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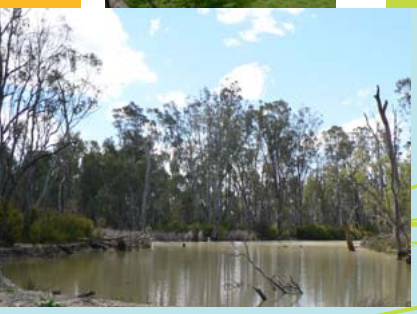

Gunbower Forest

Ramsar Site

Ecological Character Description

June 2011

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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* (DEWHA 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 EPBC Act (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 ECDs 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 the Ramsar Convention 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.

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Glossary

Definitions of words associated with ECDs (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).
Blackwater	Tannin stained, low oxygen water as a result of the microbial breakdown of organic matter.
Change in ecological character	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	Countries that are Member States to the Ramsar Convention on Wetlands; 160 as at August 2010. Membership in the Convention is open to all states that are members of the United Nations, one of the United Nations specialised agencies, or the International Atomic Energy Agency, or is a Party to the Statute of the International Court of Justice.
Critical stage	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	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	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	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.
Ecosystem services	The benefits that people receive or obtain from an ecosystem. The components of ecosystem services are provisioning (e.g. food and water), regulating (e.g. flood control), cultural (e.g. 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 be 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; however, an essential element is not in itself critical for defining the ecological character of the site.
Fluvial geomorphology	The study of water-shaped landforms.
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 ("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 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 pelicans, cormorants, darters and allies: *Pelecaniformes*; • herons, bitterns, storks, ibises and spoonbills: *Ciconiiformes*; • flamingos: *Phoenicopteriformes*; • screamers, swans, geese and ducks (wildfowl): *Anseriformes*; • 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	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 [http://www.ramsar.org/cda/ramsar/display/main/main.jsp?zn=ramsar&cp=1-26-76%5E21235_4000_0__].

List of Abbreviations

ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
AWSG	Australasian Waders Studies Group
CAMBA	China Australia Migratory Bird Agreement
CMA	Catchment Management Authority
CMS	The Convention on the Conservation of Migratory Species of Wild Animals (also known as CMS or Bonn Convention)
CPS	Components, processes and services
DEWHA	Department of Environment, Water, Heritage and the Arts (Commonwealth) (now DSEWPaC)
DSE	Department of Sustainability and Environment (Victoria)
DPI	Department of Primary Industries (Victoria)
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities (Commonwealth) (formerly DEWHA)
ECD	Ecological Character Description
EPA	Environment Protection Authority
EPBC Act	Environment Protection and Biodiversity Conservation Act, 1999 (Commonwealth)
EPBC Regulations	Environment Protection and Biodiversity Conservation Regulations, 2000 (Commonwealth)
GBCMA	Goulburn Broken Catchment Management Authority
IUCN	International Union for Conservation of Nature
JAMBA	Japan Australia Migratory Bird Agreement
LAC	Limits of Acceptable Change
RAOU	Royal Australasian Ornithologists Union
MDBA	Murray-Darling Basin Authority
MDBC	Murray-Darling Basin Commission
NCCMA	North Central Catchment Management Authority
ROKAMBA	Republic of Korea Australia Migratory Bird Agreement
VWSG	Victorian Waders Studies Group

Executive Summary

This ECD Publication represents the second ECD prepared for the Gunbower Forest Ramsar site. The first ECD (DSE 2010) was prepared in 2005 using the *Framework for Describing the Ecological Character of Ramsar Wetlands* (DSE 2005) which pre-dated the current *National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands* (National Framework) (DEWHA 2008). This second ECD updates the description of ecological character in line with the National Framework.

The Gunbower Forest Ramsar site is located in northern Victoria and consists of the section of the Murray River floodplain within Victoria (i.e. south of the main river channel) between Torrumbarry and Koondrook. It is part of the Gunbower-Koondrook-Perricoota Forest Icon Site, one of six icon sites under The Living Murray program established in 2002.

The Ramsar site contains an area of river red gum (*Eucalyptus camaldulensis*) forest that is subjected to periodic inundation. The forest features a variety of permanent and temporary wetlands, including lakes, swamps, lagoons and flooded forest. These wetlands provide habitat for a large number of bird species and native fish populations. It was originally nominated as a Wetland of International Importance under the Ramsar Convention in 1982.

The Gunbower Forest Ramsar site met the following four criteria under conditions at the time of listing and continues to do so currently:

> **Criterion 1:** Gunbower Forest is part of the second largest river red gum forest in the Murray-Darling Basin (the largest being Barmah-Millewa Forest). The size and intact nature of this forested floodplain makes it clearly one of the best representatives of the wetland type Xf (freshwater tree-dominated wetlands) in the bioregion. In addition, the site forms an extensive area of intact floodplain between the Murray River and Gunbower Creek, and is one of the few such areas with native vegetation in the bioregion.
>
> **Criterion 2:** Gunbower Forest is a significant site in terms of supporting at least five wetland dependent species that are listed as threatened at the national and/or international level. These include Australasian bittern (*Botaurus poiciloptilus*), swamp wallaby-grass (*Amphibromus fluitans*), winged peppercress (*Lepidium monoplocoides*), silver perch (*Bidyanus bidyanus*) and Murray cod (*Maccullochella peelii*).
>
> **Criterion 4:** The Gunbower Forest Ramsar site provides habitat for 66 species of wetland bird of which 48 have been recorded breeding within the site. In addition, the site supports hundreds of colonial nesting waterbirds during times of inundation. It is also important for breeding of native fish.
>
> **Criterion 8:** 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 (LACs) are developed for each of the identified critical components, process and services and an assessment of changes since listing, with respect to the LAC is undertaken. A summary of the component, processes and services critical to the ecological character of the Gunbower Forest Ramsar site, together with the LACs and assessment of current conditions is provided in Table E1.

Assessment of changes since designation in 1982 is hampered by a lack of baseline data from the time of listing. This is particularly so for biotic critical components, processes and services. There is some evidence that tree health has declined in the forests in the period 2003 to 2010 (Cunningham et al. 2009) and that the extent of swamp wallaby-grass has declined since 2005. An assessment of current conditions with respect to LACs indicates that some of the LACs for hydrology have been exceeded. However, whether these changes are a result of sustained change or the effects of the recent (2000 to 2010) drought is unknown. It is

likely due to a combination of factors including water resource development, climate change and shorter term climatic cycles.

In addition to changes in components, process and services, there have been a number of important changes in land use and management since listing. From June 2010 a portion of the Ramsar site (formally a mix of State Forest and Crown Land) was reserved as national park under the Victorian *Parks and Crown Land Legislation Amendment (River Red Gum) Act 2010.* These alterations to land tenure have resulted in major land use changes including a restriction of logging activities in the area.

Threats to the ecological character of the site have been identified as:

- Water resource development (decreased frequency and duration of inundation and altered seasonality of inundation), leading to:
    - a reduction in the health and extent of river red gum forests and floodplain marshes;
    - altered vegetation community composition;
    - a decrease in habitat for fauna feeding and breeding; and
    - the absence or disruption of bird, fish and frog breeding events.
- Climate change (increased temperatures and decreased rainfall) which exacerbate effects of water resource development and altered fire regimes.
- Forestry activities resulting in:
    - Short term, localised mortality or displacement of flora and fauna;
    - Medium term, removal of habitat resources, altered vegetation community composition and structure; and
    - Long term, potential loss of large hollow bearing trees, affecting breeding habitat.
- Altered fire regimes (increased frequency and intensity of fires), leading to:
    - Death of mature river red gums;
    - Adverse changes to forest structure; and
    - The loss or degradation of habitat.
- Invasive species (weeds, introduced fish), which cause:
    - Increased predation or competition with native flora and fauna; and
    - Increased risk of destructive wildfire through increased understorey biomass.
- Human disturbance (recreation), which can lead to:
    - Loss or degradation of habitat through unauthorised firewood collection;
    - Soil and riparian zone degradation by off road vehicles or watercraft; and
    - Increased risk of destructive wildfire.

There several knowledge gaps associated with the ecological character of the Gunbower Forest Ramsar site. The majority of these relate to conditions at the time of listing in 1982. A number of monitoring needs to address these knowledge gaps and aid assessment against LACs have been recommended.

<u>Additional explanatory notes on LACs</u>

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 LACs, 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 LACs 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 LACs 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.

LACs 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.

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 and major tributaries. • 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 forest are generally the result of catchment scale rainfall events. • Groundwater sources are secondary with the site being termed a "flushing zone" losing groundwater to the river following inundation.	*No less than four events in any 10 year period of 13 700 megalitres a day for three months (Murray River at Torrumbarry); and a maximum interval of three years between the stated flow event.* *No less than five events in any 20 year period of 30 000 megalitres a day for two months (Murray River at Torrumbarry) and a maximum interval of five years between the stated flow event.* *No less than 10 events in any 50 year period of 40 000 megalitres a day for one month (Murray River at Torrumbarry) and a maximum interval of 10 years between the stated flow event.*	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 LACs for small (in-channel) and medium overbank floods have been exceeded.
Vegetation: • The two critical wetland vegetation categories are floodplain forests and floodplain marshes. • Approximately 15,800 hectares (80 percent of the site) is covered in inundation dependent forest and woodland made up of river red gum forest (8326 hectares), river red gum woodland (4757 hectares) and black box woodland (2694 hectares). • River red gum forest is the dominant vegetation community, comprising 65 percent of the site. • Seventy-five species of native aquatic/wetland plant species recorded in floodplain marshes. • Species richness and cover of plants in floodplain marshes is highly variable temporally and spatially. • The site is important for the threatened swamp wallaby-grass and winged peppercress.	*Extent of floodplain forest and woodland vegetation to be no less than:* • *7500 hectares of river red gum forest* • *4280 hectares of river red gum woodland* • *2400 hectares of black box woodland* *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 mapping of ecological vegetation classes (EVCs) in 2005 indicated little evidence of widespread loss of long-lived trees. Cunningham et al. (2009) indicated that 95 percent of trees were in moderate or better condition in 2009.
	Extent of spike sedge wetland to be no less than 270 hectares. *Extent of tall marsh wetland to be no less than 125 hectares.*	No recent assessment of extent of floodplain marshes. However, the 2010 floods are likely to have replenished the system.
	Presence of swamp wallaby-grass in permanent and intermittent wetlands within the site.	Decline in extent of swamp wallaby-grass from 2005 to 2010 at three permanent wetlands surveyed. However, the species is still present (Australian Ecosystems 2010).

Critical components processes and services	Limit of Acceptable Change	Current conditions
	Presence of winged peppercress near Reedy Lagoon when waterlogging occurs.	Winged peppercress was present in the site in 2005 in large numbers, but in 2007 under dry conditions was not found (DSE 2009). It is not known if the species returned following floodplain inundation in 2010.
Fish: • Data deficient. • Twelve 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 16 to 36 percent of the total abundance and up to nine percent of biomass of large bodied fish.	*Presence of the following species in no less than two in five annual surveys:* • Australian smelt (*Retropinna semoni*) • Carp gudgeons (*Hypseleotris* spp.) • Dwarf flat-headed gudgeon (*Philypnodon macrostomus*) • Flat-headed gudgeon (*Philypnodon grandiceps*) • Fly-specked hardyhead (*Craterocephalus stercusmuscarum*) • Murray-Darling rainbowfish (*Melanotaenia fluviatilis*).	All target species recorded in 2010 (Rehwinkel et al. 2010).
	Presence of Murray cod and silver perch in Gunbower Creek in three out of five annual surveys.	All fish surveys to date have recorded both Murray cod and silver perch in the site (Rehwinkel et al. 2010).
Wetland birds: • Sixty-six species of wetland bird have been recorded from the site. This includes nine species listed under international migratory agreements and the endangered Australasian bittern. • Maximum counts recorded during the 1974 floods comprise approximately 6000 individuals. • A large proportion of the wetland birds recorded within the site have been observed breeding.	*Successful breeding (80 percent of chicks fledged) of colonial nesting waterbirds during flood events.*	Data deficient, with a lack of systemic surveys in the site. Colonial nesting waterbirds may have bred in the 2010/11 flood, but data is not yet available.
	Presence of the Australasian bittern when tall marsh is inundated.	There are no recent records and no surveys for bittern in the site. This remains a knowledge gap.

Critical components processes and services	Limit of Acceptable Change	Current conditions
Diversity of wetland types: The site supports part of the second 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 average return interval and duration of specific flow events, extent and condition of river red gum forests and woodlands and extent of floodplain marshes. *See LACs for hydrology and vegetation.*	
Physical habitat: Gunbower Forest 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 average return interval 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 LACs for hydrology, vegetation and wetland birds.*	
Threatened species: The Ramsar site supports at least five species listed under the EPBC Act and/or the IUCN Red List.	This critical service is indicated by the presence of individual threatened species at the site. No direct LAC has been developed for threatened species generally. Instead the critical service will be assessed through presence of individual threatened species. *See LACs for wetland birds, 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 LACs for hydrology and native fish.*	
Organic carbon cycling As part of a major floodplain system, the site is important for the cycling of nutrients, particularly carbon both on the floodplain and as a source of organic carbon to receiving waterways.	This service is provided by the uptake of carbon by vegetation, the deposition of organic matter (coarse woody debris and litter) on the floodplain and the mobilisation of particular and dissolved organic carbon to receiving river systems with flood return waters. This service is maintained by vegetation extent, forest structure and hydrology. Therefore no direct LAC has been developed and instead the critical service will be assessed indirectly through changes in hydrology and floodplain forest extent *See LACs for hydrology and vegetation.*	

1. Introduction

This Ecological Character Description (ECD) represents the second ECD prepared for the Gunbower Forest Ramsar site. The first ECD (DSE 2010) was prepared in 2005 using the *Framework for Describing the Ecological Character of Ramsar Wetlands* (DSE 2005) which pre-dated the current *National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands* (National Framework) (DEWHA 2008). This second ECD updates the description of ecological character in line with the National Framework.

1.1 Site details

The Gunbower Forest Ramsar site is located in northern Victoria and consists of the section of the Murray River floodplain within Victoria (i.e. south of the main river channel) between Torrumbarry and Koondrook. It is an area of river red gum (*Eucalyptus camaldulensis*) forest, subject to periodic inundation. The forest features a variety of permanent and temporary wetlands, including lakes, swamps, lagoons and flooded forest. These wetlands provide habitat for a large number of bird species. It was originally nominated as a "Wetland of International Importance" under the Ramsar Convention in 1982. Site details for this Ramsar wetland are provided in Table 1.

Table 1: Site details for the Gunbower Forest Ramsar site.

Site Name	Gunbower Forest
Location in coordinates	Latitude: 35° 39' S to 36° 00' S Longitude: 144° 08' E to 144° 30' E
General location of the site	The Gunbower Forest Ramsar site is located on the Murray River floodplain in the State of Victoria, approximately 30 kilometres northwest of Echuca. Bioregion – Drainage Division 4: Murray-Darling (Australian Water Resources Council 1987).
Area	19 931 hectares
Date of Ramsar site designation	Designated on 15/12/1982
Ramsar Criteria met by wetland	Ramsar criteria 1, 2, 4 and 8
Management authority for the site	At the time of listing, the site was managed by what is currently called DSE State Forests and Parks Victoria. In June 2010 a portion of the area was designated as a National Park and is currently managed by Parks Victoria.
Date the ECD applies	1982
Status of Description	This represents the second ECD for the site, updating DSE 2010.
Date of Compilation	June 2011
Name(s) of compiler(s)	Jennifer Hale and Rhonda Butcher on behalf of DSEWPaC.
References to the Ramsar Information Sheet (RIS)	RIS compiled by Marcus Cooling in 2006.
References to Management Plan(s)	Department of Sustainability and Environment, 2003, Gunbower Forest Ramsar Site: Strategic Management Plan, Victoria.

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 EPBC 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 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 (RIS) which is prepared at the time of designation. It conforms to the National Framework (DEWHA 2008) which was developed by Australian and state/territory governments.

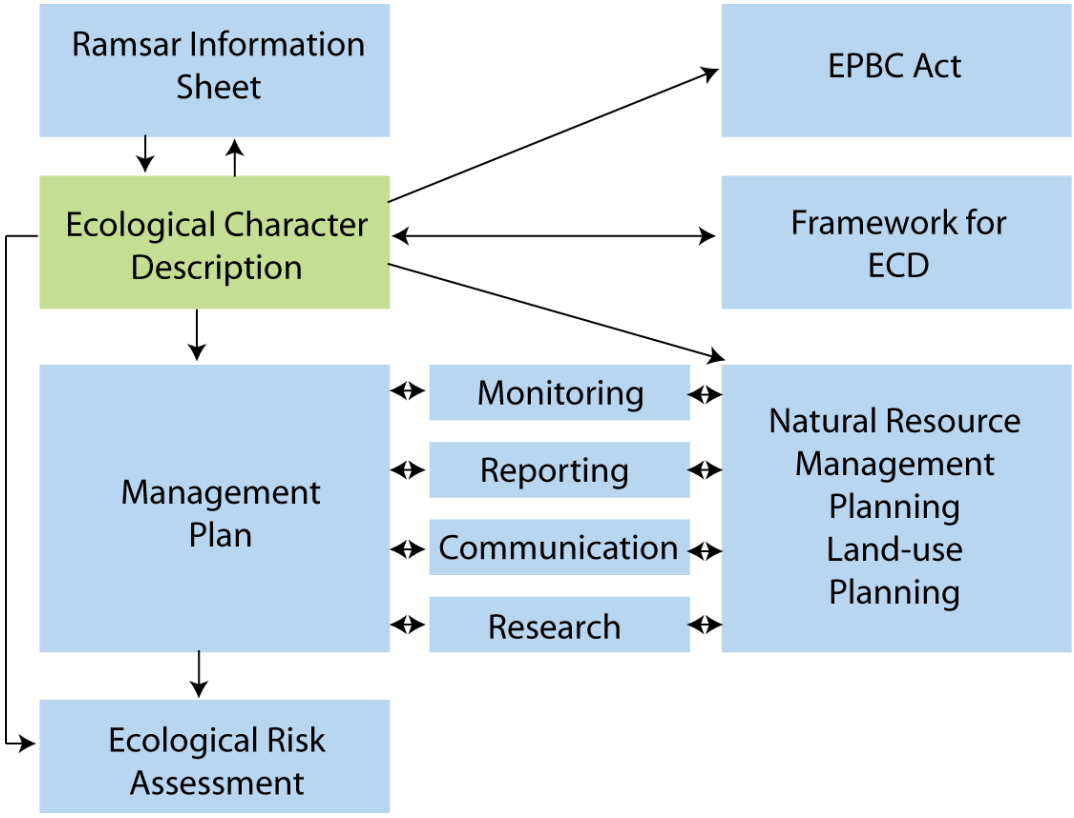

Figure 1: The ecological character description in the context of other requirements for the management of Ramsar sites (adapted from DEWHA 2008).

The National Framework

The National 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 LACs that may indicate when 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 (EPBC Regulations) (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 and as such is not repeated here.

International

Ramsar Convention

The Convention on Wetlands of International Importance, 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 three bilateral agreements and an international convention for the conservation of migratory birds, which are relevant to the Gunbower Forest Ramsar site:

- Japan-Australia Migratory Bird Agreement (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;

- China-Australia Migratory Bird Agreement (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;

- Republic of Korea-Australia Migratory Bird Agreement (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 Convention on Migratory Species of Wild Animals (CMS or Bonn Convention) – the Bonn Convention 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

EPBC 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 EPBC Regulations. 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. 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 EPBC 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

The Water 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 River Murray 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 River Murray system. It is a partnership of the Australian, New South Wales, Victorian, South Australian and Australian Capital Territory governments.

The [Murray-Darling] Basin Plan

The Basin Plan is a strategic plan for the integrated and sustainable management of water resources in the Murray-Darling Basin. It provides 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 identifies, and seeks 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 takes into account the impact of this protection and restoration on individual communities, industries, regions and the wider economy (http://www.mdba.gov.au/what-we-do/basin-plan).

Victorian state policy and legislation

Crown Land (Reserves) Act 1978

This Act provides the framework for the reservation, administration and management of Crown land reserves including nature conservation reserves. It also deals with the making of regulations, committees of management and leasing and licensing.

Environment Protection Act 1970

This Act establishes the Environment Protection Authority and makes provision for the Authority's powers, duties and functions. These relate to improving the air, land and water environments by managing waters, control of noise and control of pollution. State Environment Protection Policies (SEPPs) are subordinate legislation made under the provisions of the Act. SEPP (Waters of Victoria) sets water quality objectives to protect the beneficial uses of inland waters.

Fisheries Act 1995

The Fisheries Act provides a framework for the regulation, management and conservation of Victorian fisheries. It deals with commercial and recreational licences, fish culture, noxious aquatic species, research and development, the declaration and management of fisheries reserves; and the preparation of management plans for individual fisheries, declared noxious aquatic species and fisheries reserves.

Flora and Fauna Guarantee Act 1988

This Act provides a legislative and administrative framework for the conservation of biodiversity in Victoria. The Act provides for the listing of threatened taxa, communities and potentially threatening processes. It requires the preparation of action statements for listed species, communities and potentially threatening processes and sets out the process for implementing interim conservation orders to protect critical habitats. The Act also seeks to provide programs for community education in the conservation of flora and fauna and to encourage co-operative management of flora and fauna.

Forests Act 1958

This Act protects and manages Victoria's State Forests and provides licensing requirements for the harvesting of those forests. Administered by the Secretary of the Department of Sustainability and Environment and subject to the supervision of the Minister for the Environment, the Act states that working plans shall be established for state forests and allows the Minister to proclaim unoccupied Crown land to be a protected forest. The Act manages 'burning off' procedures, the use of fire, saw mills and the cutting of trees.

National Parks Act 1975

This Act makes provision for the preservation and protection of the natural environment including wilderness areas and remote and natural areas. This includes the protection and preservation of indigenous flora and fauna and of features of scenic or archaeological, ecological, geological, historic or other scientific interest in those parks. It allows for the study of ecology, geology, botany, zoology and other sciences relating to the conservation of the natural environment in those parks; and for the responsible management of the land in those parks.

Water Act 1989

This Act establishes rights and obligations in relation to water resources and provides mechanisms for the allocation of water resources. This includes the consideration of environmental water needs of rivers and wetlands as well as for human uses such as urban water supply and irrigation.

Wildlife Act 1975

This Act ensures procedures are in place to protect and conserve Victoria's wildlife and prevent any taxa of wildlife from becoming extinct. The Act also provides for the establishment of State Game Reserves. Regulations under the Act ensures that the consumptive use or other interactions with flora and fauna in Victoria does not threaten the sustainability of wild populations, while facilitating cultural and recreational pursuits in a humane, safe, ethical and sustainable manner.

Catchment and Land Protection Act 1994

This Act sets up a framework for the integrated management and protection of catchments. It establishes processes to encourage and support community participation in the management of land and water resources and provides for a system of controls on noxious weeds and pest animals.

Aboriginal Heritage Act 2006

This Act provides for the protection and management of Victoria's Aboriginal heritage. It establishes the Victorian Aboriginal Heritage Council to advise the Minister in the management of cultural heritage and registered Aboriginal parties. The Act also deals with cultural heritage management plans, cultural heritage permits and agreements. The Act also includes enforcement provisions and processes for handling dispute resolution. This includes the review of certain decisions through the Victorian Civil and Administrative Tribunal (VCAT).

Securing our natural future: A white paper for land and biodiversity at a time of climate change (November 2009)

The Land and Biodiversity White Paper is a long-term, strategic framework to secure the health of Victoria's land, water and biodiversity in the face of ongoing pressures and a changing climate over the next fifty years. The framework for action is based on three inter-related elements:

- building ecosystem resilience across Victoria,
- managing flagship areas to maintain ecosystem services, and
- improving connectivity in areas identified as biolinks.

The Northern Region Sustainable Water Strategy (Northern Region SWS) 2010

The Northern Region SWS aims to identify and understand threats to water availability and quality over the next 50 years, and outlines policies and actions to manage the consequences of prolonged drought and climate change.

1.4 Method

The method used to develop the ECD for the Gunbower Forest Ramsar site is based on the twelve-step approach provided in the National Framework (DEWHA 2008), 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. Details of members of this group and more details of the method are provided in Appendix A.

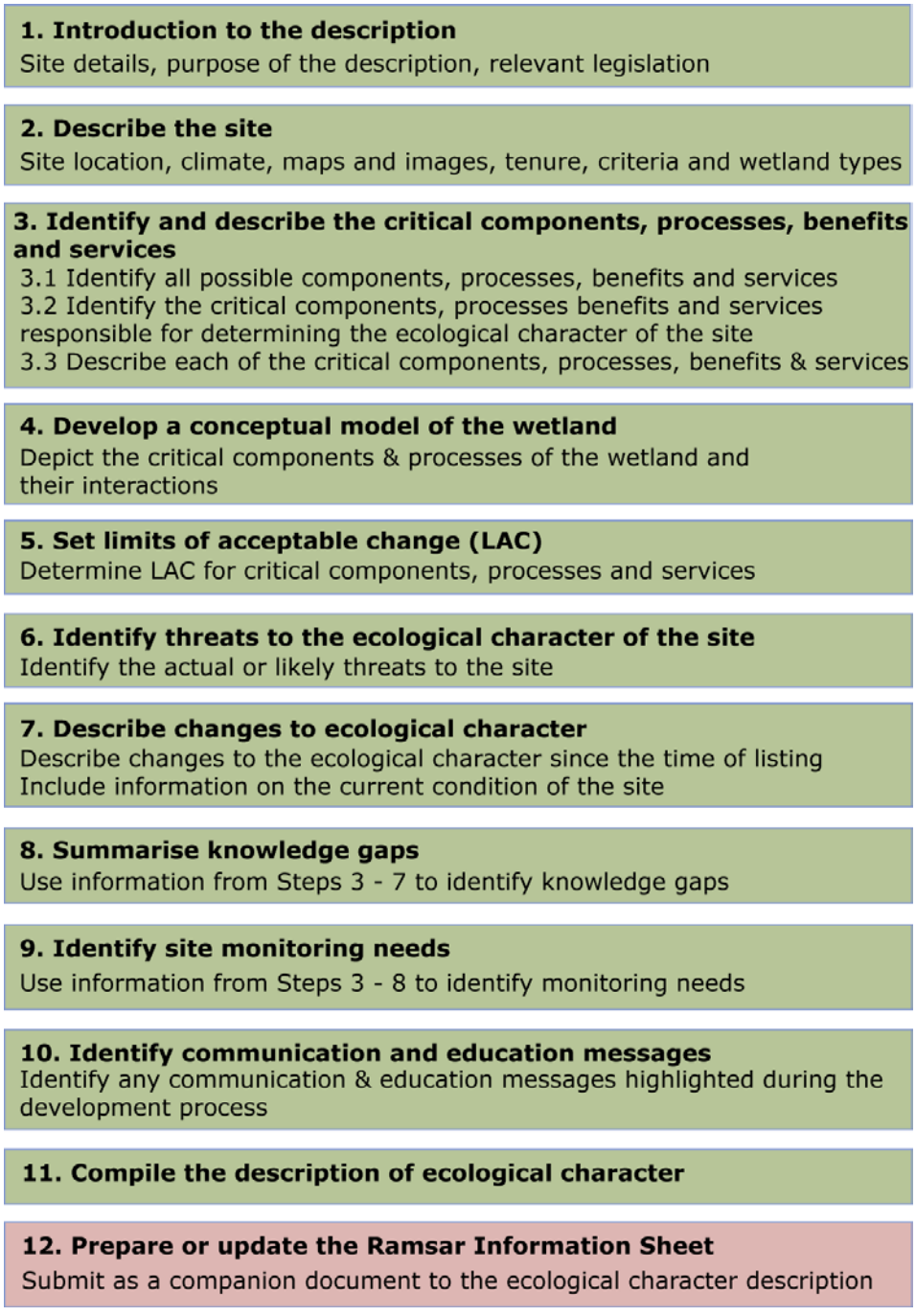

Figure 2: Twelve step process for developing an ECD (adapted from DEWHA 2008).

2. General Description of Gunbower Forest Ramsar Site

2.1 Location

The Gunbower Forest Ramsar site is located in northern Victoria, within the Murray-Darling Drainage Division (bioregion). The site covers 19 931 hectares on Gunbower Island, an area of river red gum forest and wetlands between the Murray River and the anabranch Gunbower Creek. The site is 255 kilometres north of Melbourne and approximately 30 kilometres north west of the town of Echuca (population in 2006; 12 400) within the Shires of Campaspe and Gannawarra local government areas (Figure 3). It is part of the Gunbower-Koondrook-Perricoota Forest Icon Site, one of six icon sites under The Living Murray program established in 2002.

The Gunbower Forest site is within the Murray-Darling Basin, which covers over one million square kilometres and comprises 14 percent of the continent. The forest is located on the floodplain of the Murray River, the longest river in Australia.

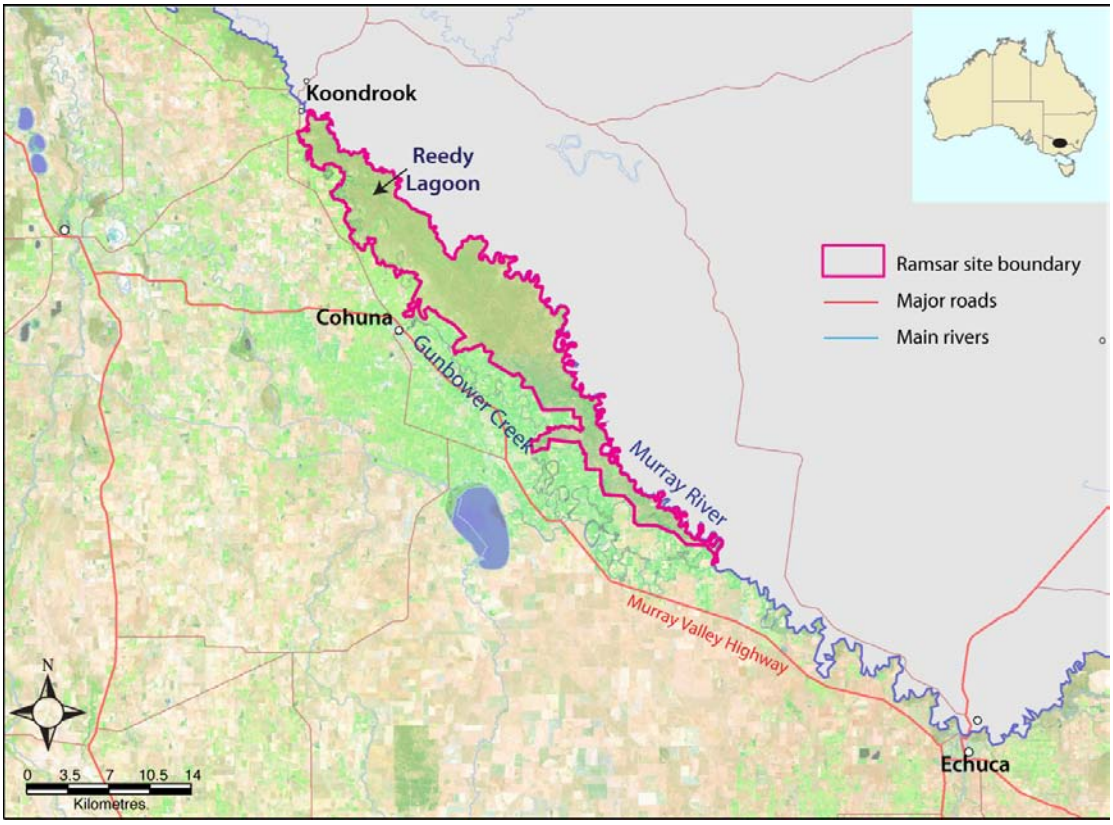

Figure 3: Location of the Gunbower Forest Ramsar site (adapted from DSE 2010).

2.2 Land tenure

At the time of listing (1982) the Gunbower Forest Ramsar site comprised two primary land tenures. Gunbower Island State Forest covered approximately 85 percent of the site and was managed for the purposes of timber production and harvesting (DSE 2003). The remaining parts of the site (approximately 3000 hectares) were Crown Land. In June 2010, 8892 hectares was declared a National Park by the Victorian Government in order to protect and enhance the river red gum forests (Parks Victoria 2010). The site currently comprises of Gunbower State Forest (8843 hectares), Gunbower National Park (8892 hectares) and Murray River Park (1666 hectares; Figure 4).

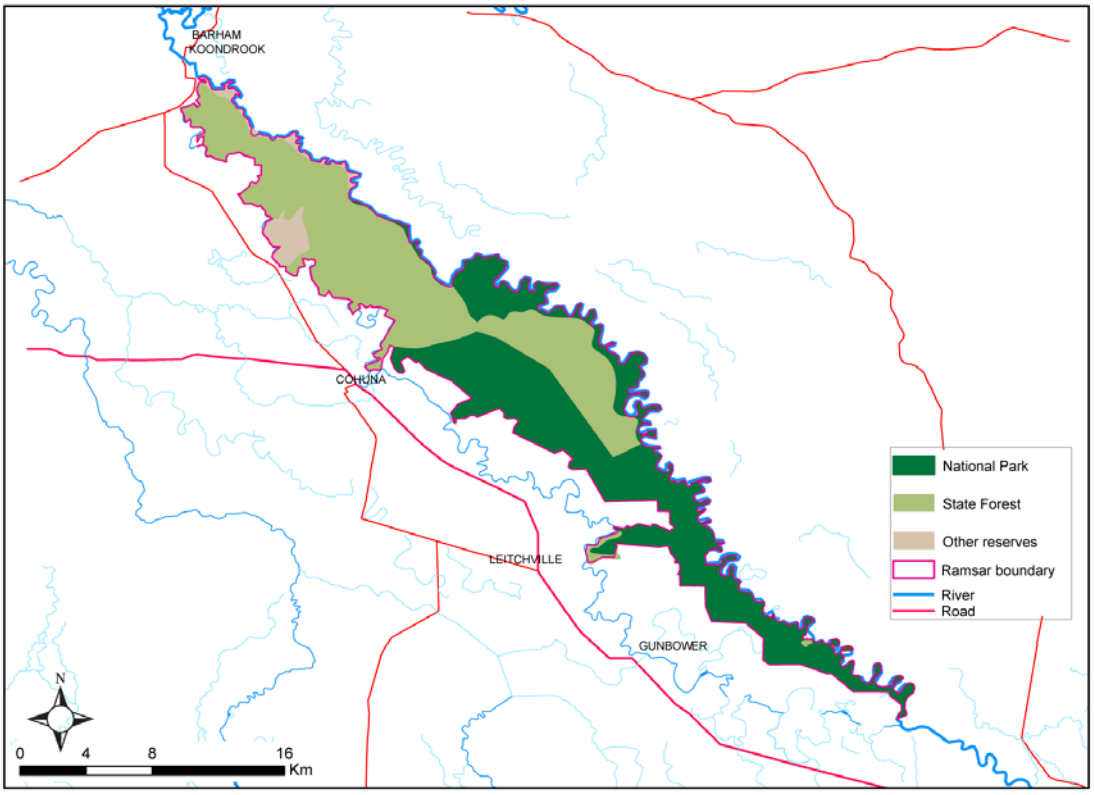

Figure 4: Current land management within the Gunbower Forest Ramsar site (data provided by DSE). Note that this does not reflect the conditions at the time of listing.

2.3 Wetland types

According to the Ramsar wetland classification, there are six wetland types within the Gunbower Forest Ramsar site. In order of dominance, these are:

- Xf - Freshwater, tree-dominated wetlands;
- Ts - Seasonal / intermittent freshwater marshes/pools on inorganic soils;
- O - Permanent freshwater lakes (over eight hectares);
- M - Permanent rivers/streams/creeks;
- N - Seasonal / intermittent / irregular rivers / streams / creeks; and
- 9 - Canals and drainage ditches.

The extent and location of Ramsar wetland types within the Gunbower Forest Ramsar site have been approximated from wetland and vegetation mapping, termed water regime classes (Table 2 and Figure 5). For the purposes of this ECD, wetland type Xf (freshwater tree dominated wetlands) was considered to include river red gum forest and woodland and black box (Eucalyptus largiflorens) woodland. Grey box woodland was excluded and not considered "wetland" as it is not a flood dependent species.

The water regime classes map lentic wetlands only and do not include the extent of flowing wetland types within the site. Flowing wetlands within the site include small parts of Gunbower Creek (in the north of the site) as well as other effluents such as Yarran Creek and Spur Creek.

Examples of wetland types are provided in (Figures 6, 7 and 8).

Table 2: Extent (hectares) of Ramsar wetland types within the Gunbower Forest Ramsar site (adapted from water regime classes provided by NCCMA).

Ramsar wetland type	Relevant water regime class(es)	Extent (hectares)	Examples
Xf – Freshwater, tree-dominated wetlands	River red gum forest and woodland, black box woodland	15 000	Majority of Gunbower Forest – river red gum forest and woodland
O – Permanent freshwater lakes	Permanent wetlands	415	Reedy Lagoon, Pig Swamp
Ts – Seasonal / intermittent freshwater marshes/pools on inorganic soils	Semi-permanent wetlands	995	Little Reedy Lagoon
N – Seasonal / intermittent / irregular rivers / streams / creeks	No equivalent class	NA	Spur Creek
M – Permanent rivers/streams/creeks	No equivalent class	NA	Gunbower Creek
9 – Canals and drainage ditches	No equivalent class	NA	Drains within the site

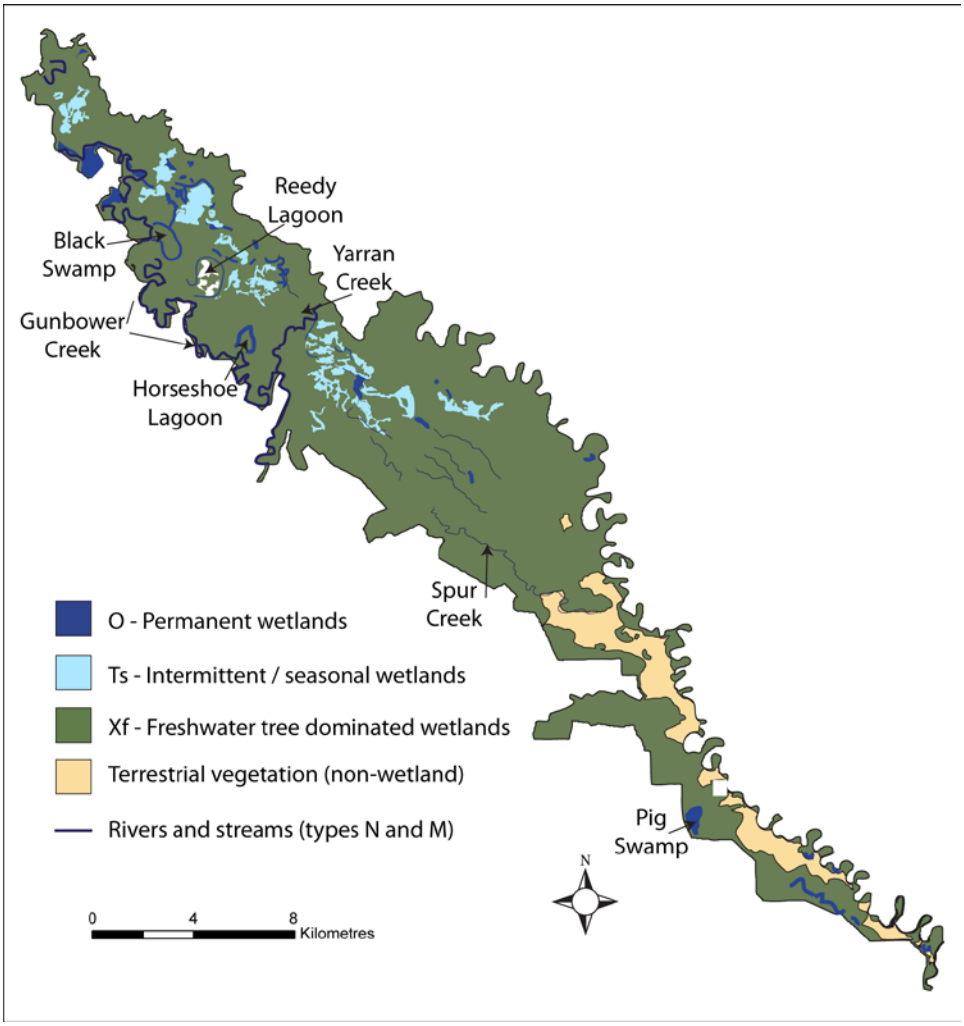

Figure 5: Ramsar wetland types in the Gunbower Forest Ramsar site (data provided by NCCMA).

Figure 6: Example of wetland type Xf (freshwater tree dominated) (photo M. Kohout; 2010).

Figure 7: Example of wetland type M (permanent rivers / streams / creeks) – Gunbower Creek (photo M. Kohout; 2010).

Figure 8: Example of wetland type O (permanent freshwater lakes) – Reedy Lagoon (photo J. Mollison; 2009).

2.4 Ramsar criteria

2.4.1 Criteria under which the site was designated

At the time that Gunbower Forest was first nominated as a Wetland of International Importance, the criteria for identifying Wetlands of International Importance were the "Cagliari criteria", adopted at the first Conference of Contracting Parties in Cagliari in 1980. The original nomination documentation for the Gunbower Forest Ramsar site considered that the site met two of these criteria, as shown in (Table 3). However, no specific justification for these criteria was provided.

Table 3: Criteria for Identifying Wetlands of International Importance as at listing date, 1990. Criteria for which Gunbower Forest was listed are highlighted in green.

Basis	Number	Description
Criteria for waterfowl	1a	it regularly supports 10,000 ducks, geese and swans; or 10,000 coots or 20,000 waders.
	1b	it regularly supports 1% of the individuals in a population of one species or subspecies of waterfowl.
	1c	it regularly supports 1% of the breeding pairs in a population of one species or subspecies of waterfowl.
Criteria based on plants and animals	2a	it supports an appreciable number of rare, vulnerable or endangered species or subspecies of plant or animal.
	2b	it is of special value for maintaining the genetic and ecological diversity of a region because of the quality and peculiarities of its flora and fauna.
	2c	it is of special value as the habitat of plants or animals at a critical stage of their biological cycle.
	2d	it is of special value for one or more endemic plant or animal species or communities.
Criterion based on representative wetlands	3	it is a particularly good example of a specific type of wetland characteristic of its region.

The 2006 RIS assessed the site against the eight criteria adopted at the 4th Conference of Contracting Parties in Montreux in 1990, two of which the Gunbower Ramsar site was considered to meet. Justification for the criteria (as contained in the 2006 RIS) was as follows:

Criterion 3: 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.

The site maintains the ecological diversity of the bioregion by supporting vegetation communities representative of the Victorian Murray Fans Bioregion, which is a component of the Riverina IBRA Bioregion.

The site supports a high diversity of species. A total of 278 indigenous flora species and 205 indigenous fauna species have been recorded on the Victorian Wildlife Atlas and the Victorian Flora Information System. The high diversity of species results from the diverse habitats provided by different water regimes in the forest. The wetland areas support breeding by more than 22 waterbird species, and diverse fish, macroinvertebrate and frog species. Nationally threatened plant species are *Amphibromus fluitans* (vulnerable), *Callitriche cyclocarpa* (vulnerable) and *Lepidium monoplocoides* (endangered). Nationally threatened fauna species include *Litoria raniformis* (vulnerable) and *Mucculochella peelii* (vulnerable).

Criterion 5: A wetland should be considered internationally important if it regularly supports 20 000 or more waterbirds.

No justification provided.

2.4.2 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. A ninth criterion was added at the 9th Ramsar Conference in Uganda in 2005.
- Revision of population estimates for waterbirds (Wetlands International 2006; Bamford et al. 2008), which influences the application of Criterion 6.
- 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 1 and 3.
- Updating of threatened species listings, which affects Criterion 2.

Therefore an assessment of the Gunbower Forest Ramsar site against the current nine Ramsar criteria has been undertaken (Table 4).

Table 4: Criteria for Identifying Wetlands of International Importance (adopted by the 6th (1996) and 9th (2005) Meetings of the Conference of the Contracting Parties). Criteria for which the Gunbower Forest 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.

An assessment against each of the criteria for the Gunbower Forest Ramsar site is as follows:

Criterion 1: The application of this criterion must now be considered in the context of the newly 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 New South Wales into Victoria and South Australia. There is no comprehensive inventory of Ramsar wetland types across the bioregion. However, there is some evidence to support this criterion for the Gunbower Forest Ramsar site.

Advice from the Convention (Ramsar Convention 2009) indicates that this criterion should apply in terms of representativeness to the best examples of a wetland type in the appropriate bioregion. In this context, Gunbower is part of the second largest river red gum forest in the Murray-Darling Basin (the largest being Barmah-Millewa Forest). The size and intact nature of this forested floodplain makes it clearly one of the best representatives of the wetland type Xf in the bioregion.

In addition, this criterion can also be applied with respect to hydrological importance, if for instance the site: “plays a major role in the natural control, amelioration or prevention of flooding” or “is a major natural floodplain system” (Ramsar Convention 2009). The Gunbower Forest Ramsar site clearly meets the latter of these options as it forms an extensive area of intact floodplain between the Murray River and Gunbower Creek, and is one of the few such areas with native vegetation in the bioregion.

This criterion was met at the time of listing and continues to be met.

Criterion 2: 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 on 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 Gunbower Forest 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, terrestrial species such as the plains wanderer (*Pedionomus torquatus*) and mountain regent honeyeater (*Anthochaera phrygia*) have not been considered to contribute to the meeting of this criterion. In addition, there are records from 1920 to 1951 for the Australian painted snipe (*Rostratula australis*), but no records post 1960 and so this species has also not been considered with respect to this criterion.

There are eight wetland dependent threatened species that have been recorded within the site since 1960s (Table 5). However, there is a very low degree of certainty that the site is important for the growling grass frog (*Litoria raniformis*), trout cod (*Maccullochella macquariensis*) and western water-starwort (*Callitriche cyclocarpa*), with only isolated records for these species. The site is considered important for supporting five threatened species:

- Australasian bittern (*Botaurus poiciloptilus*);
- Murray cod (*Maccullochella peelii*);
- Silver perch (*Bidyanus bidyanus*);
- Swamp wallaby-grass (*Amphibromus fluitans*); and
- Winged peppercress (*Lepidium monoplocoides*).

This criterion was met at the time of listing and continues to be met.

Table 5: Threatened species recorded in the Gunbower Forest Ramsar site post 1960 (CE = critically endangered; E = endangered; V = vulnerable).

Species	Listing		Records	Strength of evidence
	IUCN	EPBC		
Australasian bittern *Botaurus poiciloptilus*	E	E	Recorded in Pigs Swamp in 1993 (DSE unpublished) and on a number of occasions between 2003 and 2008 (Birds Australia unpublished).	Despite the cryptic nature of this species there are a number of records from within the site. There is a high degree of certainty that the site is important for this species.
Murray cod *Maccullochella peelii*	CE	V	Present in streams and creeks within the site in 1993, 1994 (DSE unpublished), 2005 (Richardson et al. 2005), 2009 and 2010 (Rehwinkel et al. 2010).	There are multiple records for this species from within Gunbower Creek. The site is important for this species with moderate certainty.
Silver perch *Bidyanus bidyanus*	V		Present in streams and creeks within the site in 1993 and 1994 (DSE unpublished) 2009 and 2010 (Rehwinkel et al. 2010).	There are multiple records for this species from within Gunbower Creek. The site is important for this species with moderate certainty.
Trout cod *Maccullochella macquariensis*	E	E	Present in lagoons within the site in 2009 and 2010 (Rehwinkel et al. 2010).	Relatively recent records only and very low abundances. There is a low degree of certainty that the site is important for this species.
Growling grass frog *Litoria raniformis*	E	V	Reedy Lagoon in 1982 (DSE unpublished).	Single record only and despite a number of fish surveys in recent years (Ward 2009) the species has not been found again. There is a low degree of certainty that the site is important for this species.
Swamp wallaby-grass *Amphibromus fluitans*		V	Present in the forest in numerous locations (DSE unpublished). Found at Reedy Lagoon, Black Swamp and Little Gunbower wetland complex from 2005 to 2010 (Australian Ecosystems 2010).	Present in both permanent wetlands and in the understorey of river red gum forest at a large number of locations within the Ramsar site. There is a high degree of certainty that the site is important for this species.
Western water-starwort *Callitriche cyclocarpa*		V	Records from within the site in 1987 (DSE unpublished).	Single record only and despite extensive wetland vegetation surveys (2005 to 2010) has not been recorded since (Australian Ecosystems 2010). There is a low degree of certainty that the site is important for this species.
Winged peppercress *Lepidium monoplocoides*		E	Reedy Lagoon in 1984 (DSE unpublished); 2004 and 2005 (DSE 2009). In 2005 the population was estimated at 50 000 individuals.	Present at Reedy Lagoon on a number of occasions and at a relatively high abundance. There is a high degree of certainty that the site is important for this species.

Criterion 3: Guidance from the Ramsar Convention (Ramsar 2009) indicates that the application of this criterion should consider endemism and “hot-spots” of biodiversity. Although there is insufficient information at the bioregional scale to adequately assess this criterion, the site supports less species than the adjacent Barmah Forest (553 native species of flora and 273 fauna at Barmah Forest as opposed to 278 native species of flora and 150 native species of fauna at Gunbower).

The justification for this criterion in the 2006 RIS (see above) was based partly on nationally listed threatened species and partially on the importance of the site for breeding. These are relevant to Criteria 2 and 4 respectively. As such, in this reassessment of the criteria, these values have been attributed to Criteria 2 and 4 (which the site is now considered to meet) rather than Criterion 3.

This criterion is not met.

Criterion 4: 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. Although not considered to be met in the 1999 assessment, there is clear evidence for the site meeting this criterion based in particular on the role of the site in supporting breeding of wetland birds, frogs, turtles and fish during periods of inundation.

A total of 48 species of wetland bird have been recorded breeding within the Gunbower Ramsar site, which is over 70 percent of the total wetland bird species richness for the site. In addition, there are records of fish spawning in wetland and stream habitats (MDBC 2007) as well as at least two species of turtle and six species of frog (DSE unpublished).

This criterion was met at the time of listing and continues to be met.

Criterion 5: 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. However, there are no records of more than 20 000 waterbirds from within the site, with maximum counts of less than 10 000 individuals (DSE 2010).

This criterion is not met.

Criterion 6: The application of this criterion suffers from the same problems as that described for criterion five above. There are no records from within the site of individual wetland bird species above the relevant one percent population thresholds.

This criterion is not met.

Criterion 7: 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. Only 13 species of native fish have been recorded from within the site, none of which are endemic and all with the similar lifecycle characteristics.

This criterion is not met.

Criterion 8: Guidance from the Ramsar 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 and floodplains, with Gunbower Creek an important passage for native fish. 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).

This criterion was met at the time of listing and continues to be met.

Criterion 9: The application of this criterion relies on estimates of the total population of non-bird species. In the case of Gunbower Forest this would require population estimates of frog or fish 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 relevant population.

This criterion is not met.

3. Critical Components and Processes

3.1 Identifying critical components and processes

The basis of an ECD is the identification, description and where possible, quantification of the critical components, processes, benefits and services of the site at the time of listing. 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, we need to identify and characterise the key or critical components, processes, benefits and services that determine the character of the site. These are the aspects of the ecology of the wetland, which, if they were to be significantly altered, would result in a significant change in the system.

The National Framework (DEWHA 2008) suggests that the minimum components, processes, benefits and services which should be included in an ECD are those:

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

In addition to critical components and processes, there are characteristics of the site that are not critical (that is if they were to change, they would not lead directly to a change in character) but are still important in the ecology of the system. These supporting components and processes include some of the characteristics of the site, which may act as early warning indicators of a potential change in character and therefore should be considered in management planning for the site.

In identifying critical components and processes, the role that those 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 9. 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. 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.

It should also be noted that the separation of components from processes is not straightforward. 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.

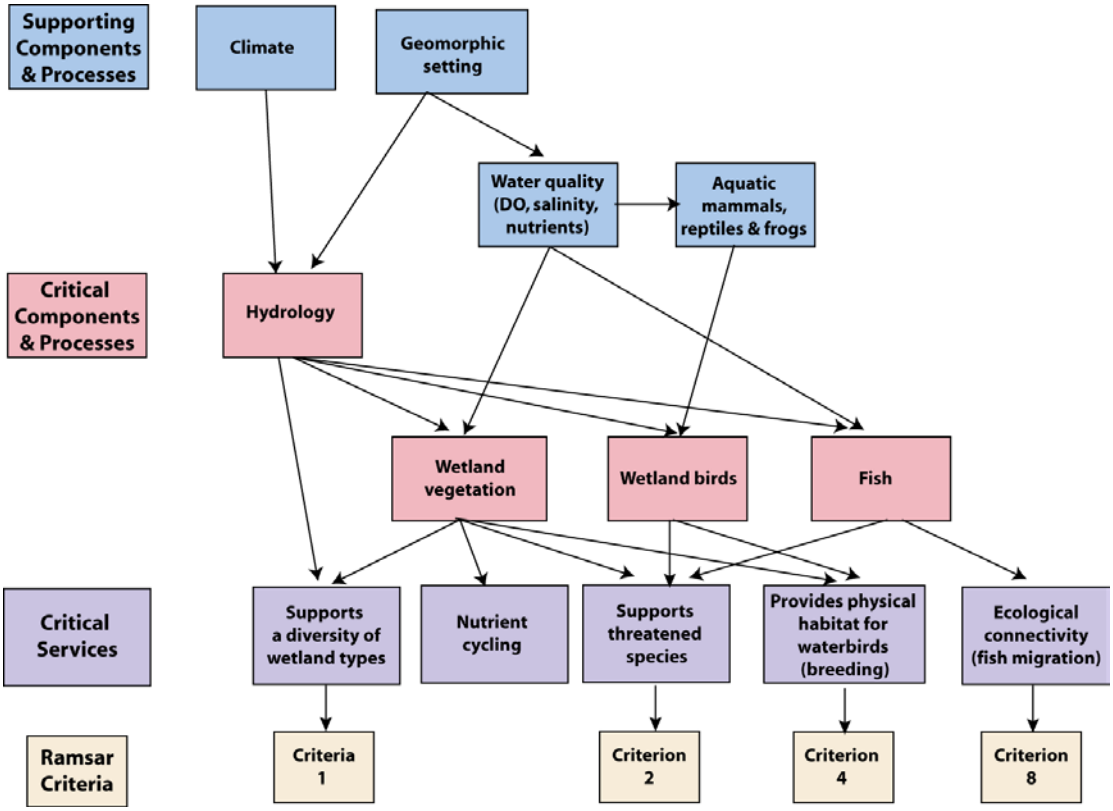

Figure 9: Simple conceptual model showing the key relationships between components and processes; benefits and services and the reasons for the site being listed as a wetland of international importance.

The identified critical components and processes for the Gunbower Forest Ramsar site are:

- hydrology;
- wetland vegetation;
- wetland birds; and
- fish.

It should be noted that with respect to threatened species, only those for which the site comprises important habitat were considered to meet all four of the DEWHA (2008) criteria for determining critical components processes and services. In particular species that have been recorded on a single occasion, or for which the sites does not contain core habitat were not considered to be “important determinants of the sites unique character”. The threatened species that are identified as critical to the ecological character of the Gunbower Forest Ramsar site are:

- Australasian bittern;
- Murray cod;
- silver perch;
- swamp wallaby-grass; and
- winged peppercress.

3.2 Supporting components and processes

The components and process that are considered important in supporting the critical components, processes, benefits and services of the Gunbower Forest Ramsar site are described briefly below and summarised in Table 6.

Table 6: Summary of supporting components and processes within the Gunbower Ramsar site.

Components and processes	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. • Rainfall is highly variable.
Geomorphic setting	• On the floodplain of the River Murray. • Hydrology is controlled in part by the Barmah Choke, where the River Murray channel narrows considerably and restricts flows influencing hydrology downstream. • Highly depositional environment with soils predominantly comprising silty-clays.
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.
Aquatic mammals, reptiles and frogs	• Data deficient. • Two species of wetland dependent mammal: water rat (*Hydromys chrysogaster*) and platypus (*Ornithorhynchus anatinus*). • Eleven species of frog. • Four water dependent species of reptile: broad-shelled turtle (*Macrochelodina expansa*); long-necked tortoise (*Chelodina longicollis*); Murray short-necked tortoise (*Emydura macquarii*) and yellow-bellied water skink (*Eulamprus heatwolei*).

3.2.1 Climate

Gunbower Forest is situated within the semi-arid/grassland climatic zone of south-eastern Australia (Bureau of Meteorology 2011). 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. 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, on average, occurs year round with highest monthly median rainfall in June (41 millimetres) and lowest in February (15 millimetres). There is some degree of variability in rainfall as evidenced by the 10th and 90th percentiles, which range from less than 1 millimetre per month to greater than 85 millimetres per month (Figure 10).

Annual average rainfall at Echuca is in the order of 450 millimetres per year. Once again, there is some degree of variability in annual rainfall (ranging from around 200 millimetres up to 900 millimetres in the 60 years of records from this site) (Figure 11).

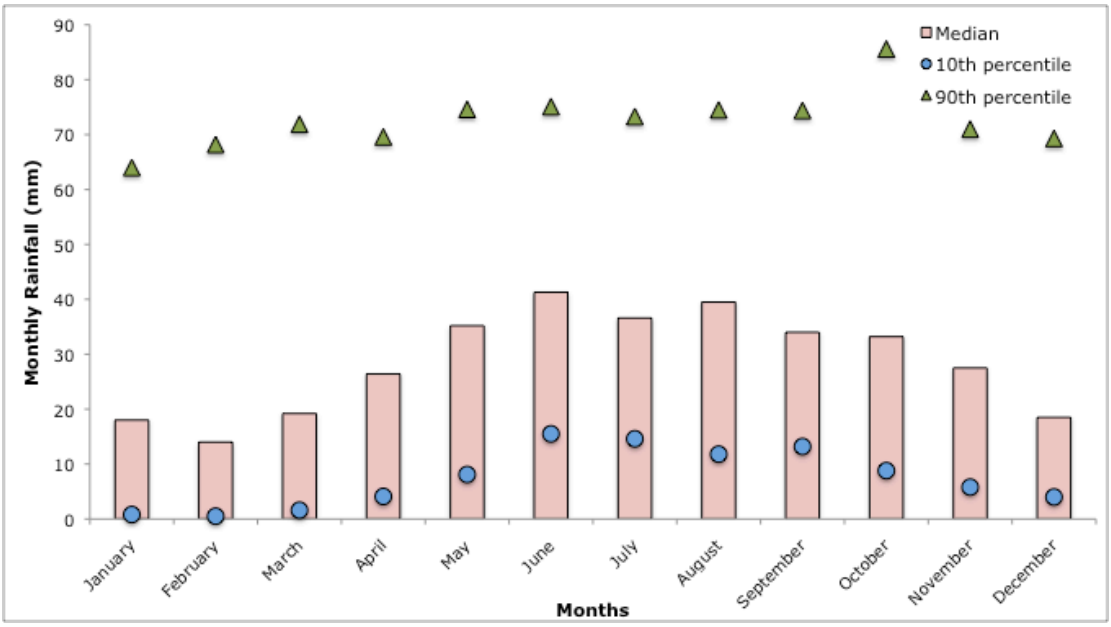

Figure 10: Median, 10th and 90th percentile monthly rainfall at Echuca (1859 – 2010; Bureau of Meteorology).

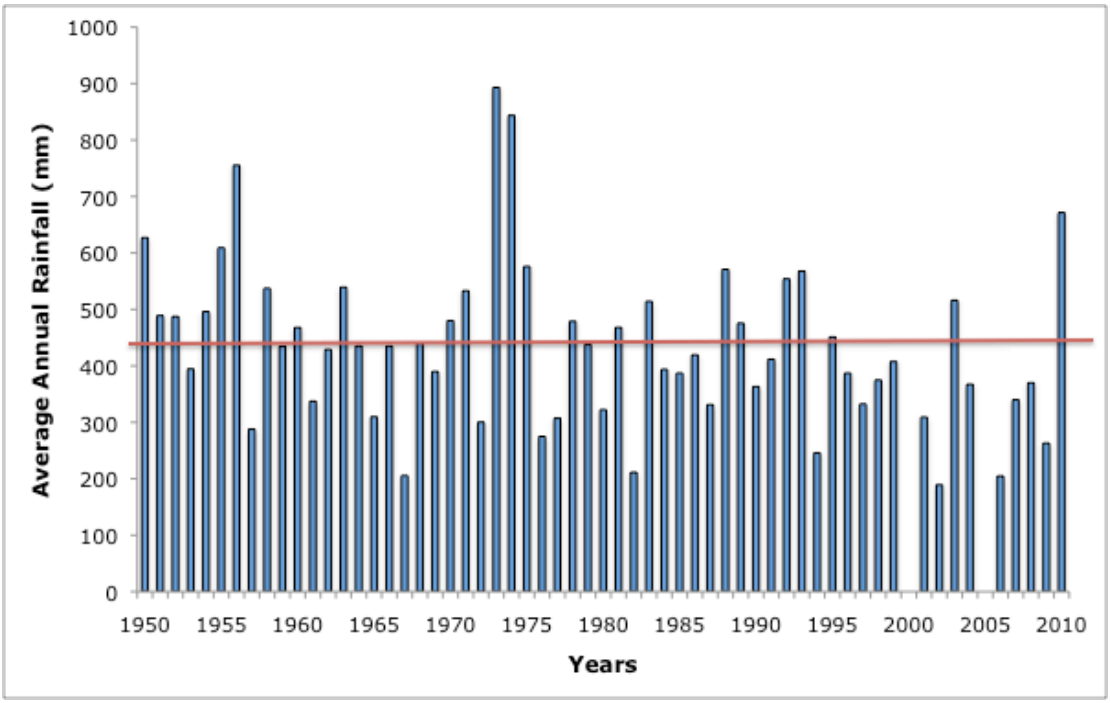

Figure 11: Average annual rainfall at Echuca (1950 – 2010; Bureau of Meteorology). Horizontal line shows long term average.

Temperatures range from cool to warm (Figure 12), with average summer maximum temperatures around 30 degrees Celsius and average minimum temperatures around 15 degrees Celsius. During winter average maximum temperatures are considerably cooler (15 to 13 degrees Celsius) as are average minimum temperatures (four to five degrees Celsius). Average relative humidity ranges from 50 percent during summer to 90 percent during winter months. This combined with the relatively low winter temperatures results in rainfall exceeding evaporation during winter, but the reverse situation for the remainder of the year.

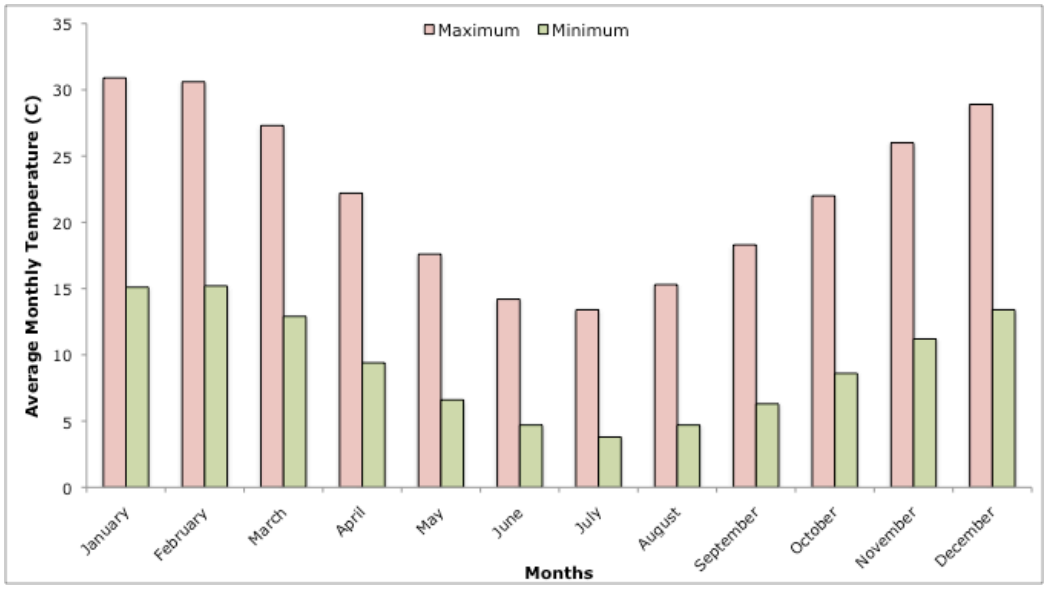

Figure 12: Average monthly maximum and minimum temperatures at Echuca (1881 – 2010; Bureau of Meteorology).

3.2.2 Geomorphic setting

The site is composed of Quaternary alluvial sediments on the floodplain of the Murray River. Quaternary geological and geomorphological processes have fundamentally shaped the character of Gunbower Forest. 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 flat, with a regional east-west slope of some 0.2 metres per kilometre (Bacon et al. 1993). Within the site itself the elevation is highest near Torrumbarry Weir at about 80 metres Australian Height Datum (AHD) reducing to approximately 72 metres AHD near Koondrook Weir (Water Technology 2009). A digital elevation model of the site shows the general topography as well as some of the floodplain features (Figure 13). Yarran Creek banks are higher than the surrounding land and form a hydraulic barrier to flow across the floodplain (Water Technology 2009). Of note also is the area in the mid forest (downstream of Spur Creek) that is characterised by a network of channels, some of which are deeply incised. The north-western (downstream) areas of the site are at the lowest elevation and it is here where larger depressional floodplain wetland complexes occur (Water Technology 2009).

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). The site is a highly depositional environment, although there are no specific measures of sedimentation within the site.

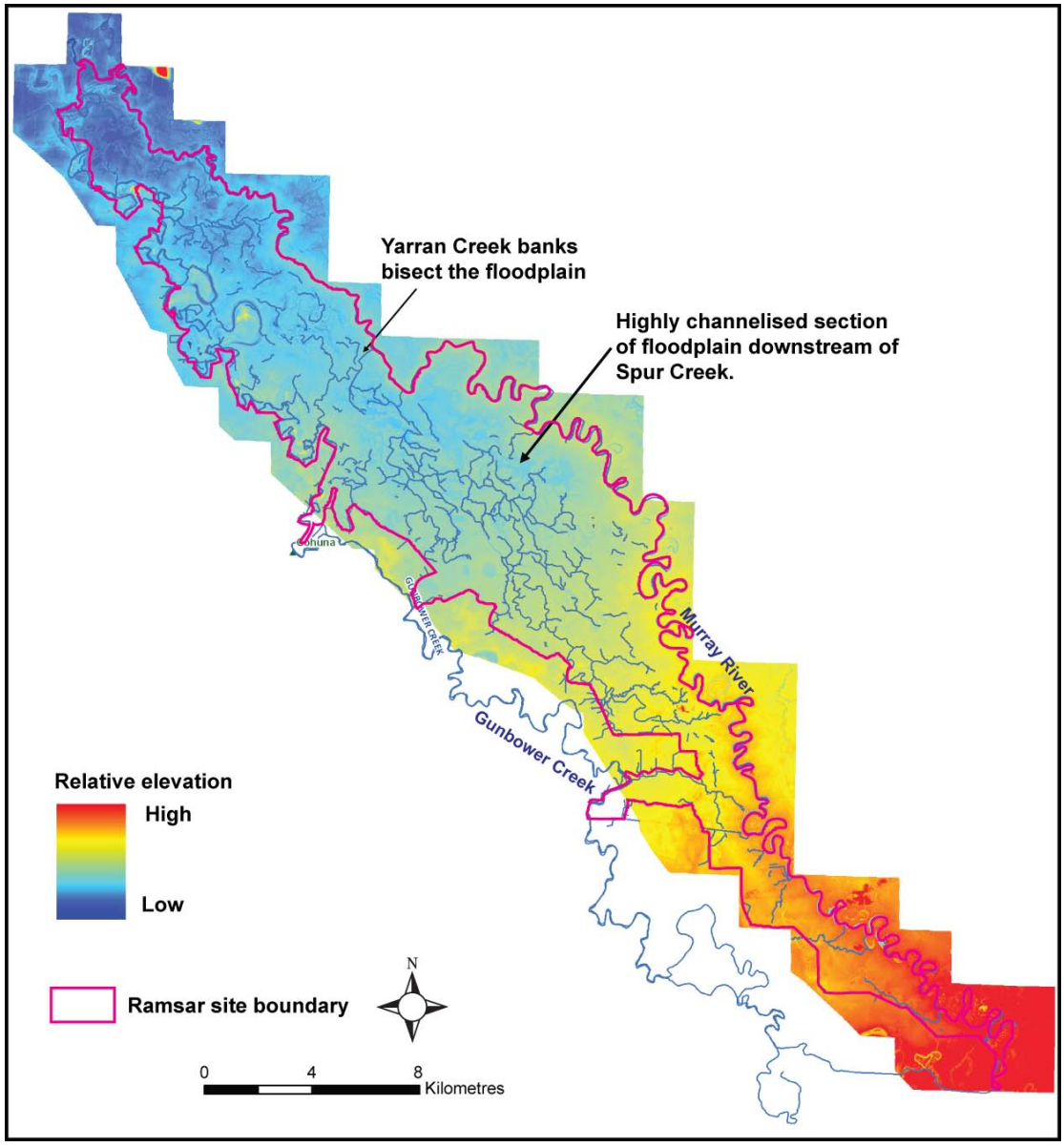

Figure 13: Digital elevation model (DEM) of Gunbower Forest Ramsar site (supplied by NCCMA).

3.2.3 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 18 NTU and a ninetieth percentile of 40 NTU downstream of Torrumbarry Weir (data from Victorian Water Resources Data Warehouse).

Water quality in Gunbower Creek is highly variable and dependent on water quality in the Murray River, the floodplain and hydrology of the creek itself. Salinity is mostly fresh, but in times of low or no flow can be considered brackish with electrical conductivity rising above 2000 micro Siemens per centimetre. Similarly, turbidity varies from low (less than 10 NTU) to relatively high (almost 100 NTU; Figure 14).

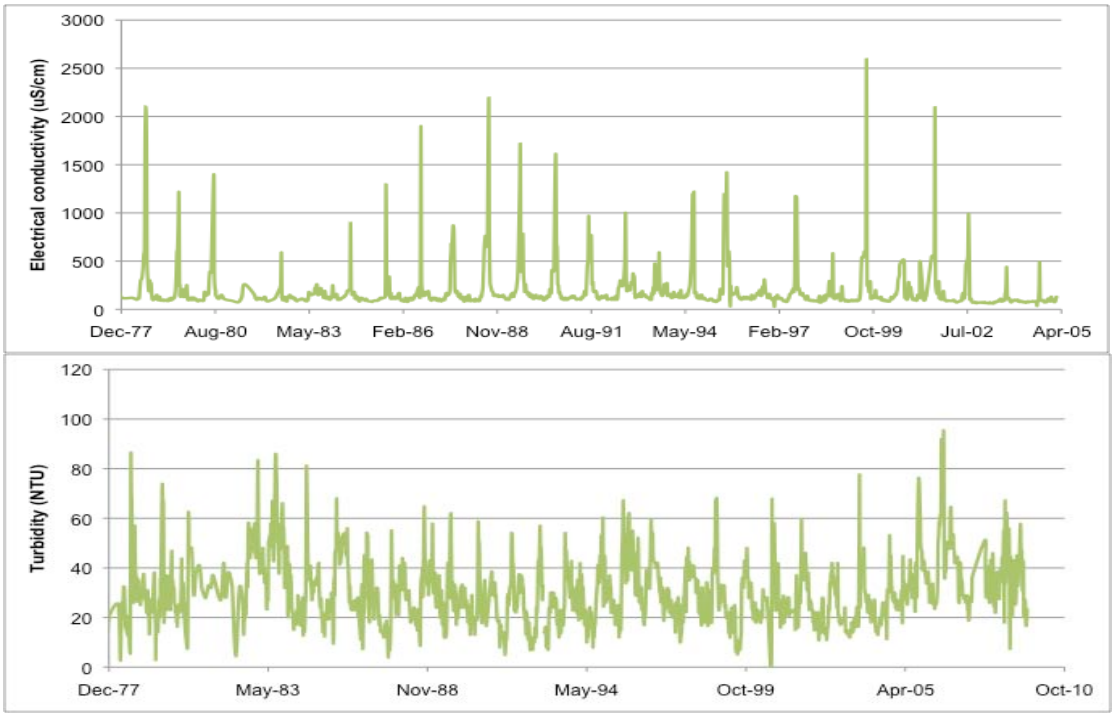

Figure 14: Electrical conductivity and turbidity in Gunbower Creek immediately downstream of the Ramsar site (data from the Victorian Water Resources Data Warehouse).

Water quality in permanent and frequently flooded wetlands on the floodplain can vary considerably between sites and over time and is greatly influenced by floodplain inundation. Results of monitoring at Little Reedy and Reedy Lagoons over a spring inundation event in 1993, illustrate the variability in water quality in response to inundation and drawdown (Figure 15). Turbidity ranged from less than 10 NTU to over 90 NTU, dropping following inundation and then rising as water levels receded. Chlorophyll-a concentrations were highest as waters receded and nutrients became concentrated in smaller pools of water. Salinity remained fresh throughout, but varied between 50 and 200 micro Siemens per centimetre.

The flooding of ephemeral wetlands and floodplain surfaces may trigger blackwater 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 blackwater events from the Ramsar site, most notably in the floods of 2010, which inundated large areas of floodplain that had been dry for a decade. Water discharging from the forest was very low in dissolved oxygen (less than one milligram per litre) causing decreased oxygen concentrations in Gunbower Creek (MDBA unpublished).

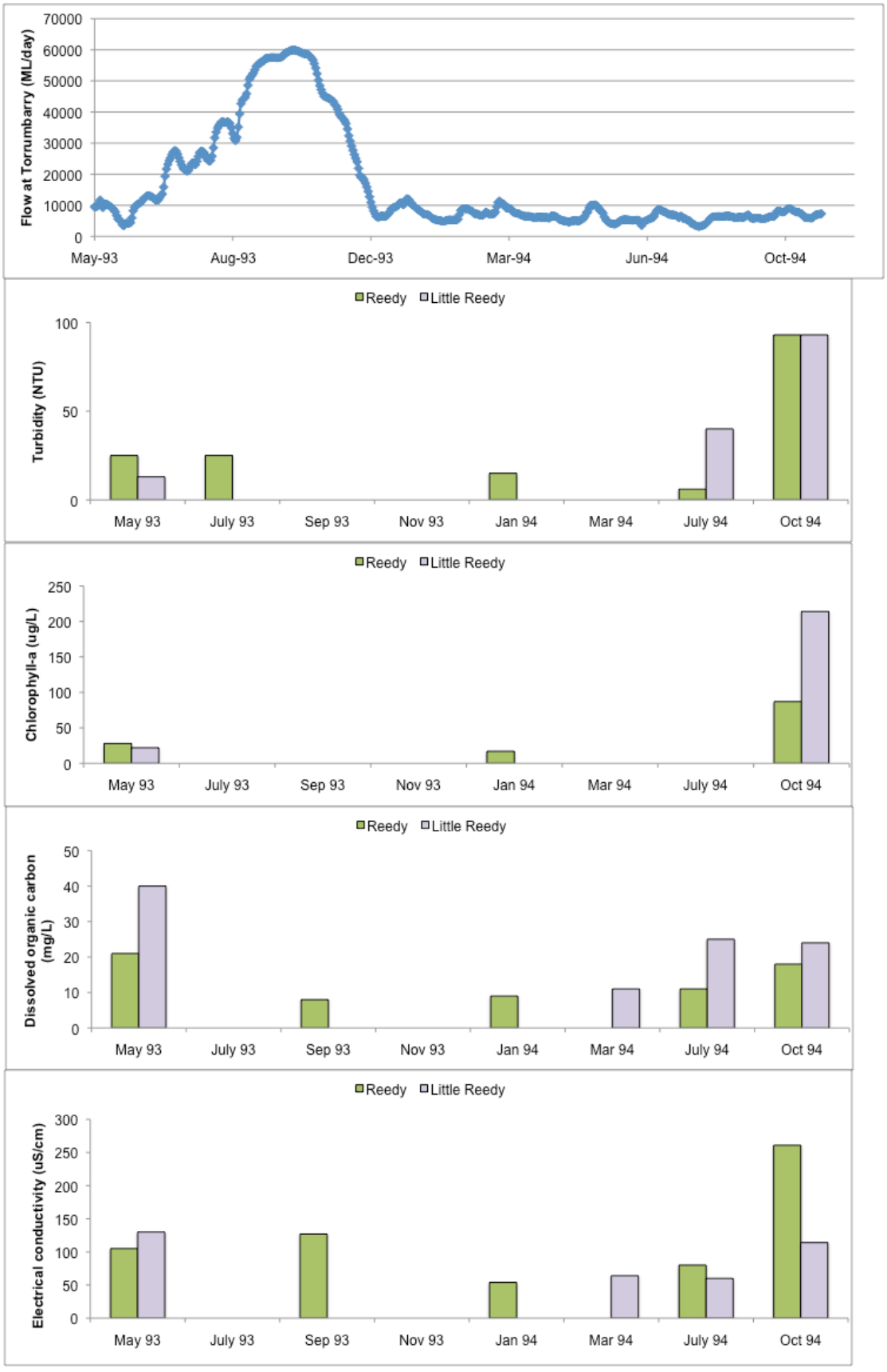

Figure 15: Water quality in Reedy and Little Reedy Lagoons within the Gunbower Forest Ramsar site May 1993 to October 1994 (data from the Victorian Water Resources Data Warehouse).

3.2.4 Aquatic mammals, reptiles and frogs

Two species of wetland dependent mammals have been recorded within the site: the water rat (*Hydromys chrysogaster*) and platypus (*Ornithorhynchus anatinus*). These species are largely restricted to the stream and channel habitat within the site, although they may extend into deeper marsh areas during floods.

Four species of wetland dependent reptile and eleven species of frog have been recorded within the Gunbower Forest Ramsar site (Appendix C). Although population sizes are not known, there is evidence that frogs and turtles use the shallow, well-vegetated temporary wetlands for breeding during flood events (Davies 2004; DSE unpublished).

3.3 Critical components and processes

The attributes and characteristics of each of the identified critical components and processes of the Gunbower Forest Ramsar site are described below. Where possible, quantitative information is included; however, there are significant knowledge gaps (see Section 8). A summary of the critical components and processes is provided in Table 7.

Table 7: Summary of critical components and processes within the Gunbower Forest Ramsar site.

Component/ process	Description
Hydrology	• Inundation of the site is driven largely by flows within the Murray River and major tributaries. • 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 forest are generally the result of catchment scale rainfall events. • Groundwater sources are secondary with the site being termed a “flushing zone” losing groundwater to the river following inundation.
Wetland vegetation	• There are two critical wetland vegetation categories: floodplain forests and floodplain marshes. • Approximately 80 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 16 000 hectares. • River red gum forest is the dominant vegetation community, comprising 65 percent of the site. • Seventy-five native aquatic/wetland plant species recorded in floodplain marshes. • Species richness and cover of plants in floodplain marshes is highly variable temporally and spatially. • The site is important for the threatened swamp wallaby-grass and winged peppercress.
Fish	• Data deficient. • Twelve 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 16 - 36 percent of the total abundance and up to ninety percent of biomass of large bodied fish.
Wetland birds	• Sixty-six species of wetland bird have been recorded from the site. This includes nine species listed under international migratory agreements as well as the endangered Australasian bittern. • Maximum counts recorded during the 1974 floods comprise approximately 6000 individuals. • A large proportion of the wetland birds recorded within the site have been observed breeding.

3.3.1 Hydrology

The hydrology of the Gunbower Forest Ramsar site is defined by flow in the Murray River. The hydrology of the Murray River and its tributaries was largely managed for water supply, flood mitigation, navigation and hydroelectricity production long before Gunbower Forest was designated as a Wetland of International Importance in 1982. River regulation began almost a century ago with a large number of dams, locks and weirs constructed between 1915 and 1974. Regulators were constructed on several streams within the Ramsar site in the 1930s and 1940s where they leave the Murray River (DSE 2010). Hydrology within the site has been regulated and managed since this time. 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. Hydrology is considered in terms of surface water and groundwater.

Surface water

Surface water inflows into the Gunbower Forest Ramsar site are controlled by releases from Torrumbarry Weir, which is located directly upstream of the site and was completed in 1926. The flow downstream of Torrumbarry Weir (Figure 16) depends largely on flows in the Murray River at Barmah and the flow from the Goulburn River, which joins the Murray River near Echuca. There are two types of surface water flows that are significant for the ecological character of the forest (MDBC 2005):

- in-channel flow, which features inundation of effluent streams, channels and floodplain depressions connected at pool level; and
- overbank flow as water moves laterally from channels and spreads across the floodplain.

In-channel flow is controlled by a large number of regulating structures within the forest and along Gunbower Creek (Figure 17). Gunbower Creek is an irrigation supply channel and is used to deliver water to the Torrumbarry Irrigation District. Flow commences to enter Gunbower Forest from the River Murray through Shillinglaws Regulator on Yarran Creek when flow at Torrumbarry reaches approximately 13 700 megalitres a day. Flow then enters Gunbower Forest from Spur Creek, Barham Cut, Wattles Regulator and Broken Axle Creek at various flow thresholds up until the river reaches bankfull at approximately 27 800 megalitres a day (Water Technology 2009). Widespread inundation begins when overbank flows commence at flows over 30 000 megalitres a day (URS 2001).

Inundation of low lying creeks and wetlands within Gunbower Forest Ramsar site is very complex, with numerous creeks, wetlands and hydraulic controls. Black Swamp, Reedy Lagoon and Little Gunbower Wetland, along with Iron Punt Lagoon and Whistler Lagoon are all interconnected by a series of small creeks with various commence to flow levels. Black Swamp and Reedy Lagoon are directly connected to Gunbower Creek by regulators. The Little Gunbower wetland complex is connected to Gunbower Creek via the Little Gunbower Creek regulator and the River Murray via Barham Cut (Water Technology 2009).

At high inflows water creates general sheet flow through the floodplain, spreading from these wetland complexes into surrounding river red gum forest and woodland and at high flows, of over 30 000 megalitres a day to black box woodlands (Water Technology 2009). To create widespread flooding in the forest, flows in the River Murray would need to be sustained above 30 000 megalitres a day for at least an estimated four to six weeks although this period would reduce as sustained flows increased above 30 000 megalitres a day (URS 2001). The relationship between flow thresholds and inundation of dominant vegetation communities is illustrated in Figure 18.

Water can also enter the forest via Gunbower Creek. Gunbower Creek receives flow from the Torrumbarry Weir pool on the River Murray and during the irrigation season, flows are sufficient to enable water to be delivered into Gunbower Forest. Around the time of listing, managed flows (usually as a result of rainfall rejections) could be diverted into the forest at Yarran Creek and via two small regulators located at Reedy Lagoon and Black Swamp (URS 2001).

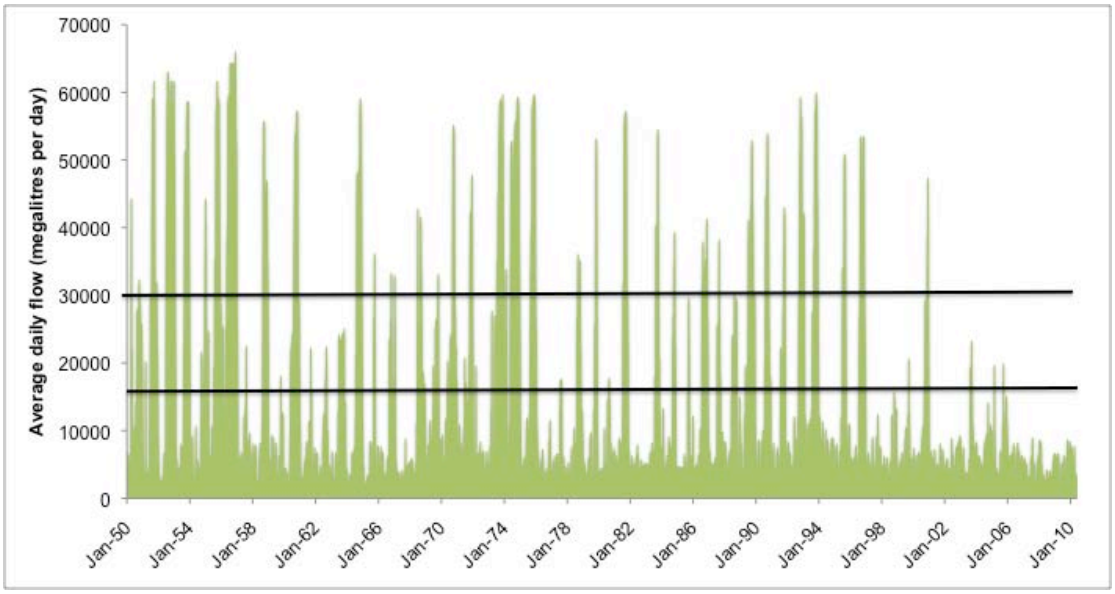

Figure 16: Average daily flow (megalitres per day) in the Murray River downstream of Torrumbarry Weir from 1950 to 2010 (actual flow, data from the Victorian Water Resources Data Waterhouse). Lines show commence to flow level (13 700 megalitres per day) and threshold for broad scale inundation (30 000 megalitres per day).

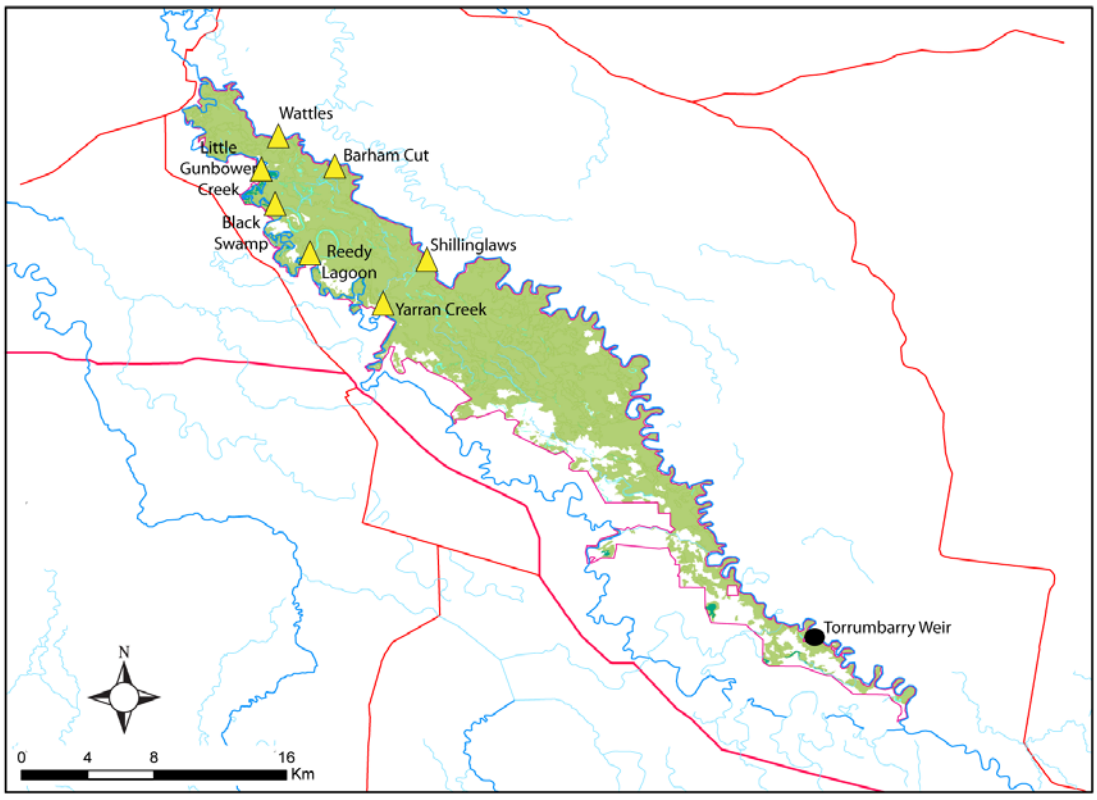

Figure 17: Location of regulators within the Gunbower Ramsar site (Water Technology 2009).

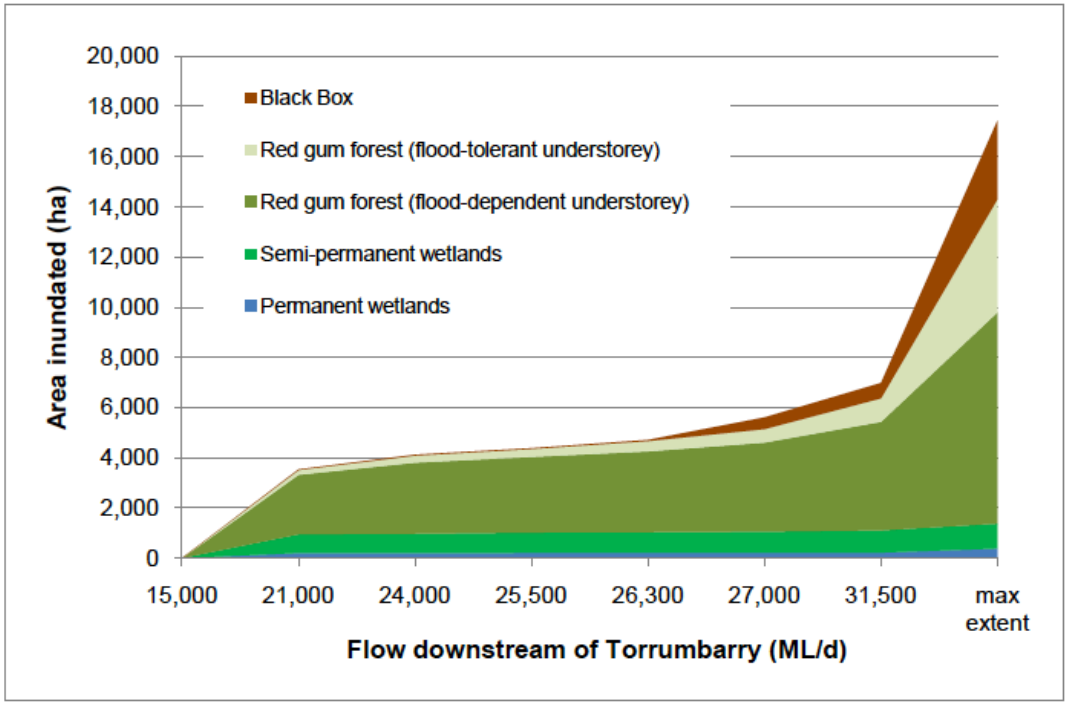

Figure 18: Flows required to inundate selected vegetation types in Gunbower Forest (MDBA 2010a).

Large flow events vary in frequency and duration and are largely driven by large rainfall events. Significant flood events occurred frequently, with 25 events in the fifty years between 1951 and 2000 (see Figure 16). Characterisation of the flow conditions at the time of listing is problematic as there has been a level of development both before and after listing and a highly variable natural flow regime which is difficult to describe adequately over short periods of time. Data is available for a model of Murray River flow from 1891 to 1990 based on water resource conditions in 1990 (Ecological Associates 2003). This has been considered as broadly indicative of the time of listing, given that there is a 100 year record and that the model is based on conditions just eight years post listing[1]. Average recurrence intervals for significant flood thresholds in the forest based on modelled monthly flow from 1891 to 1990, are provided in Table 8.

Average daily flows from around the time of listing illustrate the typical seasonality (Figure 19). 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.

[1] Note that the most recent major water storage relevant to the site at the time of listing was Dartmouth Dam, which was completed in 1979. The modelled data selected includes the effects of this structure which had been in place for a short time prior to the Ramsar site listing in 1982.

Table 8: Modelled flood flow recurrence intervals at the Murray River downstream of Torrumbarry for specific flow events in Gunbower Forest (modelled 1990 development 1891 to 1990 data from Ecological Associates 2003).

Murray River flow (megalitres a day)	Inundation extent	Duration (months)	Frequency (events per 100 years)
Above 13 700	Streams and low lying wetlands commence to fill	3	39
Above 21 000	All permanent and semipermanent wetlands, approximately 30 percent of river red gum forest	2	39
		5	15
Above 30 000	Broad scale inundation (overbank). Approximately 50 percent of river red gum forest and 30 percent of river red gum woodland.	2	24
Above 40 000	Virtually all river red gum forest and woodland and black box woodland	1	20

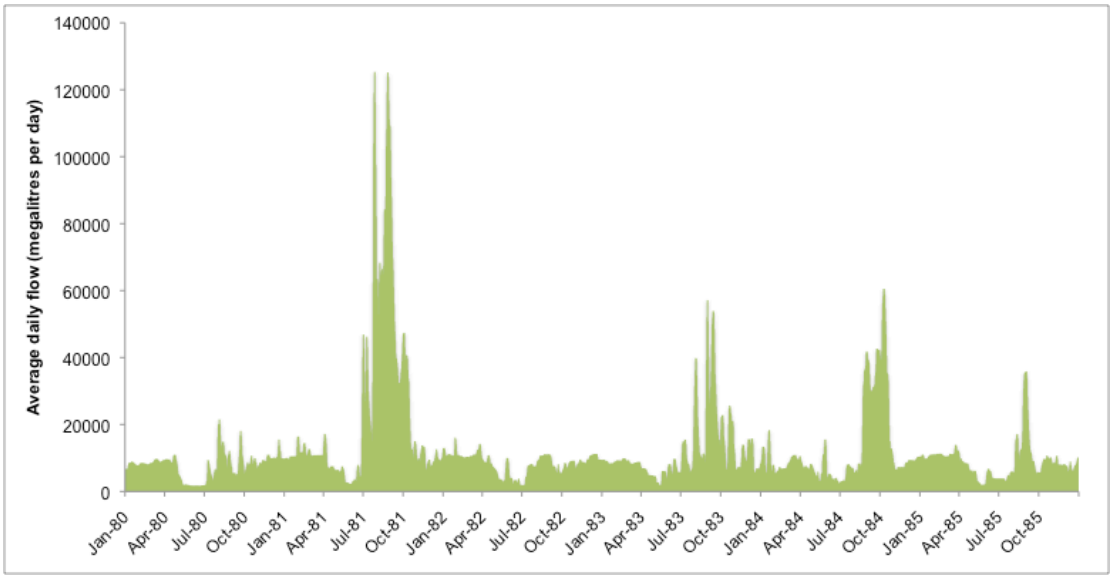

Figure 19: Average daily flow (megalitres per day) in the Murray River downstream of Torrumbarry from 1980 to 1985 (data from the Victorian Water Resources Data Waterhouse).

Groundwater

The Gunbower Forest is underlain by the following hydrogeological units (DSE 2010; Figure 20):

1. The Coonambidgal Formation, which dominates the surface geology and consists of relative shallow deposits of clay, sand and sandy clay. The Coonambidgal Formation formed from the deposits of recent streams and postdates the underlying Shepparton Formation.

2. The Shepparton Formation, which is between 80 and 120 metres thick. It consists of thin, irregular and discontinuous sand and gravel beds that vary from isolated ribbon-like bodies to semi-continuous sheets. The Upper Shepparton Formation is composed of low permeability clay and clayey silts with lenses of high permeability sands. The Lower Shepparton Formation sediments have sand layers of high permeability and may have good hydraulic connections with the underlying Calivil Formation.

3. Unconsolidated sediments around 120 metres below the surface from the Renmark Group (basal aquifer system in the Murray basin) and Calivil Formation (the Deep Lead aquifer system).

4. Palaeozoic age bedrock greater than 180 metres below the surface with transmissivity and yield an order of magnitude smaller than overlying unconsolidated aquifer systems.

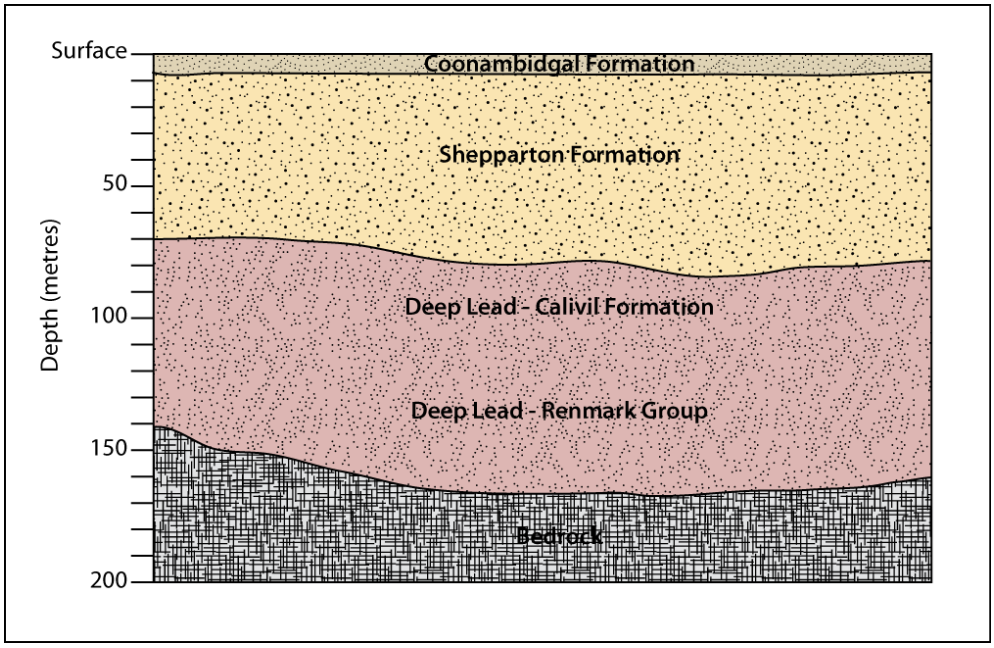

Figure 20: Cross section of hydrogeology in the region (adapted from Goulburn-Murray Water 2006).

Groundwater under Gunbower Forest is considered to be a separate hydrological unit from the rest of the Riverine Plain, being bound on both sides by rivers (the Murray River and Gunbower Creek). It is underlain by the Shepparton Formation, incised by thin channels of Coonambidgal Formation materials, which together comprise the watertable aquifer (SKM 2009). The depth to groundwater is variable over medium to long time frames (decades) in response to climate, hydrology and evapotranspiration. During prolonged drought conditions, the water table may be between eight and 12 meters below the surface, as compared to less than two metres after widespread inundation of the floodplain (SKM 2009).

The aquifer under the floodplain is low in salt (compared to nearby irrigated agricultural land) and this has been attributed to the recharge being predominantly from infiltration during inundation with relatively low salinity river water (SKM 2009), as opposed to lateral movement of groundwater from adjacent irrigated agricultural lands. As flood waters recede and surface water returns to the river, water stored in the soil profile also moves laterally back towards the river, leading the floodplain to be termed a “flush zone” (SKM 2009).

SKM (2009) also emphasised the role of floodplain forests in the water balance of Gunbower Forest. Unlike adjacent areas covered with crops or shallow rooted vegetation, groundwater is accessed for evapotranspiration from the soil down to 15 metres on the floodplain by river red gum and black box trees. Evapotranspiration rates are calculated to average 300 millimetres per year, which is nearly three times the average rate in surrounding landscapes.

3.3.2 Wetland vegetation

There have been 278 native plant species recorded within the Ramsar site, including both aquatic and terrestrial species. Seventy-five native aquatic/wetland plant species have been recorded in floodplain marshes at the site. There are two broad vegetation types within the site that are considered critical to the character of the Gunbower Forest Ramsar site (Figure 21):

- Floodplain 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.

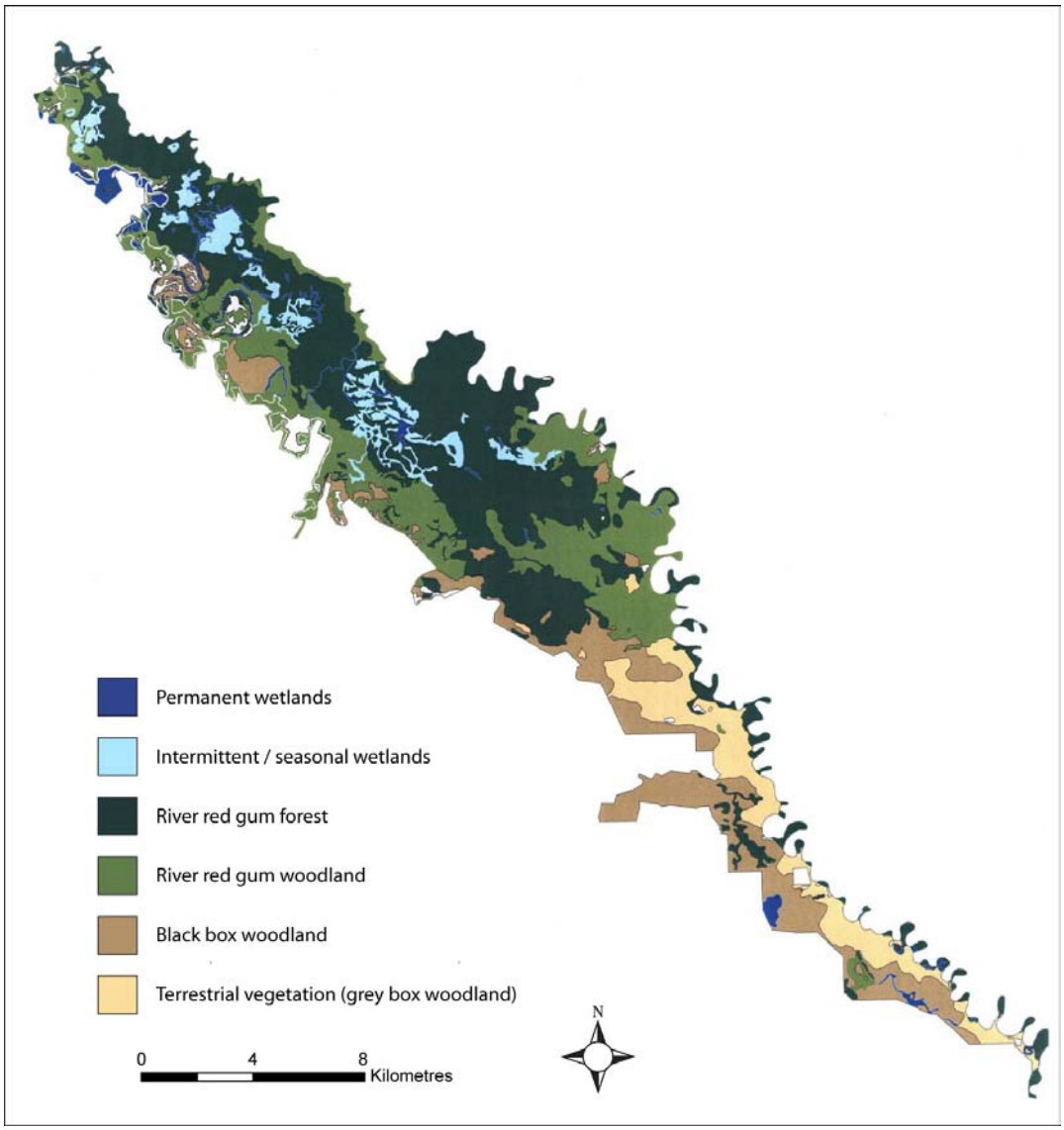

Figure 21: Broad vegetation groups within the Gunbower Forest Ramsar site (data supplied by NCCMA). Note that permanent and semi permanent wetlands include areas of floodplain marsh as well as open water.

Floodplain forests and woodlands

River red gum dominated forest and woodland communities are the characteristic feature of the Ramsar site. River red gum is the canopy dominant in all forests and in the wetter woodland communities. 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 (Roberts and Marston 2000).

The forest and woodland communities have been classified and described according to a number of different systems. Close to the time of listing, the extent of floodplain forest and dominant overstorey species were mapped and described based on a timber assessment conducted over 1988 and 1989 (Woodward 1990). This was extrapolated into mapped "water regime classes" that provided a better ecologically based description of the vegetation (Table 9). This estimated the total river red gum forest and woodland extent as approximately 13 000 hectares around 65 percent of the total Ramsar site. In addition, mapping estimated approximately 2700 hectares of black box woodland at higher elevations (DSE 2010).

Table 9: Extent of floodplain forests and woodlands within the Gunbower Forest Ramsar site (URS 2001; area supplied by NCCMA).

Vegetation association	Water regime class	Description	Area (ha)
River red gum forest	River red gum with flood dependent understorey	River red gum overstorey with an understorey of flood dependent species such as *Triglochin* spp. *Eleocharis acuta* and *Paspalidium jubiflorum.*	8326
River red gum woodland	River red gum with flood tolerant understorey	River red gum overstorey with an understorey of flood dependent species such as *Amphibromus* spp., chenopods, *Carex tereticaulis,Whalenbergia fluminalis* and *Senecio* spp.	4757
Black box woodland	Black box	Black box overstorey with some flood tolerant woodland trees. Understorey includes chenopods and terrestrial grasses.	2694

Current classification and mapping of vegetation communities in Victoria is by "Ecological Vegetation Classes" (EVCs). The EVCs that correlate with river red gum forests and woodlands are within the group "Riverine Grassy Woodlands or Forests" and there are a number of different classes that occur within the Ramsar site (Table 10). According to this mapping and classification there are 17 718 hectares of riverine forest and woodland across the site, with river red gum forest comprising 68 percent of the Ramsar site (Figure 22).

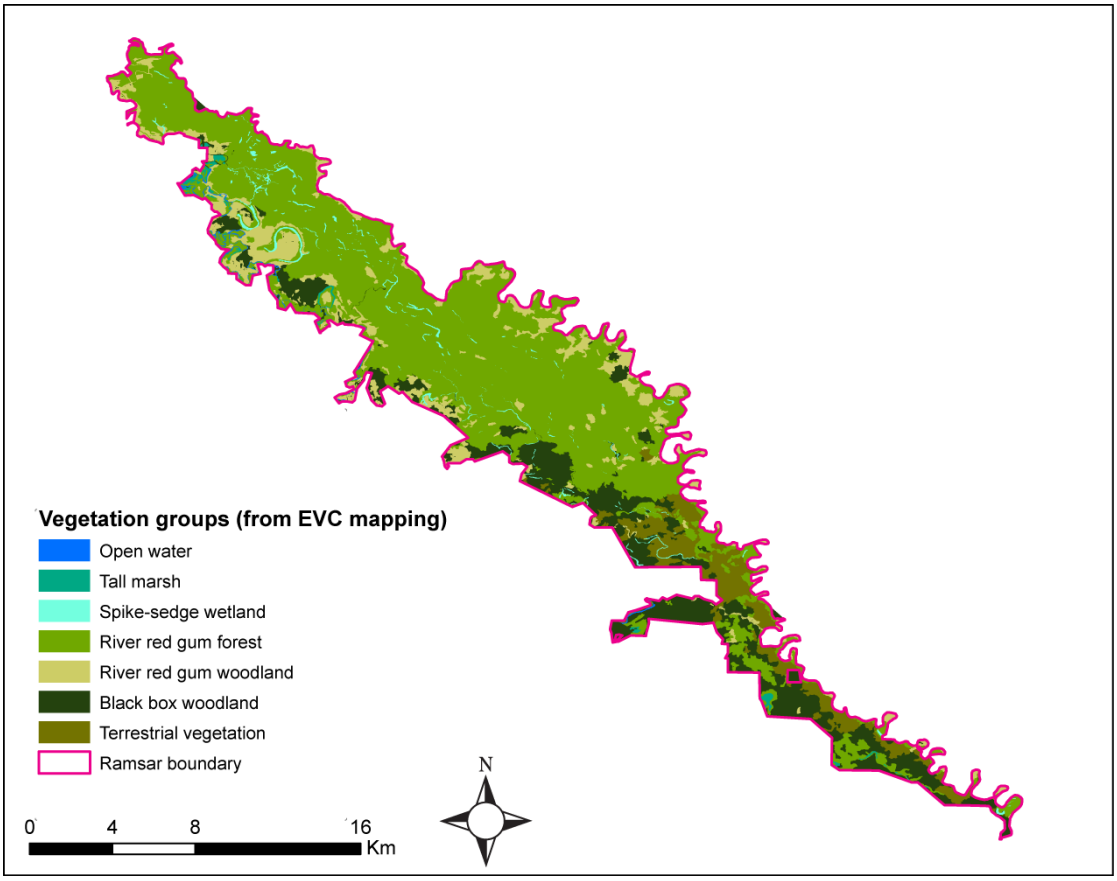

Figure 22: Vegetation associations as mapped from EVCs (data supplied by DSE).

Table 10: Riverine Grassy Woodlands or Forests EVCs within the Gunbower Forest Ramsar site (data supplied by DSE).

Vegetation association	EVC	Description	Extent (hectares)
River red gum forest	Riverine Swamp Forest	Open eucalypt (river red gum) forest to 25 metres tall with understorey dominated by obligate wetland species (or opportunistic annuals during sustained dry periods) and can range from closed sedgeland or herbland to grassy-herbaceous or extremely sparse and with cover primarily leaf-litter, blackwater or exposed alluvium. Occupies low-lying areas subject to reasonably regular flooding, typically flood-prone lower river terraces and low-lying areas adjacent to floodways through or within riverine forest.	5581
	Sedgy Riverine Forest	Eucalypt (river red gum) forest to 25 metres tall with understorey dominated by larger sedges. Understorey composition indicative of at least occasional shallow flooding and a tolerance of gaps between floods of several years. Typically on heavy soils which can become wet in winter.	2212
	Grassy Riverine Forest	River red gum forest to 25 metres tall with a groundlayer dominated by graminoids. Occasional tall shrubs present. Occurs on the floodplain of major rivers, in a slightly elevated position where floods are infrequent, on deposited silts and sands, forming fertile alluvial soils.	2317

Vegetation association	EVC	Description	Extent (hectares)
	Forest complexes	Mixed forest communities (i.e. combinations of Riverine Swamp Forest, Sedgy Riverine Forest and Grassy Riverine Forest).	2107
River red gum woodland	Riverine Grassy Woodland	River red gum woodland to 20 metres tall with a groundlayer dominated by graminoids and sometimes lightly shrubby or with chenopod shrubs. Occurs on the floodplain of major rivers, in a slightly elevated position where floods are rare, on deposited silts and sands, forming fertile alluvial soils.	2000
	Floodplain Riparian Woodland	An open eucalypt (river red gum with occasional yellow box) woodland or open forest to 20 metres tall over a medium to tall shrub layer with a ground layer consisting of amphibious and aquatic herbs and sedges. Occurs along the banks and floodplains of the larger meandering rivers and major creeks. Elevation and rainfall are relatively low and soils are fertile alluviums subject to periodic flooding and inundation.	197
Black box woodland	Riverine Chenopod Woodland	This is an open woodland on rarely flooded, elevated riverine terraces adjacent to the riverine floodplain on extremely infrequent shallow flooding areas with grey silty soil. The open overstorey is dominated by black box with river red gum and grey box occasionally present. The scattered medium shrub layer consists of species such as mallee wattle and river coobah, nitre bush and lignum in wetter sites.	3303

Condition of the forest communities at the time of listing is a knowledge gap. There is evidence that the forest was in less than optimum condition prior to the time of listing (Bren 1988; Leitch 1989). Condition assessments based on conditions in 2003 (some two decades after the site was listed as a Wetland of International Importance) indicate that 29 percent of the forest was in good condition and 64 percent was in moderate condition (Cunningham et al. 2009; Figure 23). Recent flooding history just prior to listing (major flood in 1981) and relative to the 2003 condition assessment (flood in 2000/01) indicate that the condition of forests at the time of listing is likely to have been equal to or better than that in 2003 (J. Roberts, floodplain vegetation expert, personal communication, May 2011).

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. The State-wide Forest Resource Inventory has mapped extents of age classes of trees within the Ramsar site benchmarked to 2002. This indicates that approximately 50 percent of trees could be classified as mature (60 to 150 years old), 40 percent as mixed age with smaller amounts of regrowth and senescent and late mature trees (Figure 24).

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. Fallen timber loads within the Ramsar site have been estimated at 27 tonnes per hectare (Mac Nally et al. 2002). However, organic matter accumulations are strongly influenced by the period between floods with estimates of leaf, twig and bark litter in recently flooded areas up to five times less than those on floodplains that have not been inundated for over 3 years (Gigney et al. 2006).

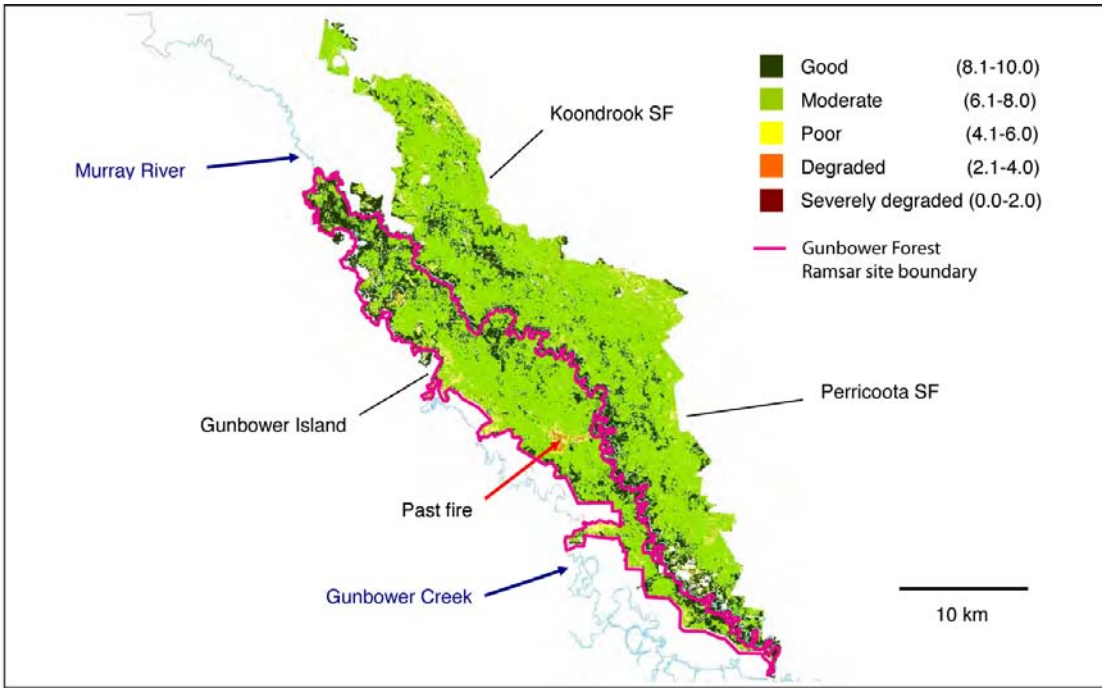

Figure 23: Canopy condition in the Gunbower Forest in 2003 (adapted from Cunningham et al. 2009).

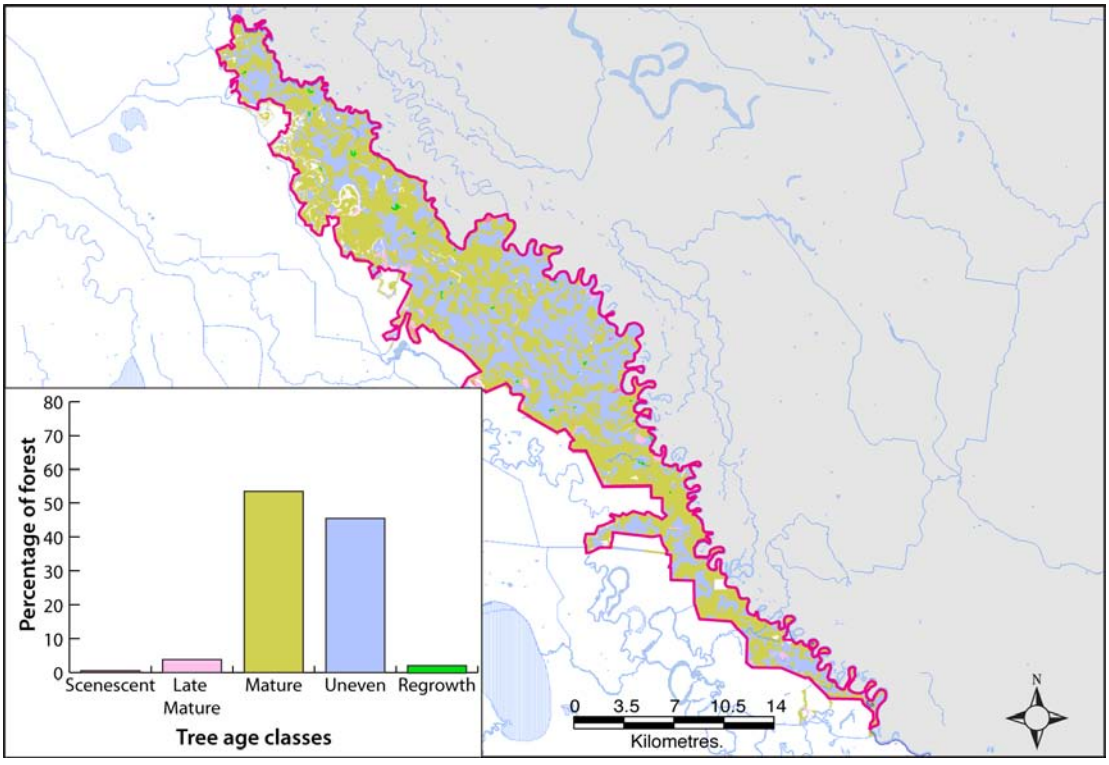

Figure 24: Tree age classes in the Gunbower Forest Ramsar site in 2002 (data from DSE 2010).

Floodplain marshes

The low lying, more frequently inundated areas of Gunbower Forest contain wetlands, referred to collectively as floodplain marshes, which are associated with a variety of geomorphic settings including intermittent drainage lines, flood-runners, oxbow lagoons and floodplain depressions. Within the Ramsar site they are most prevalent around the large open water of Reedy Lagoon in the northern portion of the site (see Figure 22).

Mapped water regime classes relevant to floodplain marsh vegetation are permanent (415 hectares) and semi-permanent wetlands (995 hectares) (see Figure 21). However, this does not indicate the extent of vegetation, simply the extent of different water regimes. Contemporary mapping indicates just three wetland EVCs within the site with a total extent of approximately 570 hectares (Table 11).

Table 11: Wetland EVCs within the Gunbower Ramsar site (data supplied by DSE).

EVC	Description	Typical species	Extent (hectares)
Spike-sedge wetland	Low sedgy vegetation of seasonal or intermittent wetlands, dominated by spike-sedges and usually species-poor. Typically treeless, but sparse eucalypts (mostly river red gum) can be present in marginal sites.	Common spike sedge (*Eleocharis acuta*) monospecific or with common blown grass (*Lachnagrostis filiformis*) with opportunistic aquatic species.	310
Tall marsh	Wetland dominated by tall emergent graminoids, typically in thick species-poor swards. Rushland, sedgeland or reedbed.	Club sedge (*Bolboschoenus* spp.), giant rush, common reed, river club-sedge (*Schoenoplectus tabernaemontani*), bulrush (*Typha* spp.).	140
Open water	No vegetation.		120

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 flood cycle. Recent surveys of permanent and semi-permanent wetlands provide an indication of the likely composition and dynamics of floodplain marshes within the site at the time of listing.

Over the period 2005 to 2010, a total of 75 species of aquatic/wetland plant were recorded in permanent and semi-permanent wetlands in Gunbower Forest (Australian Ecosystems 2010). Species richness in permanent and semi-permanent wetlands varied between wetlands as well as spatially within wetlands and over time (Figure 25). In permanent wetlands sampled, species richness (aquatic/wetland plants) ranged from less than five to 30 species. In semi-permanent wetland, the range was less than five to over 40 species (although this includes damp soil and terrestrial species). All sites in both permanent and semi-permanent wetlands had low species numbers in 2008 (an extreme dry year) and higher numbers of species in 2010 (following increased rainfall).

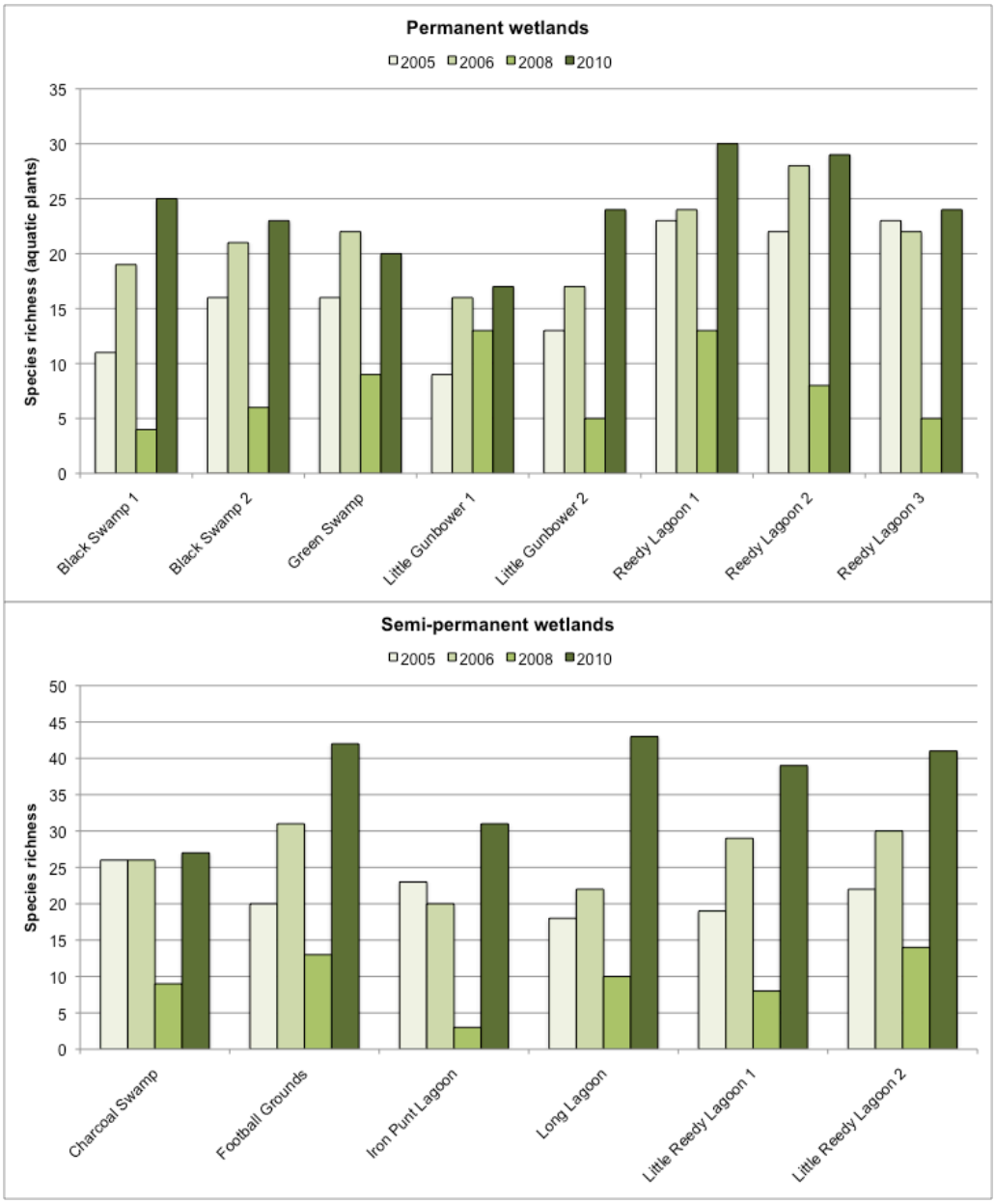

Figure 25: Species richness in autumn surveys of wetlands in Gunbower Forest 2005 to 2010 (data from Australian Ecosystems 2010).

Cover of aquatic/wetland plants in permanent and semi-permanent wetlands is also highly variable both temporally and spatially (Figure 26). Cover was lowest in 2008 with an average cover of 11 percent (standard deviation of 12 percent) in permanent wetlands and six percent (standard deviation of six percent) in semi-permanent wetlands. Cover was highest in permanent wetlands in 2006 (66 ± 30 percent; mean ± standard deviation) and in semi-permanent wetlands similar values were recorded in 2005, 2006 and 2010 with averages of 40 to 48 percent. In permanent wetlands average cover (all sites within a wetland across all years sampled) ranged from 22 percent (standard deviation of 12 percent) at Green Swamp to 55 percent (standard deviation of 32 percent) at Reedy Lagoon. In semi permanent wetlands average cover was lowest at Iron Punt Lagoon (20 ± 24 percent; mean ± standard deviation) and highest at Football Grounds (60 ± 32 percent; mean ± standard deviation). In all instances the very high standard deviations, compared to mean values illustrate the high degree of variability in cover of plants in these floodplain marshes.

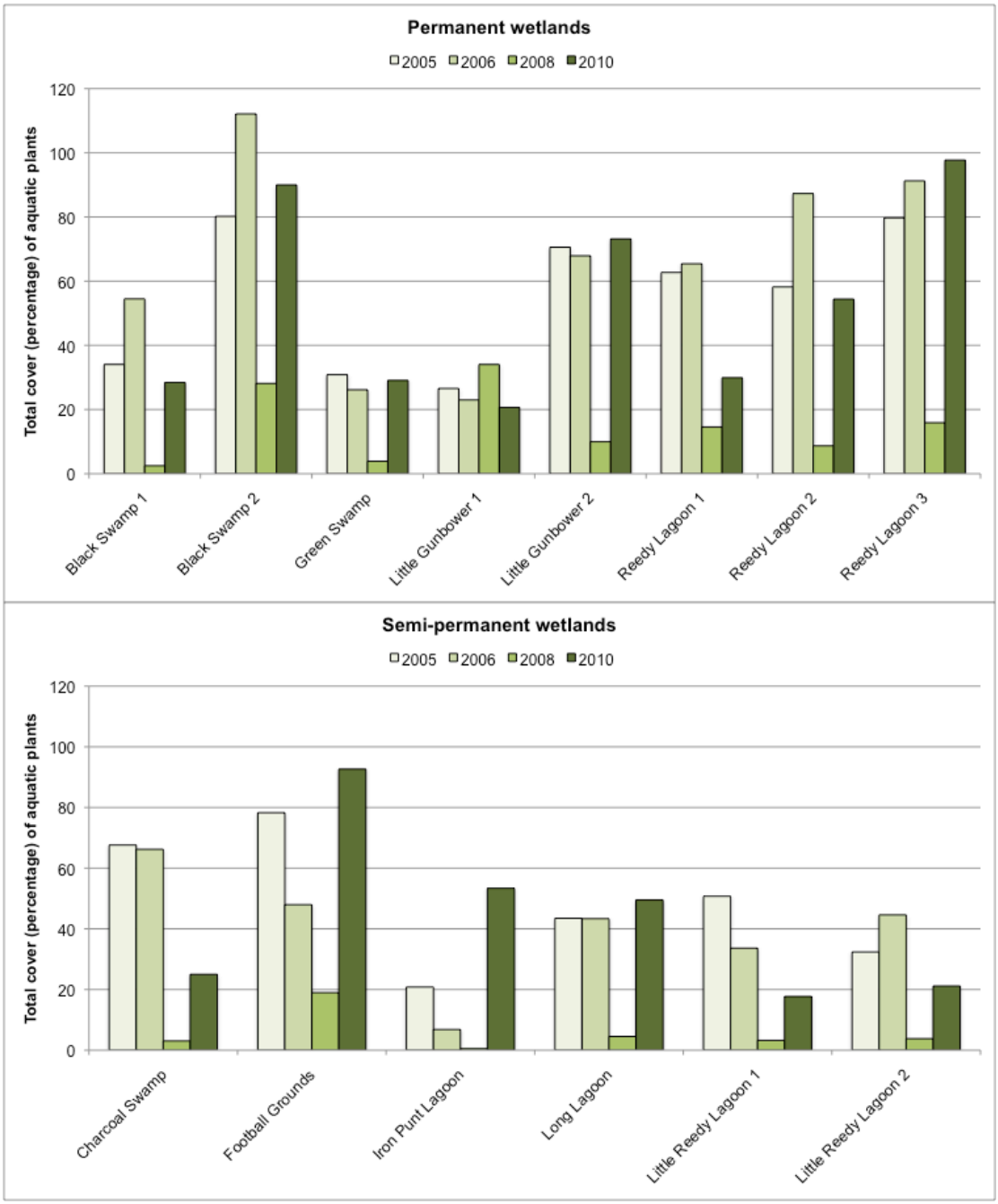

Figure 26: Percent cover in autumn surveys of wetlands in Gunbower Forest 2005 to 2010 (data from Australian Ecosystems 2010).

3.3.3 Fish

There are 12 species of native fish that have previously been recorded within the Gunbower Forest Ramsar site (Rehwinkel et al. 2010; Appendix D). Three of the native species are classified as threatened under the EPBC Act and/or the IUCN Red List (see Table 5).

There is no information on fish communities within the Ramsar site from the time of listing. Surveys have been conducted in 1998 and 2005 – 2010 and this information is summarised here. It is not known if this represents conditions at the time of listing, but it is likely that the site supported native fish populations at listing and continues to do so.

Quantitative data for fish from within the Ramsar site are limited (Table 12). In surveys conducted in 2005, 2009 and 2010, carp gudgeons (*Hypseleotris* spp.) were the most abundant species accounting for between 60 and 88 percent of the total catch. Introduced species comprised between 9 and 30 percent of the total abundance and in terms of biomass, accounted for over 90% of the total weight of large bodied fish (Rehwinkel et al. 2010).

Table 12: Total abundance of fish from surveys in Gunbower Forest (Richardson et al. 2005; Rehwinkel et al. 2010).

Common name	Species name	2005	2009	2010
Native				
Australian smelt	*Retropinna semoni*	157	43	371
Bony bream	*Nematalosa erebi*			3
Carp gudgeons	*Hypseleotris* spp.	13 865	16 234	15 000
Dwarf flat-headed gudgeon	*Philypnodon macrostomus*	1	16	56
Flat-headed gudgeon	*Philypnodon grandiceps*	126	1193	1445
Fly-specked hardyhead	*Craterocephalus stercusmuscarum*	120	132	345
Freshwater catfish	*Tandanus tandanus*		6	3
Murray cod	*Maccullochella peelii*	1	4	2
Golden perch	*Macquaria ambigua*	7	2	9
Silver perch	*Bidyanus bidyanus*		2	
Murray-Darling rainbowfish	*Melanotaenia fluviatilis*	26	63	90
Introduced				
Common carp	*Cyprinus carpio*	36	64	185
Goldfish	*Carassius auratus*	9	17	107
Redfin	*Perca fluviatilis*	2	2	3
Eastern gambusia	*Gambusia holbrooki*	1290	3402	7264
Oriental weatherloach	*Misgurnus anguillicaudatus*	1	3	36

Different species favour different habitats (flowing versus still) with large bodied native fish such as Murray cod predominantly in stream habitats and small-bodied fish such as smelt and gudgeons more abundant in lagoons (Figure 27). There was evidence of recruitment for fly-specked hardyhead, carp gudgeons, flat-headed gudgeons, Australian smelt and freshwater catfish from within the site in 2010 (Rehwinkel et al. 2010).

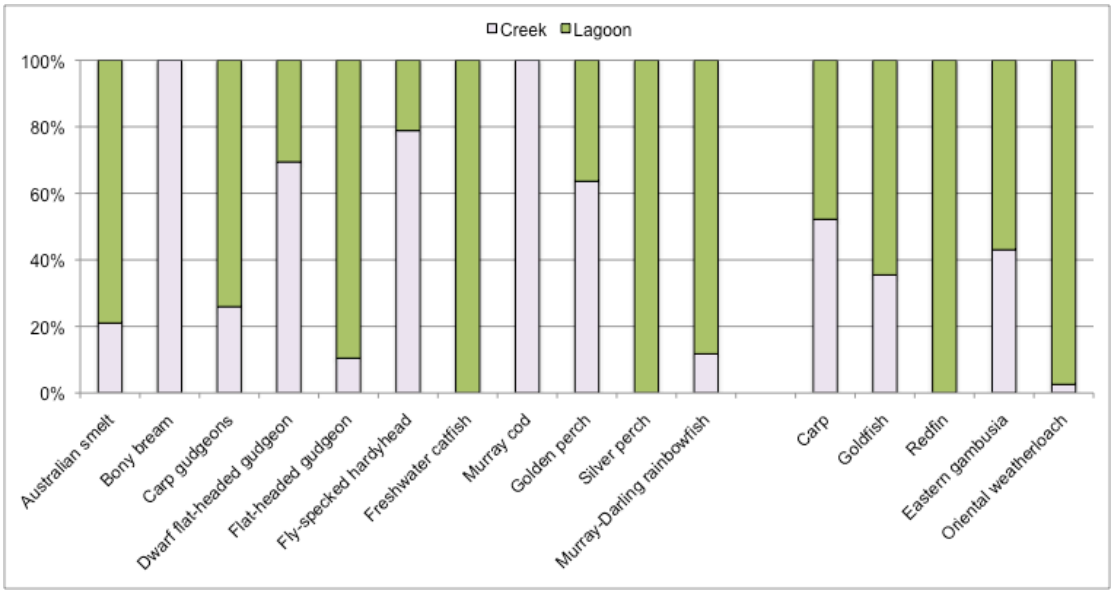

Figure 27: Percentage abundance in creek and lagoon habitats in the Gunbower Forest Ramsar site (data from 2009 and 2010 combined; Rehwinkel et al. 2010).

3.3.4 Wetland birds

A total of 66 species of wetland birds have been recorded within the site (Table 13, Appendix B). The list includes eight species that are listed as Migratory under the EPBC Act and nine species that are listed under international migratory bird agreements. Twenty-six of the wetland bird species recorded at the site are listed as Marine under the EPBC Act. The site is considered important for the nationally and internationally endangered Australasian bittern.

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 difficulty of access during floods) and the dominance by heavily forested wetlands, which reduce visibility from the air. There are records of approximately 6000 wetland birds in December 1994, comprising of 4000 Nankeen night herons (*Nycticorax caledonicus*) and 1000 intermediate egrets (*Ardea intermedia*) and smaller numbers of other herons and egrets (DSE unpublished). Further, hundreds of birds were recorded in 1996 and 2004 (MDBC 2007). There are no other records of high wetland bird abundance. However, a lack of systematic surveys precludes a quantitative characterisation of waterbird abundance and species richness.

An astonishing 48 species of wetland birds have been recorded breeding in the site, which represents over 70 percent of the total species (DSE unpublished). However, nesting records for some of these species are scant, with a large number of breeding observations from 1970s only (DSE unpublished).

Davies (2004) summarised the available data for colonial nesting waterbirds from Gunbower Forest. There are records of intermediate egret nesting in 1972/73 and 1973/74 around Iron Punt and Little Punt Lagoons, but no quantitative data. Quantitative data for colonial nesting waterbirds indicates that the site supports hundreds of nests of a number of species during times of sufficient inundation (Table 14).

Table 13: Number of wetland birds recorded within the Gunbower Forest Ramsar site (DSE unpublished). See Appendix B 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 feeding 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).	11
Gulls, terns	Terns, over open water feeding on fish and invertebrates; gulls, opportunistic feeders over a wide range of habitats.	3
Other	Non waterbirds that are reliant on wetlands for breeding or feeding (for example, the superb parrot and clamorous reed warbler).	5
Total		**66**

Table 14: Colonial nesting waterbird records from within Gunbower Forest Ramsar site (data from Davies 2004).

Year	Species	Nests	Locations
1974/5	Eastern great egret	200	Not recorded
	Intermediate egret	500	Iron Punt and Little Punt Lagoon
	Nankeen night heron	unknown	Iron Punt and Little Punt Lagoon
1994	Australian darter	few	Little Reedy Lagoon
	Cormorant	600+	Centre Break Track, Barton Track, Little Reedy Lagoon, Grey's Mill Rookery
	Egret	600+	Little Reedy and Little Punt Lagoons; Grey's Mill Rookery
	Ibis	20	Little Punt Lagoon
	Nankeen night heron	200+	Centre Break Track, Barton Track, Grey's Mill Rookery, Little Punt Lagoon

1997	Australian darter	2	Little Reedy Lagoon
	Pied cormorant	6	Little Reedy Lagoon
2000/01	Australian darter	3	Little Reedy and Long Lagoons
	Australian white ibis	20	Little Reedy Lagoon
	Eastern great egret	36	Little Reedy Lagoon, Charcoal Swamp
	Intermediate egret	1	Charcoal Swamp
	Little pied cormorant	35	Little Reedy and Long Lagoons
	Nankeen night heron	120	Charcoal Swamp
2003	Great cormorants, pied cormorants, little pied cormorants and little black cormorants	187	Little Gunbower Creek Wetland Complex
	Australian darter	3	Little Gunbower Creek Wetland Complex
	Australian white ibis	2	Little Gunbower Creek Wetland Complex

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 (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 Gunbower Forest Ramsar site at the time of listing are outlined in Table 15.

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 (DEWHA 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 was 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 Gunbower Forest Ramsar site are:

- supports a diversity of wetland types;
- provides physical habitat for waterbird feeding and breeding;
- supports threatened wetland species;
- maintains ecological connectivity for fish spawning and recruitment; and
- organic carbon cycling.

Table 15: Ecosystem services and benefits provided by the Gunbower Forest Ramsar site (those considered critical are shown shaded).

Category	Description
Provisioning services	
Wetland products (timber)	At the time of listing, the site was designated State Forest and nearly half of the site remains so and is managed predominantly for timber production.
Wetland products (fodder)	Grazing – at the time of listing, grazing was undertaken through much of the site.
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.
Cultural services	
Recreation and tourism	The general public have mostly unrestricted use of the forests and rivers for recreational pursuits through a road network to and within the forests. Common activities include recreational fishing, bird watching and bushwalking.
Spiritual and inspirational	Traditionally, Gunbower Island was frequented by two clans; the Barapa Barapa and the Yorta Yorta. The Barapa Barapa and Yorta Yorta people have long connections with the area now known as Gunbower National Park. The area was known as Kanbowro – twisting and tortuous like the necks of the black swans. The area contains many shell middens (kitchen hearths), burial sites and scar trees.
Science and education	The site contains interpretative ecotourism and education. National focus of research, environmental management and education through the 'Living Murray' program (MDBC, 2007).
Regulating services	
Carbon sequestration	Although this aspect has not been quantified, the forests and their floodplain soils would account for 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 site protects agricultural lands downstream from floods (Dexter 1978). 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	
Diversity of wetland types	The site supports the part of the second largest remaining river red gum forest and provides a mosaic of vegetated wetland habitats.
Physical habitat	Gunbower Forest provides habitat for feeding and breeding of wetland birds.
Threatened species	The Ramsar site supports at least five species listed as threatened 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.
Organic carbon cycling	As part of a major floodplain system, the site is important for the cycling of nutrients, particularly carbon both on the floodplain and as a source of organic carbon to receiving waterways.

4.3 Critical services

4.3.1 Supports a diversity of wetland types

As described in Section 2.3, the Gunbower Forest 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, river red gum woodland and black box woodland;
- Permanent lakes and intermittent freshwater marshes – freshwater marshes, open water; and
- Permanent and Intermittent rivers and streams – in-stream habitats.

This diversity of habitat is brought about by the interactions between geomorphology, hydrology and vegetation (Figure 28). 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 adaptations to low oxygen in the soil following inundation that determines a plant species optimum water regime (Brock and Cassanova 1997). The water regime requirements for different wetland types are provided in Table 16.

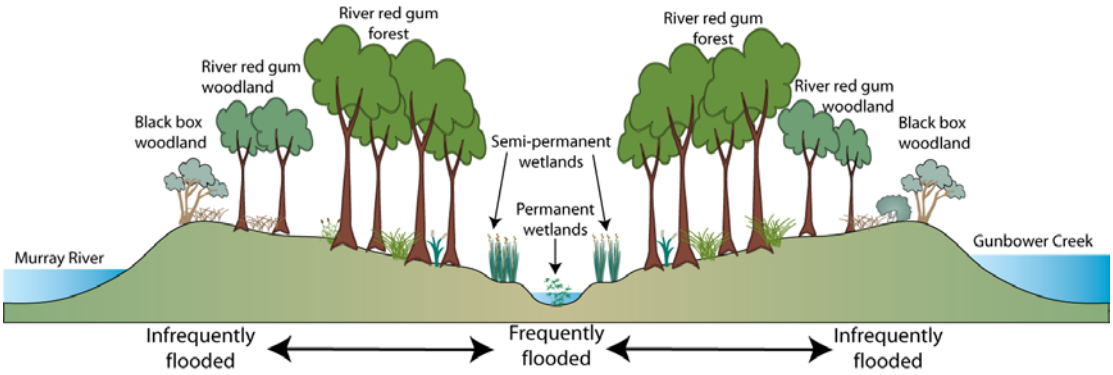

Figure 28: Vegetation associations, geomorphic setting and flood regime in Gunbower Forest (adapted from MDBC 2005).

Table 16: Water requirements of wetlands within Gunbower Forest (DSE 2010).

Vegetation	Frequency	Duration	Timing
Permanent wetlands	Ten years in 10	Nine to 12 months	Late winter to spring, persisting for 12 months in nearly all years
Semi-permanent wetlands (intermittent marshes)	Six to nine years in 10	Five to eight months	Spring to summer persisting for 12 months in many years
River red gum forest	Seven to nine years in 10	Four months (range of one to eight months)	Spring
River red gum woodland	Three years in 10 (range of one to four years)	Two to five months (range of one to four months)	Spring
Black box woodland	One year in 10 (range of one to four years in 10)	One month (range of one to four months)	Late spring

Freshwater tree dominated wetlands

River red gum forested wetlands dominate the site and natural regeneration of river red gum is largely dependent 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 2007).

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 seedlings, which is important for maintaining the distribution of treeless communities (marshes) at the site (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 site was managed as a State Forest with over 80 percent of the site managed predominantly for timber harvesting (DSE 2003). This management included stand thinning, select tree harvesting and (rarely) active regeneration and direct seeding (Di Stefano 2001). There is evidence from the site and nearby similar locations 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. Plant community composition and extent of these wetlands varies temporally and spatially in response to patterns of inundation and drying. Brock and Cassanova (1997) classified plants into functional groups based on water regime and adaption to flooding and this has been adapted to the flora of freshwater marshes in the site Table 17.

Table 17: Plant functional groups and examples from Gunbower Forest (Australian Ecosystems 2010).

Functional Group	Description	Examples from Gunbower
Submerged	Do not tolerate drying.	*Azolla* spp.; stoneworts
Amphibious responders - floating	Tolerate flooding and drying: truly amphibious plants that change aspects of their morphology under different water conditions. This group responds by developing floating leaves.	*Ludwigia peploides;* moira grass (*Pseudoraphis spinescens*)
Amphibious responders - plastic	Tolerate flooding and drying: truly amphibious plants that change aspects of their morphology under different water conditions. This group responds in a range of ways other than by developing floating leaves, e.g. growing laterally along the mud, putting down roots at nodes when stranded and growing vertically to extend the leaves above the water.	Swamp wallaby-grass; common spike-sedge (*Eleocharis acuta*); water milfoil (*Myriophyllum* spp.)
Amphibious tolerators -low growing	Tolerate flooding and drying; not truly amphibious and have the same germination, growth and reproduction patterns in a wide range of water conditions. These plants tolerate by being able to survive underwater for some period.	Creeping knotweed (*Persicaria prostrata*); starwort (*Stellaria* spp.)
Amphibious tolerators - emergent	Tolerate flooding and drying; not truly amphibious and have the same germination, growth and reproduction patterns in a wide range of water conditions. These plants tolerate flooding by having an upright growth form that keeps the photosynthetic parts above water at all times.	Swamp billy buttons (*Craspedia paludicola*); Rushes (*Juncus* spp.); *Typha* spp.
Terrestrial - damp	Do not tolerate flooding and require good soil moisture at all times.	Loosestrife (*Lythrum* spp.)
Terrestrial - dry	Do not tolerate flooding and can survive drying.	Golden everlasting (*Xerochrysum bracteatum*)

The proportion of each plant functional group varies between permanent and intermittent (semi-permanent) wetlands and over time. Data collected over the period 2005 to 2010 provides an indication of the likely dynamics in freshwater marshes in the system around the time of listing (Figure 29). There are a higher proportion of submerged and amphibious responders in permanent wetlands as opposed to intermittent wetlands in the site, while amphibious tolerators are more often the dominant group in intermittent wetlands. During 2008 (an extreme dry year) cover of submerged and amphibious responders dropped dramatically. However, cover of these groups increased following inundation in 2010.

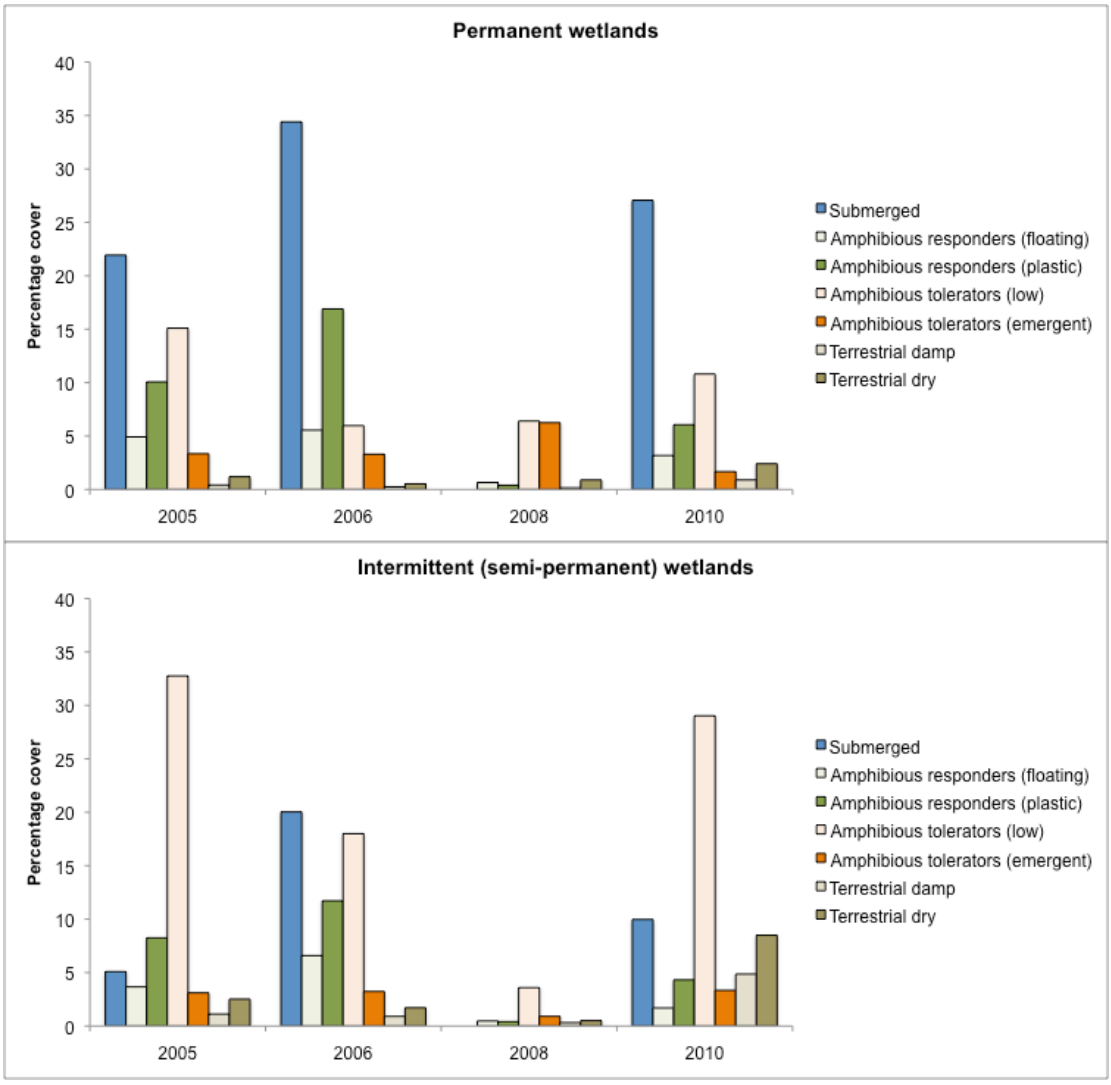

Figure 29: Average percentage cover of plant function groups in wetlands within the Gunbower Forest Ramsar site 2005 to 2010 (data from Australian Ecosystems 2010).

Intermittent rivers and streams

Gunbower Forest features an extensive and complex network of in stream habitats. Gunbower Creek is a major feature providing important habitat for native fish. They are all hydrologically connected to the Murray River and effluent streams, such as Yarran Creek and Spur Creek systems form a network with 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 (MDBA 2010a). In-stream habitats also support the aquatic and semi-aquatic plant species described 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 (Abel et al. 2006).

4.3.2 Provides physical habitat for wetland bird breeding and feeding

Gunbower Forest provides a range of habitats that support wetland birds in terms of feeding and breeding. Sixty-six 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 30).

Feeding

The service of providing habitat for wetland bird feeding is considered in terms of broad feeding/habitat guilds. The Gunbower Forest Ramsar site provides and spatial and temporal mosaic of habitats that support a diversity of wetland birds. The general habitat requirements for a number of wetland birds that have been recorded within the Ramsar site are provided in Table 18.

Table 18: General diet and feeding habitat requirements of a number of wetland birds in the Gunbower Forest Ramsar site (Marchant and Higgins 1990).

Species	Habitat characteristics
Piscivores	
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.
Diving ducks	
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.
Blue-billed duck (*Oxyura australis*)	Prefer deep, large permanent open water. Roosting – nocturnally usually on open water. Diet – seeds and leaves of aquatic plants and invertebrates (chironomids, caddis flies, dragonflies). Foraging – deep diving.
Dabbling ducks	
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.
Waders	
Yellow-billed 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.

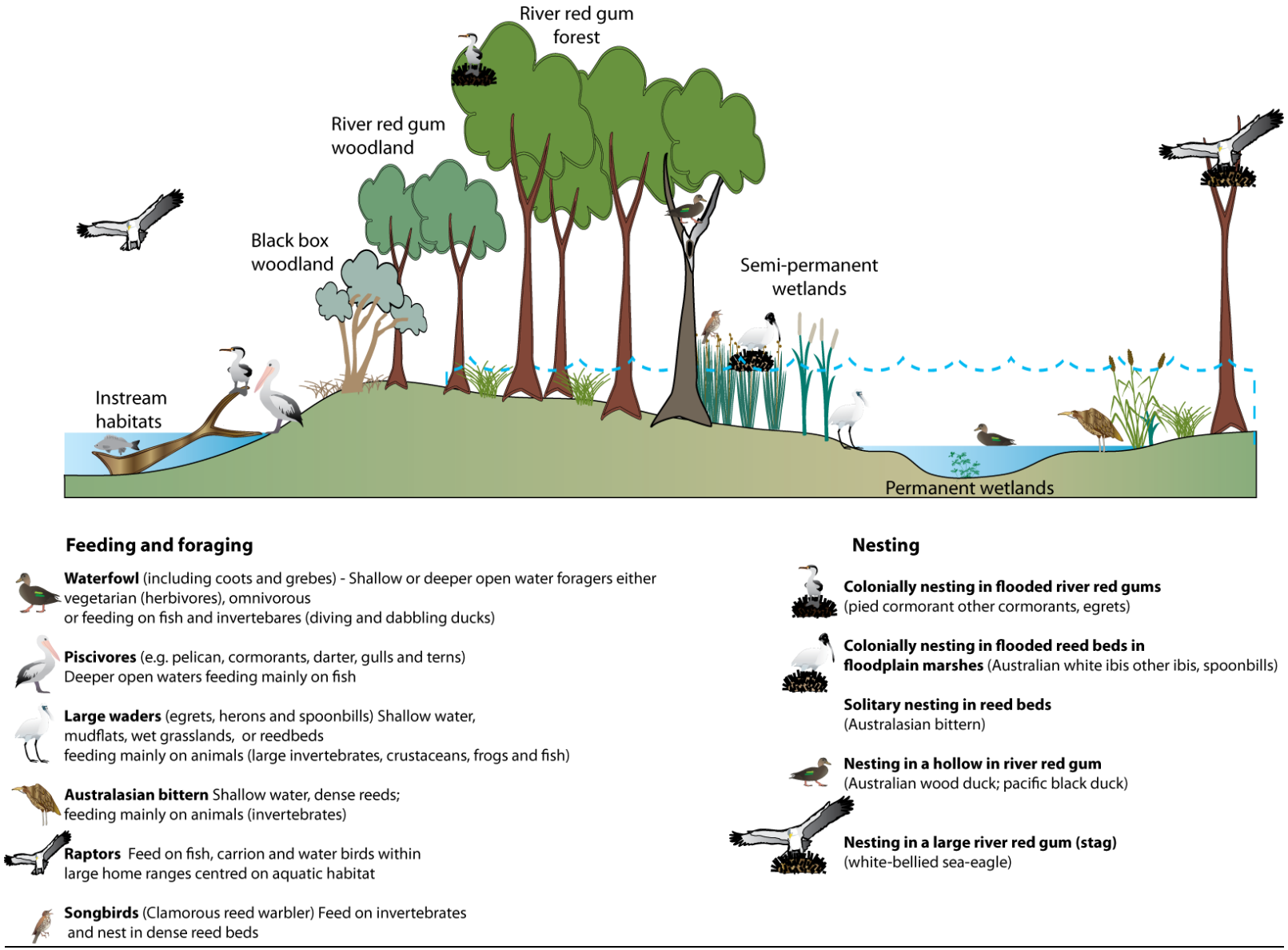

Figure 30: Conceptual diagram illustrating the variety of habitats for wetland birds within the Ramsar site.

Breeding

The Gunbower Forest Ramsar site is significant for supporting breeding of wetland birds, particularly colonial nesting waterbirds such as 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 *Eleocharis* or other emergent macrophytes in marshes (DSE 2010). The greatest concentrations of important waterbird breeding colonies at the site are in Reedy Lagoon, Little Reedy Lagoon and Black Swamp.

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 19.

Table 19: Nesting habitat and inundation requirements for some species of wetland bird previously recorded breeding in the Ramsar site ([2]Briggs 1990; [3]Jaensch 2002).

Species[1]	Stimuli for breeding[2]	Nesting Habitat[3]	Inundation requirements[3]
Little pied cormorant	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	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.
Eastern great egret	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	Flooding / seasonal	Wooded swamp (such as *Eucalyptus* spp.); high (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.

Species[1]	Stimuli for breeding[2]	Nesting Habitat[3]	Inundation requirements[3]
Nankeen night heron	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.
Australian white ibis	Flooding / seasonal	Wide variety of habitats used for breeding: typically wooded swamp (such as *Eucalyptus* spp.), 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).
Royal spoonbill	Flooding / seasonal	Typically use platforms of Giant rush and Common reed among the main ibis colonies; occasionally also wooded swamps. Requires inundation until young fledge. Requires inundation until young fledge.	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).
Black swan	Flooding / seasonal	Nest mound built in open water, on an island, or in swamp vegetation.	Minimum water depth of 30 to 50 cm until cygnets are independent. First flight 20 to 25 weeks.

4.3.3 Supports threatened species

Although there are records for a number of threatened species from within the Gunbower Forest Ramsar site, only four of these are considered critical to the ecological character of the site (see Section 3.1). The habitat requirements and important habitats within the site for each of these are described briefly below.

Australasian bittern

The Australasian bittern is a shy and cryptic wading species of wetland bird. Habitat preferences are for permanent, densely vegetated freshwater wetlands (Garnett 1992). It forages mainly at night in shallow water up to 30 centimetres deep and feeds on frogs, fish and invertebrates as well as occasionally plant material (Marchant and Higgins 1990).

Permanent and intermittent freshwater marshes with emergent vegetation provide habitat for this species within the Ramsar site. The Australasian bittern has been recorded at Reedy Lagoon and Pig Swamp (DSE unpublished) and there is a single breeding record from within the site (exact location not provided). However, given the cryptic nature of this species coupled with a low survey effort for non-colonial nesting waterbirds, it is likely that the small number of records do not reflect the utilisation of the site by this species.

Murray cod and silver perch

These two large-bodied native fish utilise predominantly flowing environments within the site. Murray cod prefers deep holes in rivers, with instream cover such as rocks, snags and undercut banks, while silver perch are found mostly in lowland, turbid and slow-flowing rivers (Lintermans 2007). Both species have been recorded in Gunbower Creek in all surveys to date, however abundances are low (Rehwinkel et al. 2010).

In addition, Gunbower Forest provides temporary habitat for Murray cod and silver perch when floods link the fish's normal riverine habitat with the floodplain. The provision of quality habitat for both species depends on a productive floodplain ecosystem. Murray cod hunt on large aquatic prey such as small fish and large invertebrates, whereas silver perch consume both large aquatic prey and plant material (Ecological Associates 2003).

Swamp wallaby-grass

Swamp wallaby-grass is a slender, up to one metre tall aquatic or semi-aquatic native grass. It inhabits intermittent wetlands and the littoral zone of permanent wetland systems, as well as occurring as the understorey in river red gum forests following inundation (Australian Ecosystems 2009). The species is a sward-forming grass species that spreads by adventitious stems growing along the ground or through water. It can survive prolonged periods without inundation as a low-growing turf, but is primarily a grass of aquatic environments and grows most vigorously when flooded by shallow water (Australian Ecosystems 2009).

It is relatively widespread throughout the Gunbower Forest Ramsar site, being found at eight out of ten wetlands surveyed from 2006 to 2010 (Table 20).

Table 20: Presence of swamp wallaby-grass in select wetlands within the Gunbower Forest Ramsar site (Australian Ecosystems 2010).

Wetland	2005	2006	2008	2010
Black Swamp	X	X		X
Green Swamp				
Little Gunbower	X			X
Reedy Lagoon	X	X	X	X
Charcoal Swamp	X			X
Football Grounds	X	X	X	X
Iron Punt Lagoon				
Long Lagoon	X	X	X	X
Little Reedy Lagoon	X	X		X

Winged peppercress

Winged peppercress is an annual herb with erect stems, to 20 centimetres tall. Critical habitat characteristics are poorly understood for this species (DSE 2009). The species grows at sites that are seasonally wet, either through periodic flooding or where rainfall runoff collects, and a regular wetting and drying regime is probably required to maintain an open habitat and facilitate seed germination (Mavromihalis 2010).

A winged peppercress population occurs near Reedy Lagoon, with approximately 750 individuals recorded in 1984. In 2004 the population covered an area of approximately 600 square metres and comprised 750 to 1000 individuals and in 2005 the population was estimated at 50 000 individuals (DSE 2009).

4.3.4 Maintains ecological connectivity for spawning / recruitment of native fish

An 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 Gunbower Forest Ramsar site by native fish remains a knowledge gap. However, recent investigations in adjacent reaches of the Murray River 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. 2007). Juvenile and larval native fish species have been recorded in wetland, lake and creek habitats within the site (Rehwinkel et al. 2010) 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 (over 1000 kilometres upstream and as much as 800 kilometres downstream), which is indicative of pre- and post-spawning behaviour (McKinnon 1997). The Gunbower Forest Ramsar site (together with adjacent sites such as Millewa, Koondrook Perricoota and Barmah) 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 21.

Table 20: Migration and spawning habitats for some fish species known to occur in the Ramsar site ([1]CRCFE 2003; [2]Lintermans 2007).

Species	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.
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, which 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 up to 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.

Species	Habitat group[1]	Migration and spawning habitats[2]
Murray cod (*Maccullochella peelii*)	Main channel specialists, which 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.

4.3.5 Organic carbon cycling

River red gum forests are important in the cycling of organic carbon in lowland river systems in Australia (Robertson et al. 1999). Organic carbon is a major nutrient in freshwater systems and an important primary source of food in aquatic food webs. In forested catchments, the major terrestrial inputs of carbon to rivers are (Bunn et al. 2007):

- Coarse woody debris – logs and branches from riparian and floodplain vegetation;
- Particulate organic matter – litter inputs directly from riparian trees or washed from other areas of the floodplain; and
- Dissolved organic carbon – released from wetlands and floodplains and carried to the river on return flows.

Although there are no measures from within the Ramsar site itself, investigations on similar, river red gum forested floodplains in south-eastern Australia provide some understanding of the relative contributions of each of these sources and their role in maintaining not only the character of the Ramsar site, but in supporting surrounding river systems.

Coarse woody debris

Studies from the adjacent Barmah Forest reported wood production in the river red gum forest varied between 89 and 360 grams of carbon per square metre per year, with higher rates of productivity on more frequently flooded portions of the floodplain (Bacon et al. 1993). Wood decomposes slowly with a half-life of approximately 140 years and as such the role of coarse woody debris may be more important as structural habitat for biofilms in terms of carbon production than as a direct release of organic carbon to receiving waters (Robertson et al. 1999).

Particulate organic carbon

Production of litter in river red gum forests is also variable, both seasonally and in response to frequency of inundation. Quantitative measures of leaf litter production from Millewa Forest were between 89 and 230 grams of carbon per square metre per year (Robertson et al. 1999). Litter is more mobile than coarse woody debris and has a half-life of approximately one year in dry conditions or 50 days if inundated (Robertson et al. 1999).

Dissolved organic carbon

In addition to coarse woody debris and particulate organic matter, which must be broken down within the river/wetland to dissolved organic carbon in order to enter the food web; dissolved organic carbon can be directly transported from the forest to receiving waters. Inundation of the floodplain leads to mineralisation of organic carbon in litter and sediments. The result is often called “blackwater” due to the dark tannin stained colour of the water (Howitt et al. 2005). The period of time since the last flood, together with seasonal factors such as temperature influence the amount of carbon released (Howitt et al. 2005).

In addition to acting as a source of carbon to receiving aquatic ecosystems, floodplains also act as a store of organic carbon. In particular sediments containing particulate organic carbon may be deposited on the floodplain during inundation events. The fate of this carbon, however, is not well understood (Robertson et al. 1999).

4.4 Conceptual models

The critical components, processes and services, which combine to form the ecological character of Gunbower Forest 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 31) and dry phases (Figure 32) illustrate some of the interactions between critical components, processes and services that are described for each phase below.

4.1 Wet phase (filling and inundated state)

With the arrival of floodwaters, the following physical and chemical changes occur within the floodplain (Boon 2006):

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

Upon wetting, the following biological processes occur (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;
- flowering is stimulated in a number of species, e.g. lignum (Roberts and Marston 2000);
- aquatic plant growth is stimulated; and
- the release of nutrients and subsequent “boom” in productivity initiate the breeding of waterbirds, frogs, fish and turtles.

When inundated, these ecological processes can be expected (Boulton and Brock 1999):

- the 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;
- the productivity boom provides important food resources for waterbirds, fish, frogs, turtles and insectivorous/nectivorous terrestrial species;
- the nesting of waterbirds occurs 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 breed in shallow water and inundated vegetation and tadpoles mature and grow;
- turtles nest on sandy island habitats, eggs hatch and juveniles feed and grow; and
- fish breed in inundated vegetation and woody debris; larval and juvenile forms within water column.

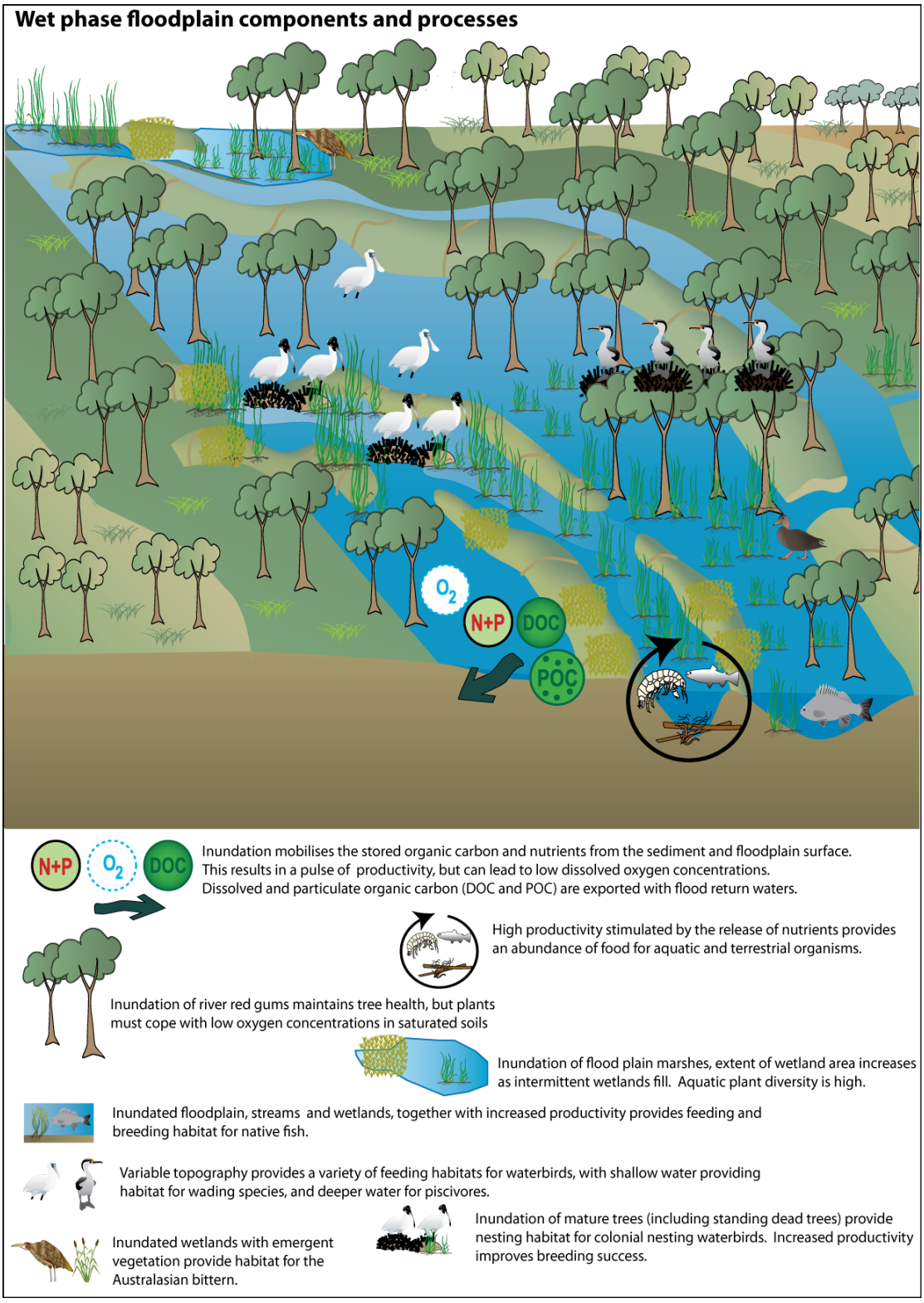

Figure 31: Simple conceptual model illustrating some of the interactions between critical components, processes and services in the Gunbower Forest Ramsar site during times of floodplain inundation (wet phase).

4.2 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 (e.g. river red gum) germinate and seedlings emerge on the damp soil;
- waterbirds fledge and disperse;
- turtles migrate to nearby wet refuges, some aestivate; and
- fish return with receding waters to the river or remain in permanent channels.

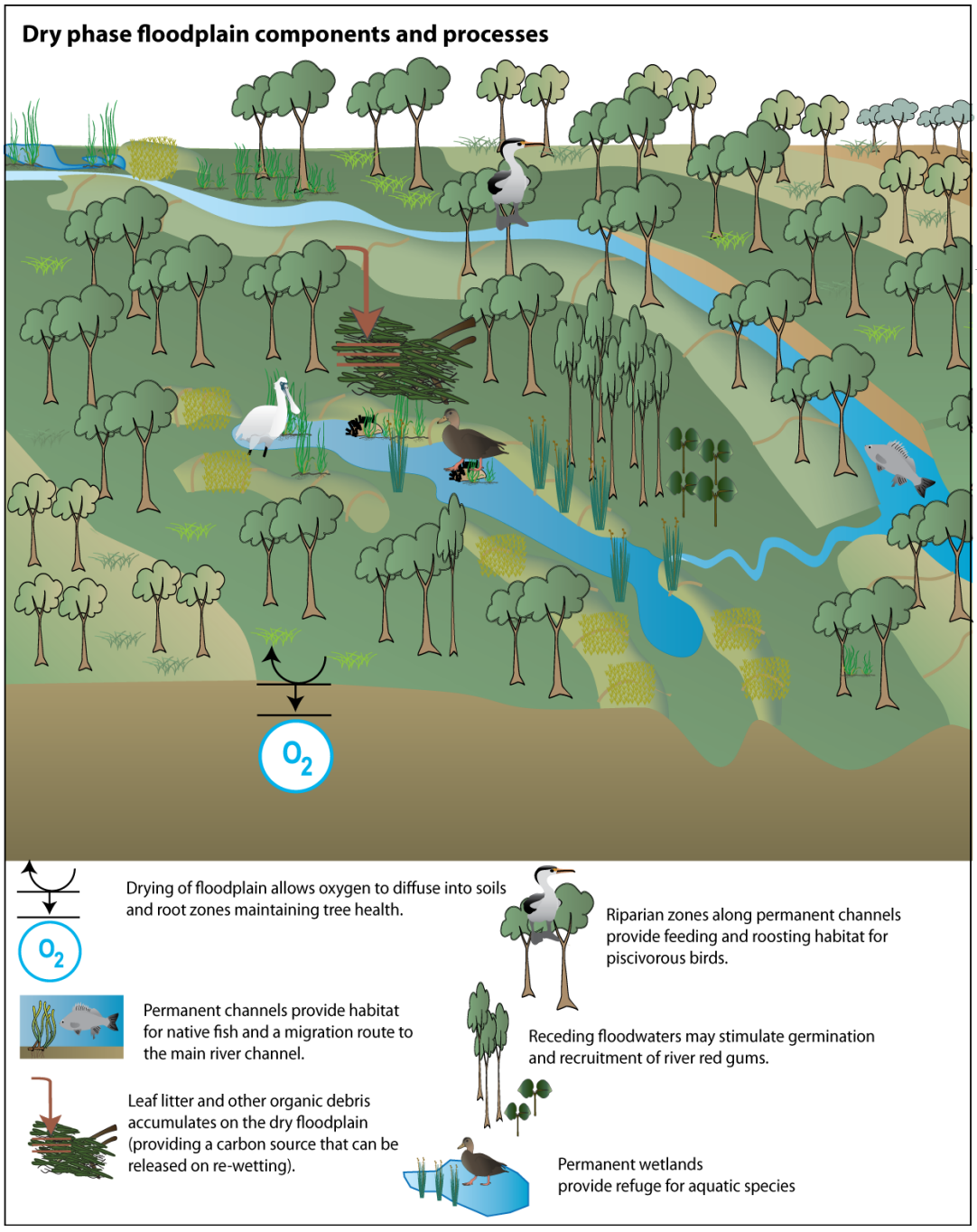

Figure 32: Simple conceptual model illustrating some of the interactions between critical components, processes and services in the Gunbower Ramsar site between floods (dry phase).

5. Limits of Acceptable Change

5.1 Process for setting Limits of Acceptable Change (LACs)

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".

Limits of Acceptable Change and the natural variability in the parameters for which limits are set are inextricably linked. Phillips (2006) suggested that LACs 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 LACs 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.

The LACs 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.

<u>Additional Explanatory Notes for LACs</u>

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 LACs, 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 LACs 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 LACs 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.

LACs 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.

5.2 LACs for the Gunbower Forest Ramsar site

LACs have been set for the Gunbower 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 timeframes need to be considered to characterise variability. Where possible, site specific information has been used to statistically determine LACs. In the absence of sufficient site-specific data, LACs are based on recognised standards or information in the scientific literature that is relevant to the site. In all 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 LACs have been recommended based on the precautionary principle. These will require careful review with increased information gained from future monitoring.

The Gunbower Forest Ramsar site was listed under conditions of altered hydrology. A comparison of the water regime requirements of critical components such as vegetation (Table 16) with hydrology at the time of listing (Table 8) indicate that at the time of listing the hydrological regime may have been insufficient to maintain the character of the site in the long term. While LACs should be set for conditions at the time of listing, it is important to ensure that long term health of the critical components, processes and services, which depend on hydrology, is maintained. Obligations for member nations under the Ramsar Convention are to “protect and *enhance*” wetlands. However, LACs are not synonymous with management targets and should not be used to set ideal future benchmarks or targets. As such, LACs for hydrology have been set as conditions at the time of listing on the understanding that any further decrease or increase in the frequency and extent of floodplain inundation is likely to result in a change in character.

LACs 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 Gunbower Forest also covers the critical services of supporting a diversity of wetland types and physical habitat for waterbirds. If hydrology was significantly altered this would lead to a loss of the services. In order to limit repetition in the LACs for Gunbower Forest, a hierarchical approach has been adopted where LACs have been set for components or processes, which in this case has also covered critical services.

The columns in Table 22 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 21: Limits of Acceptable Change for the Gunbower Forest Ramsar site.

Critical components, processes and services	Baseline/Supporting evidence	Limit of Acceptable Change	Confidence level
Critical components and processes			
Hydrology	The hydrology of the site, at the time of listing, can be characterised in terms of average return intervals of river flows for events that are considered important for critical components of the site (adapted from modelled 1990 level of development in Ecological Associates 2003): • 13 700 megalitres a day for three months (commence to flow into forest) – average return interval = 2.6 years; • 30 000 megalitres a day for two months (overbank flow inundating approximately 50 percent of river red gum forest and 30 percent of river red gum woodland) – average return interval = 4 years; • 40 000 megalitres a day for one month (inundation of all river red gum forest and woodland and black box woodland) – average return interval = 5 years. Ideally a LAC would be based on frequency and extent of inundation, but this is difficult to apply and more difficult to assess against. What is proposed is a LAC based on the average return interval at the time of listing for flow events considered important for maintaining ecological character (Murray River at Torrumbarry). However, this means that should a LAC be exceeded, further investigation as to the actual frequency and extent of inundation at the site would need to be considered prior to determining if a change in character has occurred. As discussed above, this site was listed under conditions of altered hydrology. Available data indicate that hydrology at the time of listing may be insufficient to maintain the ecological character of the site in the long-term. Contracting parties to the Ramsar Convention have an obligation to protect and *enhance* Ramsar wetlands. As such, the hydrology LACs have been set based on conditions at the time of listing on the understanding that any further change in the frequency and extent of floodplain inundation is likely to result in a change in character.	*No less than four events in any 10 year period of 13 700 megalitres a day for three months (Murray River at Torrumbarry); and a maximum interval of three years between the stated flow event.* *No less than five events in any 20 year period of 30 000 megalitres a day for two months (Murray River at Torrumbarry) and a maximum interval of five years between the stated flow event.* *No less than 10 events in any 50 year period of 40 000 megalitres a day for one1 month (Murray River at Torrumbarry) and a maximum interval of 10 years between the stated flow event.*	Medium

Critical components, processes and services	Baseline/Supporting evidence	Limit of Acceptable Change	Confidence level
	In addition, as the interval between floods is also critical for maintaining critical components, an average return interval based on the maximum intervals between events is also proposed. The maximum intervals between events from the historic record are: • 13 000 megalitres a day for three months = three years; • 30 000 megalitres a day for two months = five years; and • 40 000 megalitres a day for one month = ten years. The LAC is assessed over time spans to account for the variability in hydrology at the site (i.e. to allow for three to ten occurrences of the specified flow events within the assessment period).		
Vegetation – floodplain forest	The extent of forested wetland vegetation communities at the time of listing is indicated by water regime classes (URS 2001; NCCMA supplied data): • 8326 hectares of river red gum forest; • 4757 hectares of river red gum woodland; and • 2694 hectares of black box woodland. In addition, there are benchmarks for tree condition (Cunningham et al. 2009) with 93 percent of the red gum forest and woodland in moderate or better condition in 2003. 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. As such, an objective, statistically based LAC cannot be determined and a figure of 10 percent change has been selected informed by local knowledge and expert opinion of the steering committee.	*Extent of floodplain forest and woodland vegetation to be no less than:* • *7500 hectares of river red gum forest* • *4280 hectares of river red gum woodland* • *2400 hectares of black box woodland* *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
	Forest structure and structural diversity is an important characteristic of river red gum forests in terms of habitat value (Horner et al. 2010).	*Insufficient information to develop a LAC for forest structure at this point in time.*	Not applicable

Critical components, processes and services	Baseline/Supporting evidence	Limit of Acceptable Change	Confidence level
Vegetation – floodplain marshes	Extent of floodplain marshes is not known at the time of listing. Mapping of wetland EVCs indicates 310 hectares of spike-sedge wetland and 140 hectares of tall marsh wetland. As with the extent of floodplain forest 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 10 percent change has been selected informed by local knowledge and expert opinion of the steering committee.	*Extent of spike sedge wetland to be no less than 270 hectares.* *Extent of tall marsh wetland to be no less than 125 hectares.*	Moderate
Vegetation – threatened species	The site supports the nationally threatened swamp wallaby-grass. There is no indication of the extent of location of this species at the time of listing and the only measures available are from recent years during a prolonged drought (Australian Ecosystems 2010). As such, a LAC is proposed based on presence only.	*Presence of swamp wallaby-grass in permanent and intermittent wetlands within the site.*	Low
	The site also supports a population of the nationally threatened winged peppercress. Unlike the swamp wallaby-grass, which is perennial and widespread and could reasonably be expected to be a continuous presence in the site, the winged peppercress is an annual plant that within the Ramsar site is known from a single location near Reedy Lagoon. As such the LAC for this species is based on presence at the known location only when suitable conditions of waterlogged soil occur.	*Presence of winged peppercress near Reedy Lagoon when waterlogging occurs.*	Low
Native fish (species richness)	Data for native fish are limited from the Ramsar site. Quantitative data are available for 2005, 2009 and 2010 (Rehwinkel et al. 2010) but this is insufficient to develop a quantitative LAC. A total of 12 native fish species have been recorded in the site (Rehwinkel et al. 2010; DSE unpublished) but once again there is no indication of variability. There is a lack of underlying knowledge of variability in fish species richness and the relationship with ecological character. As such the LAC has been developed based on expert opinion (L. Beesley, DSE, personal communication May 2010) with respect to fish that are characteristic of the site and would be expected to be present.	*Presence of the following species in no less than two in five annual surveys:* • Australian smelt *(Retropinna semoni)* • Carp gudgeons *(Hypseleotris spp.)* • Dwarf flat-headed gudgeon *(Philypnodon macrostomus)* • Flat-headed gudgeon *(Philypnodon grandiceps)* • Fly-specked hardyhead *(Craterocephalus stercusmuscarum)* • Murray-Darling rainbowfish *(Melanotaenia fluviatilis).*	Low

Critical components, processes and services	Baseline/Supporting evidence	Limit of Acceptable Change	Confidence level
Native fish (threatened species)	Two threatened native species of fish known from the site (Rehwinkel et al. 2010; DSE unpublished). Population size, dynamics and distribution not fully understood, however all fish surveys to date have recorded both Murray cod and silver perch in the site (Rehwinkel et al. 2010). Murray cod were present in streams and creeks within the site in 1993, 1994 (DSE unpublished), 2005 (Richardson et al. 2005), 2009 and 2010 (Rehwinkel et al. 2010), while silver perch were present in 1993 and 1994 (DSE unpublished), 2009 and 2010 (Rehwinkel et al. 2010).	*Presence of Murray cod and silver perch in Gunbower Creek in three out of five of annual surveys.*	Low
Wetland birds (abundance)	A total of 66 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 periodically supports hundreds of colonial nesting waterbirds during significant flood events. LAC is based on successful breeding of colonial nesting waterbirds.	*Successful breeding (80 percent of chicks fledged) of colonial nesting waterbirds during flood events.*	Low
Wetland birds (threatened species)	The site supports the threatened Australasian bittern but records are scarce (DSE unpublished) and there are no population estimates. Insufficient data from the Ramsar site to set a quantitative LAC.	*Presence of the Australasian bittern when tall marsh is inundated.*	Medium
Critical Services			
Diversity of 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 average return interval 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
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 average return interval 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

Critical components, processes and services	Baseline/Supporting evidence	Limit of Acceptable Change	Confidence level
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
Carbon cycling	This service is provided by the uptake of carbon by vegetation, the deposition of organic matter (coarse woody debris and litter) on the floodplain and the mobilisation of particular and dissolved organic carbon to receiving river systems with flood return waters. This service is maintained by vegetation extent, forest structure and hydrology. Therefore no direct LAC has been developed and instead the critical service will be assessed indirectly through changes in hydrology and floodplain forest extent.	*See LAC for hydrology and vegetation.*	Not applicable

6. Threats to Ecological Character

Wetlands are complex systems and an understanding of components and processes and the interactions or linkages between them is necessary to describe ecological character. Similarly threats to ecological character need to be described not just in terms of their potential effects, but the interactions between them. One mechanism for exploring these relationships is the use of stressor models (Gross 2003). The use of stressor models in ECDs has been suggested by a number of authors to describe ecological character (Phillips and Muller, 2006; Hale and Butcher 2008) and to aid in the determination of limits of acceptable change (Davis and Brock 2008).

Stressors are defined as (Barrett et al. 1976):

"*physical, chemical, or biological perturbations to a system that are either (a) foreign to that system or (b) natural to the system but applied at an excessive [or deficient] level*"

In evaluating threats it is useful (in terms of management) to separate the driver or threatening activity from the stressor. In this manner, the causes of impacts to natural assets are made clear, which provides clarity for the management of natural resources by focussing management actions on tangible threatening activities. For example, soil disturbance and compaction may be identified as a threat to native vegetation in the forest. However, management actions cannot be targeted at soil disturbance without some understanding of why the increase is taking place. By identifying the threatening activities that could contribute to soil disturbance (for example feral horses, recreational vehicles) management actions can be targeted at these threatening activities and reduce the impact to the wetland.

There are a number of threats that could significantly impact on the ecological character of the site. The stressor model (Figure 33) illustrates the threats (threatening activities), stressors and resulting ecological effects on critical components, processes and services the Gunbower Forest Ramsar site.

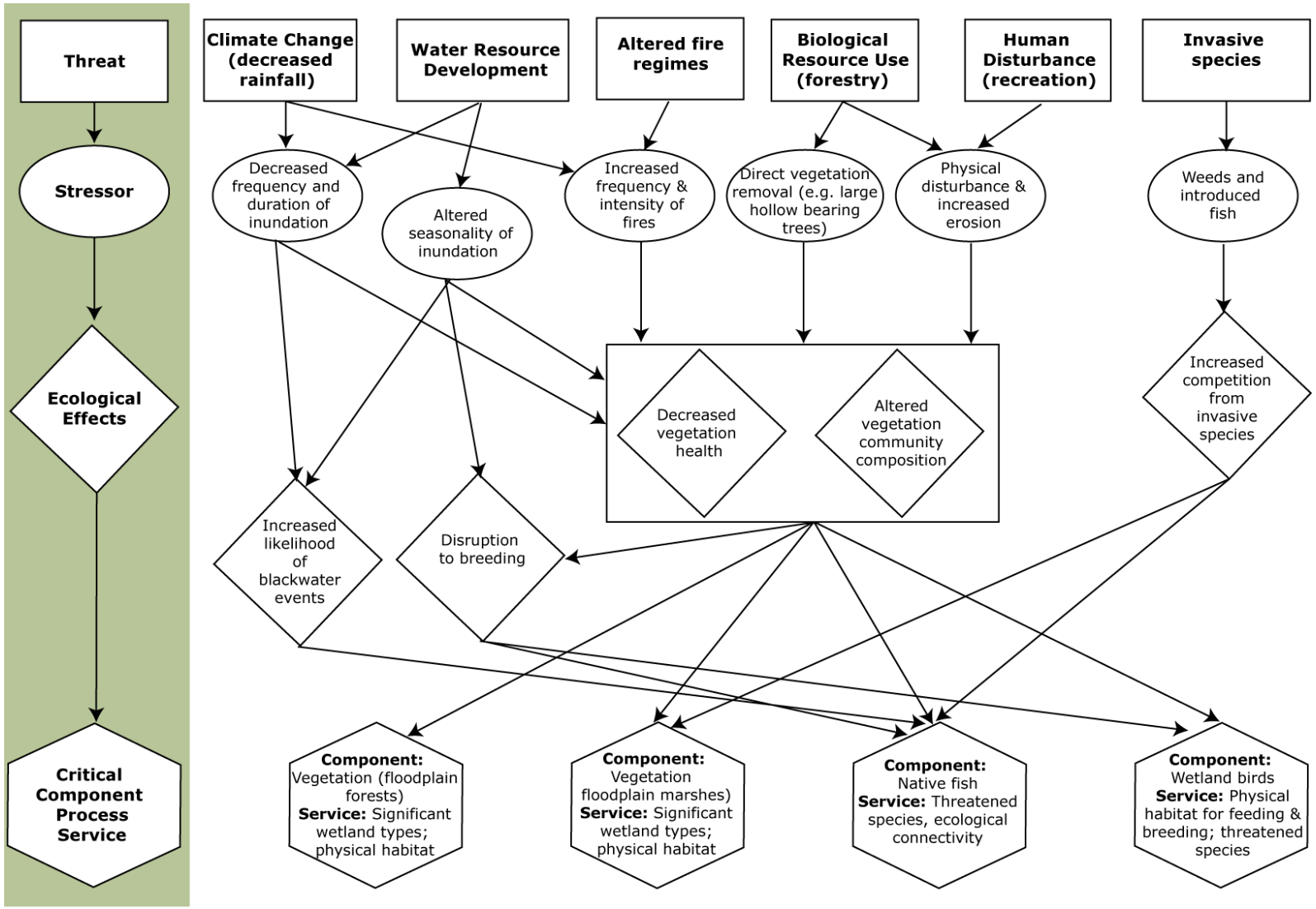

Figure 33: Stressor model of the Gunbower Forest Ramsar site (after Gross 2003 and Davis and Brock 2008).

6.1 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, 2007). 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. 2000). The Hume Dam was completed in 1936 and as a result of this and other regulatory structures, water delivery and operational rules have been influencing the hydrology of Gunbower Forest for a number of decades and were in place at the time of listing as a Wetland of International Importance. However, surface water diversion for consumptive purposes was not capped until 1995, a decade after listing and 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.

Flow seasonality, magnitude and frequency have all been altered by water resource development. There has been a decline in moderate floods that inundate the areas of the floodplain that are covered in river red gum forest and woodland forest (Leitch 1989; MDBA 2010a). In addition, there has been an increase in small floods in summer and autumn that cover 10 percent of the forest, particularly low lying wetland areas (Ladson and Chong 2005). Large floods that result in widespread inundation (including of Black Box communities higher on the floodplain) have been less affected (Maheshwari et al. 1993) and flood recurrences for these events remain close to natural (MDBA 2010a).

The potential ecological responses to altered hydrology in the Ramsar site are wide reaching (Gippel and Blackham 2002). Particular effects to identified critical components, process and services in the Ramsar site include:

- decreased condition of river red gums as a result of decreased frequency and duration of inundation (Bren 1988; Cunningham et al. 2009);

- an increased number of exotic flora species, due to decreased floodplain inundation frequency (Stokes et al. 2010).

- decreases in breeding numbers and successful fledging events of colonial nesting waterbirds due to a decrease in frequency and extent of moderate floods;

- impacts to native fish populations with low flow conditions having a negative effect on the spawning and recruitment of native fish, including the reduction in the recruitment of carp gudgeons (*Hypseleotris sp.*), southern pygmy perch (*Nannoperca australis*) and golden perch (*Macquaria ambigua*); but a favourable effect on the spawning and recruitment of pest species such as common carp (*Cyprinus carpio*) (MDBC 2008); and

- increased incidence and intensity of blackwater events due to reduced frequency of inundation, coupled with unseasonal inundation (during warmer months); resulting in very low dissolved oxygen concentrations and fish deaths.

6.2 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 Gunbower Forest Ramsar site. This reduction in floodplain and wetland inundation is likely to exacerbate the effects of river regulation already observed at the site with an increase in stress to vegetation and fauna communities.

6.3 Forestry activities

Gunbower Forest was recognised as a “working forest” at the time of designation as a Wetland 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 are considered a provisioning service provided by the site. The qualification of benefits and services arising from forest management at the site is a 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 region 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).

Tree felling may have a short term, temporary impact on the local environment by:

- disturbing local flora and fauna and possibly cause individual injury or mortality;
- disturbing fish habitat and obstructing fish passage;
- altering forest structure by removing some of the overstorey and damaging the understorey;
- increasing the amount of woody and fine debris on the forest floor and increasing 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;
- 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;).

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).

6.4 Altered fire regimes

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. However, with decreased inundation, fuel loads in the understorey can increase and result in intensive fires if ignited.

6.5 Invasive species

There are a large number of species of introduced flora within the Gunbower Forest Ramsar site and weed cover has been described as extensive (DSE 2003). A number of terrestrial weeds have been competitively advantaged by the reduced frequency of inundation (Stokes et al. 2010) and these have displaced native flora species and reduced habitat for aquatic fauna.

Invasive exotic fish have the potential to impact on wetland ecosystems in the Murray-Darling Basin by (Wilson 2005):

- direct predation;
- habitat modification;
- disease or parasite introduction; and
- resource and interference competition.

Common carp (*Cyprinus carpio*) and eastern gambusia (*Gambusia holbrooki*) are considered to pose the greatest threat to wetland ecosystems and native fish populations (Wilson 2005) and both of these species have been recorded in relatively high abundances within the Ramsar site (Rehwinkel et al. 2010).

6.6 Human disturbance

Un-managed recreational activities can have a negative impact on wetland ecosystems. For example, vehicle tracks can compact the soil, impacting on flora and fauna and increasing access for introduced predators such as foxes. Recreational activities can also degrade habitat; for example, 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-dependent 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.

6.7 Summary of threats

Although a risk assessment is beyond the scope of an ECD, the National Framework (DEWHA 2008) states that an indication of the impacts of threats to ecological character, likelihood and timing of threats should be included. The major threats considered in the previous sections have been summarised for each location within the Ramsar site in accordance with the National Framework in Table 23.

Table 22: Summary of the main threats to the Gunbower 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)	Reduced health and extent of river red gum forests and floodplain marshes. Altered vegetation community composition. Decreased habitat for fauna feeding and breeding. Absence or disruption of bird, fish and frog breeding events. Blackwater events.	Low	Current
Climate change (increased temperatures and decreased rainfall).	Exacerbate effects of water resource development and altered fire regimes.	Certain	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, introduced fish)	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

[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.

7. Current Ecological Character and Changes since Designation

7.1 Changes in land use

From June 2010 a portion of the Ramsar site (formally a mix of State forest and Crown Land reserves) was reserved as national park under the Victorian *Parks and Crown Land Legislation Amendment (River Red Gum) 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 until June 2011 (DSE unpublished 2011).

7.2 Changes in critical components, processes and services

Assessment of changes since designation in 1982 for the Gunbower Forest Ramsar site is hampered by a lack of baseline data from around the time of listing. This is particularly so for biotic critical components, processes and services. An assessment of current conditions with respect to LAC is provided in Table 24 and illustrates the problems in assessing change at this site.

There is evidence that the hydrology of the site has changed in recent years and the LAC for small flood frequencies has been exceeded (Table 24). However, whether this is a result of sustained change or the effects of the recent (2000 to 2010) drought is unknown. It is likely due to a combination of a number of factors that include water resource development, climate change and shorter term climatic cycles.

Similarly there has been a decline in tree health from 2003 to 2009 (Cunningham et al. 2009), which reflects the decreased floodplain inundation in the last decade. The extent of the threatened species swamp wallaby-grass declined at permanent wetlands surveyed from 2005 to 2010 (Australian Ecosystems 2010; Figure 34). However, the LACs for both of these critical components has not been exceeded (Table 24).

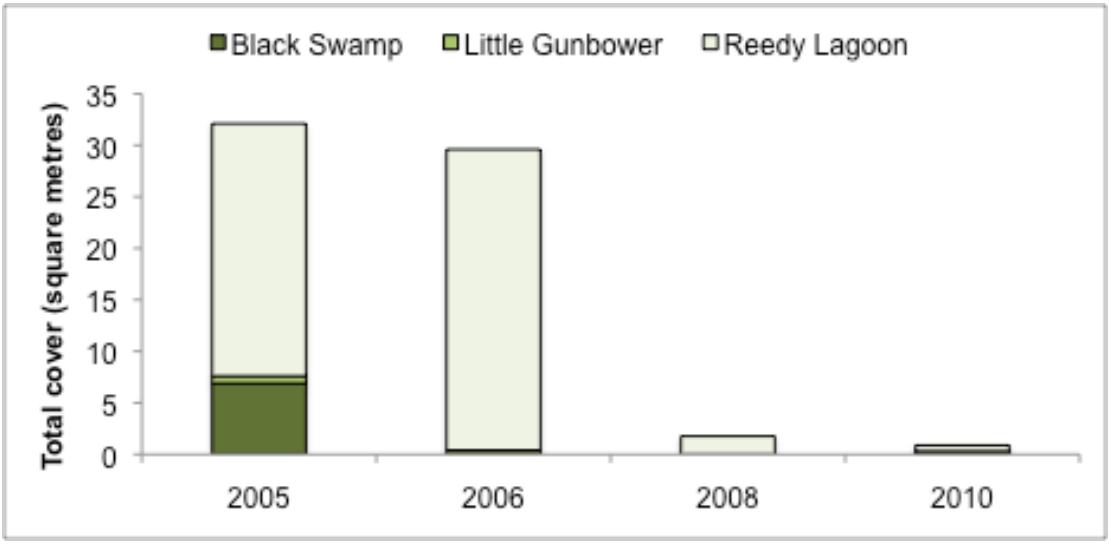

Figure 34: Extent of swamp wallaby-grass at three permanent wetlands in Gunbower Forest from 2005 to 2010.

There have been minor changes to geomorphology and potentially future changes to the critical component of hydrology due to proposed works under the Living Murray Program. The project aims to increase the frequency of flooding to river red gums in the mid-section of the forest through a combination of environmental watering and works to facilitate water delivery. Works include the construction of a new regulator on Gunbower Creek (outside the Ramsar site boundary) and widening and deepening of the channel connecting Gunbower Creek to Spur Creek (within the site boundary). New regulators will also be constructed within the site boundary at Black Creek and on Gunbower Creek in the north east of the site. Erosion control works will be undertaken at the Spur Creek outfall and in the lower part of the forest where the water returns to Gunbower Creek (MDBA 2010b). Erosion works and installation of regulators will have minor negative effects on the forests in comparison with positive impacts of the proposed inundation and would not be expected to result in significant negative changes to ecological character. The increased capacity to achieve floodplain inundation is expected to result in positive changes in floodplain condition.

Table 23: Assessment of current conditions against LAC for the Gunbower Forest Ramsar site.

Component/ process	Limit of Acceptable Change	Current conditions
Hydrology	*No less than 4 events in any 10 year period of 13 700 megalitres a day for three months (Murray River at Torrumbarry); and a maximum interval of three years between the stated flow event.* *No less than five events in any 20 year period of 30 000 megalitres a day for two months (Murray River at Torrumbarry) and a maximum interval of five years between the stated flow event.* *No less than 10 events in any 50 year period of 40 000 megalitres a day for one month (Murray River at Torrumbarry) and a maximum interval of 10 years between the stated flow event.* **Note:** As previously discussed, the LACs would ideally be based on frequency and extent of inundation but this is difficult to apply and assess against. Thus, LACs are based on the average return interval at the time of listing for flow events considered important for maintaining ecological character (Murray River at Torrumbarry). However, should a LAC be exceeded, further investigation as to the actual frequency and extent of inundation at the site would need to be considered prior to determining if a change in character has occurred.	Based on flow data from the Murray River downstream of Torrumbarry (MDBA 2011): *13 700 megalitres a day for four months* – one event in last 10 years with a maximum 10 year interval (2000 to 2010). The extended period of drought from 2000 to 2010 impacted on the frequency and the maximum interval between flow events. However, environmental watering occurred on a number of occasions in this decade (for example, in 2005/6, 2007/8 and 2009) and resulted in the inundation of specific areas within the Ramsar site. **LAC for number of events and maximum period of dry exceeded; however, there is little evidence to suggest that there has been a change to the ecological character of the site since the time of listing.** *Above 30 000 megalitres a day for two months* – four events in last 20 years with a maximum interval of 14 years (1996 to 2010). **LAC for number of events and maximum period of dry exceeded; however, there is little evidence to suggest that there has been a change to the ecological character of the site since the time of listing.** *40 000* megalitres a day for one month – 18 events in past 50 years, with a maximum interval of 14 years (1996 to 2010). **LAC for number of events has not been exceeded. LAC for maximum period of dry has been exceeded; however, there is little evidence to suggest that there has been a change to the ecological character of the site since the time of listing.**
Wetland vegetation	*Extent of floodplain forest & woodland vegetation to be no less than:* • *7500 hectares of river red gum forest* • *4280 hectares of river red gum woodland* • *2400 hectares of black box woodland* *River red gum condition to be "moderate" (according to et al. 2009) or better for at least 80 percent of forest.*	EVC mapping of forest extent in 2005 does not use the same categories: 14 400 hectares of river red gum forest and woodland, 3303 black box woodland. Cunningham et al. (2009) indicated that 95 percent of trees were in moderate or better condition. **LAC has not been exceeded.**

Component/ process	Limit of Acceptable Change	Current conditions
	Extent of spike sedge wetland to be no less than 270 hectares. *Extent of tall marsh wetland to be no less than 125 hectares.*	The LAC has been based on EVC mapping from 2005 and this is the most recent mapping of extent of these communities available. **LAC is unable to be assessed.**
Wetland vegetation – threatened species	*Presence of swamp wallaby-grass in permanent and intermittent wetlands within the site.*	Swamp wallaby-grass was recorded in 2010 (Australian Ecosystems 2010). **LAC has not been exceeded.**
	Presence of winged peppercress *near Reedy Lagoon when waterlogging occurs.*	The species was recorded in 2005 in very large numbers, but a survey in 2007 failed to detect any individuals (DSE 2009). However, conditions were dry and remained dry through until 2010 and so the species is not expected to have occurred. It is not known if any individuals were present following the 2010 inundation of the site. **LAC is unable to be assessed.**
Native fish	*Presence of these species in no less than two in five annual surveys:* • Australian smelt *(Retropinna semoni);* • Carp gudgeons *(Hypseleotris spp.);* • Dwarf flat-headed gudgeon *(Philypnodon macrostomus);* • Fly-specked hardyhead *(Craterocephalus stercusmuscarum);* • Flat-headed gudgeon *(Philypnodon grandiceps); and* • Murray-Darling rainbowfish *(Melanotaenia fluviatilis).*	All target species recorded in 2010 (Rehwinkel et al. 2010). **LAC has not been exceeded.**
	Presence of Murray cod and silver perch in Gunbower Creek in three out of five of annual surveys.	These species were recorded in both 2009 and 2010. **LAC has not been exceeded.**
Wetland birds	*Successful breeding (80 percent of chicks fledged) of colonial nesting waterbirds during flood events.*	No measures of breeding success were available for recent flood events (2010/11). **LAC is unable to be assessed.**
	Presence of the Australasian bittern when tall marsh is inundated.	No recent records and no surveys for bittern in the site. **LAC is unable to be assessed.**

8. Knowledge Gaps

Throughout the ECD for the Gunbower Forest Ramsar site, mention has been made of knowledge gaps and data deficiencies for the site. While there is potentially a large list of research and monitoring needs for this wetland system, it is important to focus on the purpose of an ECD and identify and prioritise knowledge gaps that are important for describing and maintaining the ecological character of the system. Since its identification as an icon site under the Living Murray program, increased assessment and monitoring has been undertaken within the Gunbower Forest Ramsar site and the newly developed icon site monitoring program covers all identified critical CPS. There is a lack of knowledge about the condition of the site at the time of listing, but this cannot, for the most part be addressed retrospectively Table 25.

Table 24: Knowledge Gaps for the Gunbower Forest Ramsar site

Critical components, processes and services	Knowledge Gap	Recommended Action
Hydrology	Extent, frequency and duration of inundation for wetlands within the site benchmarked at the time of listing.	Regular flood inundation mapping.
Wetland vegetation – floodplain forest and woodland	The condition of forests at the time of listing. Forest structure at the time of listing: number of hollow bearing trees, tree age classes, coarse woody debris loads.	Current monitoring programs under the Living Murray collect data on forest condition and proposed monitoring includes age structure. Data collected to date has been from a short period of time (post 2003) and includes mostly drought years. An understanding of the variability of forest condition under different climatic conditions will improve over time with current monitoring.
Wetland vegetation – floodplain marshes	The extent, community composition and condition of floodplain marshes at the time of listing.	Current monitoring programs conducted by MDBA and NCCMA include assessment of floodplain marsh vegetation. Data collected to date has been from a short period of time (post 2005) and includes mostly drought years. An understanding of the variability in floodplain marsh community composition and extent under different climatic conditions will improve over time with current monitoring.
Native fish	Species composition, use of off-stream habitats, variability across site.	Current monitoring programs conducted by MDBA and NCCMA include fish surveys in creek and wetland habitats within the site. Data collected to date has been from a short period of time (post 2005) and includes mostly drought years. An understanding of fish population dynamics in the site will improve over time with current monitoring.
Wetland birds	Quantitative data for waterbirds and nesting wetland birds.	Current monitoring programs conducted by MDBA and NCCMA include waterbird surveys. Continued, regular monitoring will improve understanding.
	Importance of the site for the endangered Australasian bittern.	Include Gunbower Forest in the Birds Australia National Bittern Surveys (BA 2011).

9. Monitoring

As a signatory to the Ramsar Convention, Australia has made a commitment to protect the ecological character of its Wetlands of International Importance. Under Part 3 of the 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 protected a monitoring program is required.

A comprehensive monitoring program is beyond the scope of an ECD. What is provided is an identification of monitoring needs required to both set baselines for critical components and processes and to assess against limits of acceptable change. It should be noted that the focus of the monitoring recommended in an ECD is an assessment against LAC and determination of changes in ecological character. This monitoring is not designed as an early warning system whereby trends in data are assessed to detect changes in components and processes prior to a change in ecological character of the site. This should be included in the management plan for the site. The recommended monitoring to meet the obligations under the Ramsar Convention and the EPBC Act with respect to the Gunbower Forest Ramsar site are provided in Table 26.

Table 25: Monitoring needs for the Gunbower Forest Ramsar site

Parameter	Purpose	Indicator	Locations	Frequency	Priority
Hydrology (river flows)	Assessment against LAC	River flow	Murray River below Torrumbarry Weir	Continuous	High
Hydrology (floodplain water regime)	Assessment against LAC	Extent of inundation	Entire site.	Flood events	High
Water quality	Assessment of threat	Salinity Dissolved oxygen	Key wetlands	Flood events	Low
River red gum forests (extent)	Assessment against LAC	Extent	Entire site	Five yearly	Medium
River red gum forests (condition)	Assessment against LAC	Condition as per Cunningham et al. (2009) or similar	Entire site	Annual	High
Floodplain marshes (extent & composition)	Assessment against LAC	Extent and composition	Entire site	Annual	High
Wetland birds (colonial nesting)	Establishment of benchmarks & assessment against LAC	Species, counts, breeding activity	At identified breeding locations	Coincident with flood events	High
Wetland birds (general)	Establishment of benchmarks & assessment against LAC	Species, counts, breeding activity	At identified breeding locations	Coincident with flood events	Medium
Wetland birds (threatened species)	Establishment of benchmarks & assessment against LAC	Australasian bittern	Wetlands with emergent vegetation	Coincident with flood events	High
Fish (composition)	Assessment against LAC	Community composition	Representative sample locations	Annual	Medium
Fish (abundance and spawning)	Establishment of benchmarks & assessment against LAC	Abundance and spawning activity	Representative sample locations	Annual	High

10. Communication and Education 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.

There are a number of programs currently in place, which focus on communication, and education of wetland values in the Gunbower Forest Ramsar site. Key CEPA messages for the site arising from this ECD, which should be promoted through these programs, include:

- 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 need for environmental water allocations and the benefits they provide at Gunbower Forest.

- 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 and environmental watering to maintain ecological character. 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 species (Australasian bittern, Murray cod, silver perch, winged peppercress and swamp wallaby-grass) and communication of their conservation value. This may help to minimise the number of threatened fish species taken.

- 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 (for example. recreational fishing, public use pressures, destructive wild fires).

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Appendix A: Methods

A.1 Approach

The method for compiling this ECD comprised of the following tasks:

Project Inception:
Consultant team leader Jennifer Hale met with the DSEWPaC project manager to confirm the scope of works and timelines as well as identifying relevant stakeholders that would be consulted.

Task 1: Review and compilation of available data
The consultant team undertook a review of the existing ECD for the site (DSE 2010) and new information available since the first ECD was developed in 2005.

Task 2: Stakeholder engagement and consultation
A Steering Committee was formed for the Gunbower Forest Ramsar site ECD. This group was comprised:

- Leah Beesley; Department of Sustainability and Environment
- Tamara Boyd; Parks Victoria
- Lyndell Davis; Department of Sustainability, Environment, Population and Communities
- John Foster; Department of Sustainability, Environment, Population and Communities
- Bronwyn Goody; Department of Sustainability, Environment, Population and Communities
- Janet Holmes; Department of Sustainability and Environment
- Richard Loyn; Department of Sustainability and Environment
- Shar Ramamurthy; Department of Sustainability and Environment
- Melanie Tranter; North Central Catchment Management Authority;
- Keith Ward; Goulburn-Broken Catchment Management Authority;
- Kane Weeks; Parks Victoria

Task 3: Development of a draft ECD
Consistent with the National Framework (DEWHA 2008) the following steps were undertaken to describe the ecological character of the Gunbower Forest Ramsar site:

1. Document introductory details – site details, purpose and legislation.
2. Describe the site - description in terms of: location, land tenure, Ramsar criteria, wetland types (using Ramsar classification).
3. Identify and describe the critical components, processes and services
4. Develop a conceptual model of the system - two types of models were developed for the system:
    - A series of control models that describe important aspects of the ecology of the site, including feedback loops. Aiding in the understanding of the system and its ecological functions.
    - A stressor model that highlights the threats and their effects on ecological components and processes.
5. Set Limits of Acceptable Change (LAC) – for each identified critical component, process and service.
6. Identify threats to the site – a summary of major threats was developed.
7. Describe changes to ecological character since the time of listing.
8. Summarise knowledge gaps
9. Identify site monitoring needs
10. Identify communication, education and public awareness messages.

Task 5 Finalising the ECD
The draft ECD was submitted to DSEWPaC, and a representative from DSE for review. Comments from agencies and stakeholders were incorporated to produce a revised ECD.

A.2 Consultant Team

Jennifer Hale

Jennifer has over twenty years experience in the water industry having started her career with the State Water Laboratory 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 the Peel-Yalgorup, the Ord River Floodplain, Eighty-mile Beach, the Coorong and Lakes Alexandrina and Albert, Lake MacLeod, Elizabeth and Middleton Reefs, Ashmore Reef and the Coral Seas Ramsar sites.

Rhonda Butcher

Rhonda is considered an expert in wetland ecology and assessment. She has a BSc (hons) and a PhD in Wetland Ecology together with over twenty years of experience in the field of aquatic science. She has extensive experience in biological monitoring, biodiversity assessment, invertebrate ecology as well as wetland and river ecology having worked for CSIRO/Murray-Darling Freshwater Research Centre, Monash University/CRC for Freshwater Ecology, Museum of Victoria, Victorian EPA and the State Water Laboratories of Victoria. Rhonda has worked on numerous Ramsar related projects over the past eight years, including the first pilot studies into describing ecological character. She has subsequently co-authored, provided technical input, and peer reviewed a number of Ecological Character Descriptions. She project managed the preparation of Ramsar nomination documents for Piccaninnie Ponds Karst Wetlands in South Australia, which included preparation of the ECD, RIS and Ramsar Management Plan. Other Ramsar sites she has been involved with the development of ECD include Coongie Lakes, Banrock Station Wetland Complex, Coorong and Lakes Alexandrina and Albert, Lake MacLeod, Peel-Yalgorup, Eighty-mile Beach, Narran Lakes, The Dales and Hosnies Spring on Christmas Island. Rhonda is currently project managing the Ramsar Rolling Review developing a framework for reporting the status of ecological character at all 64 Ramsar sites in Australia.

Halina Kobryn

Dr Halina Kobryn has over fifteen years of experience in applications of GIS and remote sensing in environmental applications. She is a GIS and remote sensing expert, specialising in natural resource assessment. Dr Kobryn has a BSc in Physical Geography and Cartography, Graduate Diploma in Surveying and Mapping and a PhD which explored impacts of stormwater on an urban wetland and explored GIS methods for such applications. She has worked at a university as a lecturer for over 15 years and taught many subjects including GIS, remote sensing, environmental monitoring and management of aquatic systems. She has developed the first course in Australia (at a graduate level) on Environmental Monitoring. She has been involved in many research and consulting projects and her cv outlines the breadth of her expertise. She has also supervised over 20 research students (honours, Masters and PhD). She has worked in Indonesia, Malaysia (Sarawak) and East Timor on projects related to water quality and river health.

Jane Roberts

Jane Roberts is a well-respected plant ecologist, providing high-level technical expertise and broad on-ground experience in vegetation as it relates to water management, ecosystem functioning and assessment. Initially trained in wetland plant ecology, her interests and skills have expanded to include rivers and floodplains, forests and woodlands, landscape change and environmental history; she pioneered the use of oral history in river ecology in Australia. A decade as a research scientist with CSIRO in agricultural regions of western NSW engendered a fascination for lowland rivers and floodplains, a deep commitment to effective NRM and to the incorporation of sound science into management and policy. Since 2000, she has been based in Canberra where she works independently as an ecological consultant, typically as a specialist member of a team for large firms or consulting groups, where she is a

valued contributor. Her clients range from government agencies, catchment authorities, research institutions to conservation organizations, and she specialises in lowland and regional areas in inland and south-eastern Australia. As well as undertaking her own projects, she sits on technical and advisory panels for projects undertaking research, complex monitoring programs and the development of state government policy or procedures.

Peter Cottingham

Peter Cottingham is a versatile and experienced facilitator and project manager, having worked in a diversity of technical and scientific environments over the past 25 years. He is currently the Principal of Peter Cottingham & Associates, undertaking a diverse range of projects for clients related to the management and rehabilitation of river and wetland systems across southeastern Australia. Prior to this, Peter was a senior Knowledge Broker with the Cooperative Research Centre for Freshwater Ecology and Leader of the River and Catchment Restoration program for the eWater CRC. Peter has led and facilitated numerous scientific panel deliberations, projects and workshops focusing on the management of river, lake and wetland across southeastern Australia. Example include key facilitation roles include projects on nutrient management in the Gippsland Lakes, the review of the MDBC Native Fish Strategy, the development of a fish information system for the MDB, wetland management priority for southeastern South Australia, and numerous scientific panels focused on environmental flow and drought management. Peter also led the development of a consistent monitoring and assessment framework from which to measure the performance of environmental flow releases. He has a proven track record in strategy and management plan development and communication at all levels of NRM organisations and across a broad range of stakeholder groups, as well as in project management and establishing and managing high-performing teams. Peter has exceptional skills as a knowledge broker and facilitator. He is very experienced in the preparation of technical and scientific reports, and in delivering presentations at conferences, seminars and workshops.

Appendix B: Waterbirds

Listing: Ma = Marine under the EPBC Act; Mi = Migratory under the EPBC Act; E = Endangered nationally or internationally; J = JAMBA; C= CAMBA; R = ROKAMBA, B = the Bonn Convention.

Common name	Species name	Breeding	Listing
Australasian bittern	*Botaurus poiciloptilus*	Yes	E (EPBC, IUCN)
Australasian grebe	*Tachybaptus novaehollandiae*	Yes	
Australasian shoveler	*Anas rhynchotis*	Yes	
Australian darter	*Anhinga novaehollandiae*	Yes	
Australian little bittern	*Ixobrychus dubius*	Yes	
Australian painted snipe	*Rostratula australis*		E (EPBC, IUCN), C
Australian pelican	*Pelecanus conspicillatus*	Yes	Ma
Australian pratincole	*Stiltia isabella*		Ma
Australian shelduck	*Tadorna tadornoides*	Yes	
Australian spotted crake	*Porzana fluminea*	Yes	
Australian white ibis	*Threskiornis molucca*	Yes	Ma
Australian wood duck	*Chenonetta jubata*	Yes	
Azure kingfisher	*Alcedo azurea*	Yes	
Baillon's crake	*Porzana pusilla palustris*	Yes	Ma
Banded lapwing	*Vanellus tricolor*	Yes	
Black swan	*Cygnus atratus*	Yes	
Black-fronted dotterel	*Elseyornis melanops*	Yes	
Black-tailed native-hen	*Tribonyx ventralis*		
Black-winged Stilt	*Himantopus himantopus*	Yes	Ma
Blue-billed duck	*Oxyura australis*		
Brolga	*Grus rubicunda*		
Buff-banded rail	*Gallirallus philippensis*	Yes	Ma
Bush stone curlew	*Burhinus grallarius*	Yes	
Cattle egret	*Ardea ibis*	Yes	Ma, Mi, C, J
Chestnut teal	*Anas castanea*	Yes	
Clamorous reed-warbler	*Acrocephalus stentoreus*	Yes	Ma, Mi, B
Common greenshank	*Tringa nebularia*		Ma, Mi, B, C, J, R
Dusky moorhen	*Gallinula tenebrosa*	Yes	

Common name	Species name	Breeding	Listing
Eastern great egret	*Ardea modesta*	Yes	Mi, C, J
Eurasian coot	*Fulica atra*	Yes	
Freckled duck	*Stictonetta naevosa*		
Glossy ibis	*Plegadis falcinellus*		Ma, Mi, B, C
Great cormorant	*Phalacrocorax carbo*	Yes	
Great crested grebe	*Podiceps cristatus*	Yes	
Grey plover	*Pluvialis squatarola*		Ma, Mi, B, C, J, R
Grey teal	*Anas gracilis*	Yes	
Gull-billed tern	*Gelochelidon nilotica macrotarsa*		Ma
Hardhead	*Aythya australis*	Yes	
Hoary-headed grebe	*Poliocephalus poliocephalus*	Yes	
Intermediate egret	*Ardea intermedia*	Yes	Ma
Latham's snipe	*Gallinago hardwickii*		Ma, Mi, B, C, J, R
Little black cormorant	*Phalacrocorax sulcirostris*	Yes	
Little egret	*Egretta garzetta*	Yes	Ma
Little grassbird	*Megalurus gramineus*		
Little pied cormorant	*Microcarbo melanoleucos*	Yes	
Masked lapwing	*Vanellus miles*	Yes	
Musk duck	*Biziura lobata*	Yes	Ma
Nankeen night-heron	*Nycticorax caledonicus*	Yes	Ma
Pacific black duck	*Anas superciliosa*	Yes	
Pied cormorant	*Phalacrocorax varius*		
Pink-eared duck	*Malacorhynchus membranaceus*	Yes	
Plumed whistling-duck	*Dendrocygna eytoni*		
Purple swamphen	*Porphyrio porphyrio*	Yes	Ma
Red-kneed dotterel	*Erythrogonys cinctus*		
Red-necked avocet	*Recurvirostra novaehollandiae*		Ma
Royal spoonbill	*Platalea regia*	Yes	
Sacred kingfisher	*Todiramphus sanctus*	Yes	Ma
Silver gull	*Chroicocephalus novaehollandiae*		Ma
Spotless crake	*Porzana tabuensis*	Yes	Ma
Straw-necked ibis	*Threskiornis spinicollis*	Yes	Ma

Common name	Species name	Breeding	Listing
Swamp harrier	*Circus approximans*	Yes	Ma
Whiskered tern	*Chlidonias hybrida*		Ma
White-bellied sea eagle	*Haliaeetus leucogaster*	Yes	Ma, Mi, C
White-faced heron	*Egretta novaehollandiae*	Yes	
White-necked heron	*Ardea pacifica*	Yes	
Yellow-billed spoonbill	*Platalea flavipes*	Yes	

Appendix C: Aquatic mammals, reptiles and frogs

Aquatic mammals, reptiles and frogs species that have been recorded within the site since 1960. Data from DSE (unpublished); Australian Ecosystems (2009) and Davies (2004).

Habitat: M = floodplain marshes; F = river red gum forest

Scientific Name	Common Name	Habitat
MAMMALS		
Hydromys chrysogaster	Water rat	M
Ornithorhynchus anatinus	Platypus	M
AMPHIBIANS		
Crinia parinsignifera	Plains froglet	M
Crinia signifera	Common froglet	M
Crinea sloanei	Sloanes froglet	M
Limnodynastes dumerilii	Southern bullfrog	F
Limnodynastes fletcheri	Barking marsh frog	M
Limnodynastes interioris	Giant bullfrog	M
Limnodynastes tasmaniensis	Spotted marsh frog	M
Litoria raniformis	Growling grass frog	M
Litoria peronii	Peron's tree frog	F
Neobatrachus sudelli	Common spadefoot	M
Pseudophryne bibronii	Brown Toadlet	M
REPTILES		
Macrochelodina expansa	Broad-shelled river turtle	M
Chelodina longicollis	Eastern long-necked tortoise	M
Emydura macquarii	Murray turtle	M
Eulamprus heatwolei	Yellow-bellied water skink	M

Appendix D: Native fish

Fish species that have been recorded within the site since 1960. Data from Richardson et al. 2005. Rehwinkel and Sharpe 2009, Rehwinkel et al. 2010.

Conservation status: CE = critically endangered; E = endangered; V = vulnerable.

Common Name	Scientific Name	Conservation status		
		Vic.	IUCN	EPBC
Australian smelt	*Retropinna semoni*			
Bony bream	*Nematalosa erebi*			
Carp gudgeon	*Hypseleotris sp.*			
Dwarf flat-headed gudgeon	*Philypnodon macrostomus*			
Flathead gudgeon	*Philypnodon grandiceps*			
Flyspecked hardyhead	*Craterocephalus stercusmuscarum*			
Freshwater catfish	*Tandanus tandanus*	V		
Golden perch	*Macquaria ambigua*			
Murray cod	*Maccullochella peelii*		CE	V
Murray-darling rainbowfish	*Melanotaenia fluviatilis*			
Silver perch	*Bidyanus bidyanus*	E	V	
Trout cod	*Maccullochella macquariensis*	E	E	E