W
**Lamium amplexicaule*	Dead nettle	W
**Marrubium vulgare*	Horehound	W
Mentha australis	River mint	F
Mentha diemenica	Slender mint	F
**Mentha pulegium*	Penny royal	F
Mentha satureioides	Creeping mint	F
**Salvia verbenaca*	Wild sage	W
Teucrium racemosum	Grey germander	W
Lentibulariaceae		
Utricularia australis	Yellow bladderwort	G
Linaceae		
Linum marginale	Native flax	F
Lobeliaceae		
Isotoma fluviatilis	Swamp isotome	G
Pratia concolor	Poison pratia	F
Loranthaceae		
Amyema linophyllum subsp. orientale	Slender-leaf mistletoe	W
Amyema miquellii	Box mistletoe	F
Amyema miraculosum subsp. boormanii	Fleshy mistletoe	W
Amyema pendulum subsp. longifolium	Drooping mistletoe	F
Lysiana exocarpi subsp. exocarpi	Harlequin mistletoe	W
Lythraceae		
Lythrum hyssopifolia	Hyssop loosestrife	F
Lythrum salicaria	Purple loosestrife	F
Malvaceae		
**Malva parviflora*	Small-flowered mallow	W
**Modiola caroliniana*	Red-flowered mallow	W
Sida corrugata	Corrugated sida	W
Sida fibulifera	Pin sida	F
Meliaceae		
+Melia azedarach	White cedar	W
Menyanthaceae		
Nymphoides crenata	Wavy marshwort	G
Moraceae		
**Maclura pomifera*	Osage orange	F
Myoporaceae		
Eremophila debilis	Amulla	F
Eremophila longifolia	Emubush	W
Myoporum montanum	Western boobialla	W
Myoporum platycarpum	Sugarwood	W
Myrtaceae		
Callistemon sieberi	River bottlebrush	F
Calytrix tetragona	Common fringe-myrtle	W
Eucalyptus camaldulensis	River red gum	F
Eucalyptus largiflorens	Black box	F
Eucalyptus melliodora	Yellow box	W
Eucalytpus microcarpa	Western grey box	W

Scientific Name	Common name	Habitat
Melaleuca lanceolata	Moona	W
Nyctaginaceae		
Boerhavia dominii	Tarvine	W
Onagraceae		
Epilobium billardierianum subsp. cinereum	A willow-herb	F
Epilobium hirtigerum	Hoary willow-herb	F
Ludwigia peploides subsp. montevidensis	Water primrose	G
**Oenothera stricta*	Evening primrose	W
Oxalidaceae		
Oxalis perennans	Woodsorrel	W
**Oxalis pes-caprae*	Soursob	W
Papaveraceae		
**Papaver hybridum*	Rough poppy	W
Pittosporaceae		
Bursaria spinosa	Native blackthorn	W
Pittosporum phylliraeoides	Butterbush	W
Plantaginaceae		
**Plantago coronopus subs. commutata*	Buck's horn plantain	W
Plantago debilis	Shade plantain	W
Plantago drummondii	Dark sago-weed	W
Plantago gaudichaudii	Narrow-leaf plantain	W
**Plantago lanceolata*	Lamb's tongue	W
Plantago turrifera	Small sago-weed	W
Plantago varia	Variable plantain	W
Polygonaceae		
Muehlenbeckia florulenta	Lignum	F
Persicaria decipiens	Slender knotweed	G
Persicaria hydropiper	Water pepper	G
Persicaria lapathifolium	Pale knotweed	G
Persicaria prostrata	Creeping knotweed	G
**Polygonum arenastrum*	Wireweed	W
**Polygonum aviculare*	Wireweed	W
Polygonum plebeium	Small knotweed	G
Rumex brownii	Slender dock	W
**Rumex conglomeratus*	Clustered dock	W
**Rumex crispus*	Curled dock	F
Rumex crystallinus	Shiny dock	G
Rumex dumosus	Wiry dock	W
**Rumex pulcher subsp. pulcher*	Fiddle dock	W
Rumex tenax	Shiny dock	G
Portulacaceae		
Calandrinia eremaea	Small purslane	W
Portulaca oleracea	Pigweed	W
Primulaceae		
**Anagallis arvensis*	Scarlet pimpenel	F
Proteaceae		
Banksia marginata	Silver banksia	W
Hakea tephrosperma	Hooked needlewood	W
Ranunculaceae		
Myosurus minimus var. australis	Mousetail	F
Ranunculus inundatus	River buttercup	G
Ranunculus lappaceus	Common buttercup	G
**Ranunculus muricatus*	Sharp buttercup	G
Ranunculus pentandrus var. platycarpus	Smooth buttercup	F
Ranunculus pumilio var. pumilio	Ferny buttercup	G

Scientific Name	Common name	Habitat
Rosaceae		
**Ranunculus sceleratus*	Celery buttercup	G
Ranunculus sessiliflorus var. sessiliflorus	Buttercup	G
Rosaceae		
Acaena novae-zelandiae	Bidgee-widgee	F
Aphanes australiana	Australian piert	F
**Pyracantha angustifolia*	Firethorn	W
**Prunus sp.*	Plum	W
**Rosa canina*	Dog rose	F
**Rosa rubiginosa*	Sweet briar	F
**Rubus ulmifolius*	Blackberry	F
Rubiaceae		
Asperula conferta	Common woodruff	F
**Galium aparine*	Cleavers	F
**Galium murale*	Small bedstraw	W
Salicaceae		
**Salix alba fragilis (hybrid)*	Willow	F
**Salix babylonica*	Weeping willow	F
**Salix fragilis*	Crack willow	F
Santalaceae		
Exocarpus aphyllus	Leafless cherry	W
Exocarpos cupressiformis	Native cherry	W
Exocarpos strictus	Dwarf cherry	F
Santalum acuminatum	Quondong	W
Santalum lanceolatum	Sandalwood	W
Sapindaceae		
Dodonaea viscosa subsp. angustissima	Narrow-leaf hopbush	W
Dodonaea viscosa subsp. cuneata	Wedge-leaf hopbush	W
Scrophulariaceae		
Glossostigma elatinoides	Small mudmat	G
Gratiola pedunculata	Stalked brooklime	G
Gratiola pubescens	Austral brooklime	G
Limosella australis	Australian mudwort	G
Limosella curdieana	Large mudwort	G
Mimulus gracilis	Slender monkey-flower	F
**Parentucellia latifolia*	Common bartsia	G
Stemodia florulenta	Blue-rod	F
Stemodia glabella	Smooth blue-rod	F
**Verbascum virgatum*	Twiggy mullein	W
**Veronica arvensis*	Wall speedwell	G
**Veronica peregrina*	Wandering speedwell	F
Solanaceae		
**Datura ferox*	Fierce thornapple	W
**Datura stramonium*	Common thornapple	W
**Lycium ferocissimum*	African boxthorn	W
**Solanum americanum*	Glossy nightshade	W
Nicotiana sp.	Tobacco	W
Solanum esuriale	Quena	W
**Solanum nigrum*	Blackberry nightshade	F
Solanum simile	Oondoroo	W
**Solanum triflorum*	Three-flowered nightshade	W
Stackhousiaceae		
Stackhousia monogyna	Creamy candles	W
Sterculiaceae		
+Brachychiton populneus subsp. trilobus	Kurrajong	W
Stylidaceae		

Scientific Name	Common name	Habitat
Levenhookia dubia	Hairy stylewort	F
Stylidium despectum	Dwarf trigger plant	W
Thymelaeaceae		
Pimelia curviflora	Curved rice-flower	F
Urticaceae		
Parietaria debilis	Smooth nettle	W
Urtica incisa	Scrub nettle	W
**Urtica urens*	Small nettle	W
Verbenaceae		
**Verbena bonariensis*	Purple-top	F
Verbena officinalis	Common verbena	F
Violaceae		
Viola betonicifolia	Showy violet	F
Zygophyllaceae		
Tribulus terrestris	Cat-head	W

Appendix C: Wetland birds recorded at the site

Species listing: M = Listed as migratory or marine under the EPBC Act; J = JAMBA; C= CAMBA; R = ROKAMBA, B = Bonn; V = Vulnerable; E = Endangered nationally or internationally.
Habitat: M - Moira Grasslands and Floodplain Marshes; F River Red Gum Forest

Common name	Species name	Habitat	Listing
Australasian bittern	*Botaurus poiciloptilus*	M	E (EPBC), (IUCN)
Australasian grebe	*Tachybaptus novaehollandiae*	M	
Australasian shoveler	*Anas rhynchotis*	M	M
Australian darter	*Anhinga novaehollandiae*	M	
Australian little bittern	*Ixobrychus dubius*	M	
Australian painted snipe	*Rostratula australis*	M	V(EPBC), C
Australian pelican	*Pelecanus conspicillatus*	M	M
Australian reed-warbler	*Acrocephalus australis*	M	
Australian shelduck	*Tadorna tadornoides*	M	M
Australian spotted crake	*Porzana fluminea*	M	M
Australian white ibis	*Threskiornis molucca*	M	M
Australian wood duck	*Chenonetta jubata*	M	M
Azure kingfisher	*Alcedo azurea*	M	
Baillon's crake	*Porzana pusilla*	M	M
Black swan	*Cygnus atratus*	M	M
Black-fronted dotterel	*Elseyornis melanops*	M	
Black-tailed native-hen	*Tribonyx ventralis*	M	
Black-winged stilt	*Himantopus himantopus*	M	M
Blue-billed duck	*Oxyura australis*	M	M
Brolga	*Grus rubicunda*	M	
Buff-banded rail	*Gallirallus philippensis*	M	
Caspian tern	*Sterna caspia*	M	M, C, J
Cattle egret	*Ardea ibis*	M	M, C, J
Chestnut teal	*Anas castanea*	M	M
Common greenshank	*Tringa nebularia*	M	M, B, C, J, R
Dusky moorhen	*Gallinula tenebrosa*	M	
Eastern great egret	*Ardea modesta*	M	M, C, J
Eurasian coot	*Fulica atra*	M	
Freckled duck	*Stictonetta naevosa*	M	M
Glossy ibis	*Plegadis falcinellus*	M	M, B, C
Golden-headed cisticola	*Cisticola exilis*	M	
Great cormorant	*Phalacrocorax carbo*	M	
Great crested grebe	*Podiceps cristatus*	M	
Grey teal	*Anas gracilis*	M	M
Hardhead	*Aythya australis*	M	M
Hoary-headed grebe	*Poliocephalus poliocephalus*	M	
Intermediate egret	*Ardea intermedia*	M	M
Latham's snipe	*Gallinago hardwickii*	M	M, B, C, J, R
Little black cormorant	*Phalacrocorax sulcirostris*	M	
Little egret	*Egretta garzetta*	M	M

Common name	Species name	Habitat	Listing
Little grassbird	*Megalurus gramineus*	M	
Little pied cormorant	*Microcarbo melanoleucos*	M	
Marsh sandpiper	*Tringa stagnatilis*	M	M, B, C, J, R
Masked lapwing	*Vanellus miles*	M	
Musk duck	*Biziura lobata*	M	M
Nankeen night-heron	*Nycticorax caledonicus*	M	
Pacific black duck	*Anas superciliosa*	M	M
Pied cormorant	*Phalacrocorax varius*	M	
Pink-eared duck	*Malacorhynchus membranaceus*	M	M
Plumed whistling-duck	*Dendrocygna eytoni*	M	M
Purple swamphen	*Porphyrio porphyrio*	M	
Red-capped plover	*Charadrius ruficapillus*	M	
Red-kneed dotterel	*Erythrogonys cinctus*	M	
Red-necked avocet	*Recurvirostra novaehollandiae*	M	M
Red-necked stint	*Calidris ruficollis*	M	M, B, C, J, R
Royal spoonbill	*Platalea regia*	M	
Sharp-tailed sandpiper	*Calidris acuminata*	M	M, B, C, J, R
Silver gull	*Chroicocephalus novaehollandiae*	M	M
Spotless crake	*Porzana tabuensis*	M	M
Straw-necked ibis	*Threskiornis spinicollis*	M	M
Superb parrot	*Polytelis swainsonii*	F	V(EPBC, IUCN)
Swamp harrier	*Circus approximans*	M	M
Whiskered tern	*Chlidonias hybrida*	M	M
White-bellied sea eagle	*Haliaeetus leucogaster*	M	M, C
White-faced heron	*Egretta novaehollandiae*	M	
White-necked heron	*Ardea pacifica*	M	
Yellow-billed spoonbill	*Platalea flavipes*	M	

Appendix D: Fish predicted and recorded within the Ramsar site

Table indicates all fish species predicted to occur by Davies et al. 2008; last record / probability of occurrence is from King et al. 2009 and MDBC Native Fish Facts (http://www2.mdbc.gov.au/subs/fish-info/native_info/). Recently recorded equals a record since 1998. Conservation status: E = endangered; V = vulnerable.

Common name	Scientific Name	Probability of occurrence	Conservation	
			NSW	EPBC
Australian smelt	*Retropinna semoni*	Recently record		
Bony bream	*Nematalosa erebi*	Recently record		
Carp gudgeons	*Hypseleotris sp.*	Recently record		
Climbing galaxias	*Galaxias brevipinnis*	Recently record		
Congoli	*Pseudaphritis urvillii*	Not recorded upstream of Darling River		
Dwarf flat-headed gudgeon	*Philypnodon macrostomus*	Not recorded in region since 1980.		
Flathead galaxias	*Galaxias rostratus*	No record – may occur		
Flathead gudgeon	*Philypnodon grandiceps*	Recent record		
Freshwater catfish	*Tandanus tandanus*	Recent record		
Golden perch	*Macquaria ambigua*	Recent record		
Macquarie perch	*Macquaria australasica*	Probably locally extinct, last record 1940s	V	E
Mountain galaxias	*Galaxias olidus*	Recent record		
Murray cod	*Maccullochella peelii*	Recent record		V
Murray hardyhead	*Craterocephalus fluviatilis*	Recent record	V	V
Murray –darling rainbowfish	*Melanotaenia fluviatilis*	Recent record		
Purple-spotted gudgeon	*Mogurnda adspersa*	No record – likely locally extinct	E	
Olive perchlet	*Ambassis agassizii*	Probably locally extinct – last record 1960s		
River blackfish	*Gadopsis marmoratus*	Recent record		
Short-finned eel	*Anguilla australis*	No record – mostly restricted to coastal streams		
Short-headed lamprey	*Mordacia mordax*	Recent record		
Silver perch	*Bidyanus bidyanus*	Recent record	V	
Southern pygmy perch	*Nannoperca australis*	Recent record		
Spangled perch	*Leiopotherapon unicolor*	No recent record (recorded in Edwards River pre 1980		
Trout cod	*Maccullochella macquariensis*	Recent record	E	E
Unspecked hardyhead	*Craterocephalus stercusmuscarum fulvus*	Recent record		

Appendix E: Other wetland dependant fauna recorded at the site

Habitat: M - Moira Grasslands and Floodplain Marshes; F River Red Gum Forest

Scientific Name	Common Name	Habitat
MAMMALS		
Hydromys chrysogaster	Water rat	M
Ornithorhynchus anatinus	Platypus	M
Myotis macropus	Southern myotis	F
AMPHIBIANS		
Myobatrachidae		
Crinia parinsignifera	Plains froglet	M
Crinia signifera	Common eastern froglet	M
Crinea sloanei	Sloanes froglet	M
Limnodynastes dumerilii	Eastern banjo frog	F
Limnodynastes fletcheri	Barking marsh frog	M
Limnodynastes tasmaniensis	Spotted marsh frog	M
Neobatrachus sudelli	Common spadefoot	W
REPTILES		
Chelodina expansa	Broad-shelled river turtle	M
Chelodina longicollis	Eastern long-necked tortoise	M
Emydura macquarii	Murray turtle	M
Eulamprus tympannum	Water skink	M