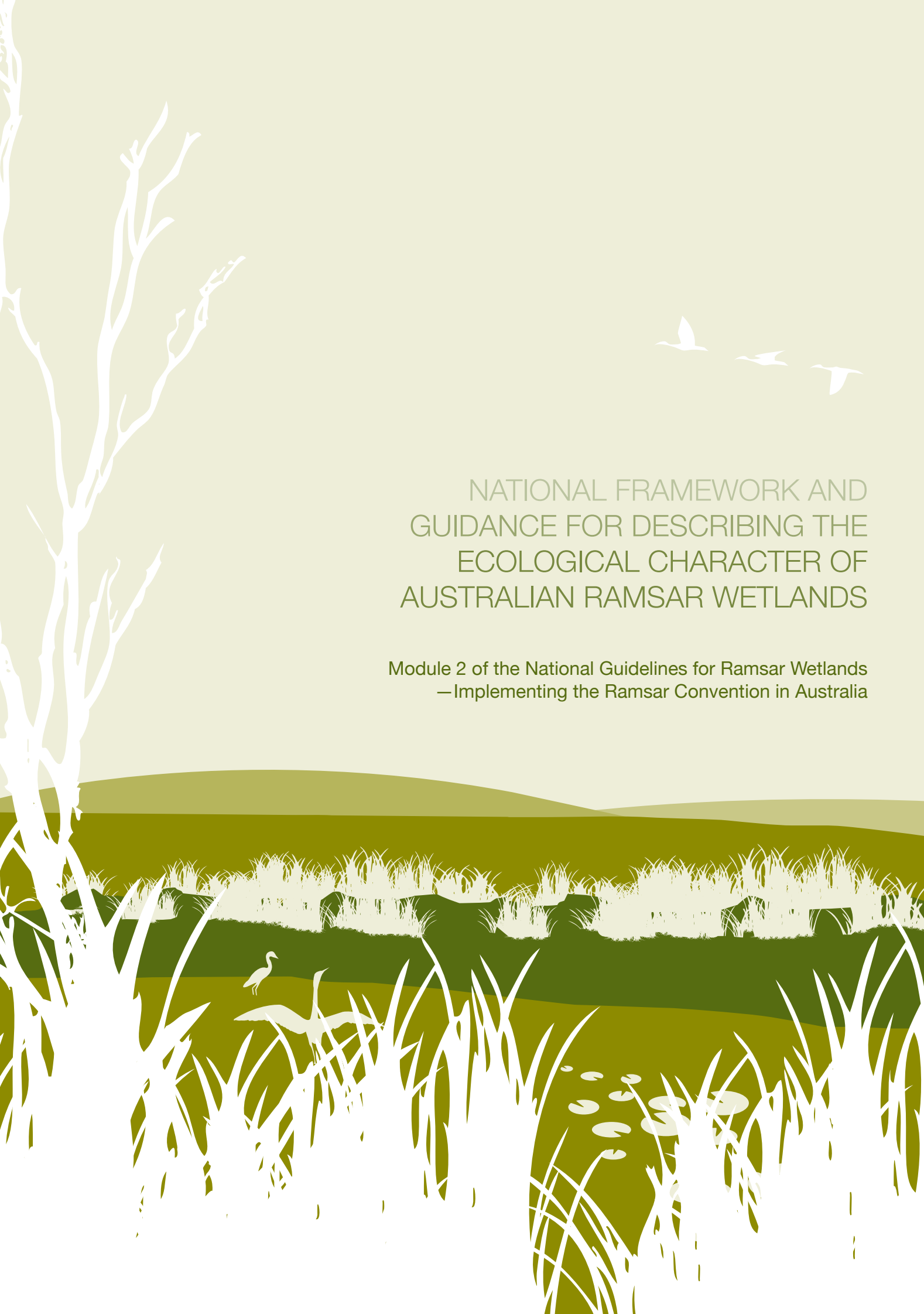
NATIONAL FRAMEWORK AND GUIDANCE FOR DESCRIBING THE ECOLOGICAL CHARACTER OF AUSTRALIAN RAMSAR WETLANDS

Module 2 of the National Guidelines for Ramsar Wetlands
—Implementing the Ramsar Convention in Australia



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The framework was developed by the Wetlands Section of the Department of the Environment, Water, Heritage and the Arts with assistance from the Wetlands and Waterbirds Taskforce.

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Acronyms and abbreviations

AUSRIVAS	Australian River Assessment System
CAMBA	China–Australia Migratory Bird Agreement
CBD	Convention on Biological Diversity
CEPA	communication, education and public awareness
CMP	Conservation Measures Partnership
DSE	Victorian Department of Sustainability and Environment
DEWHA	Australian Government Department of the Environment, Water, Heritage and the Arts
DIWA	*A Directory of Important Wetlands in Australia* (Environment Australia 2001)
ECD	ecological character description
EIA	environmental impact assessment
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
IUCN	International Union for the Conservation of Nature
JAMBA	Japan–Australia Migratory Bird Agreement
NRM	natural resource management
NRMMC	Natural Resource Management Ministerial Council
Ramsar	Convention on Wetlands of [International Importance, Especially as Waterfowl Habitat], 1971, Ramsar (Iran)
RIS	Ramsar Information Sheet
ROKAMBA	Republic of Korea–Australia Migratory Bird Agreement

Executive summary

Understanding and documenting ecological character is central to maintaining and protecting the values of internationally and nationally important wetlands. As part of the Ramsar Convention, contracting parties are expected to manage their Ramsar sites so as to maintain the ecological character of each site, remain informed of any changes to the ecological character of Ramsar sites and notify the Ramsar Secretariat of any changes at the earliest opportunity (Ramsar Convention 1987, Article 3.2 and further clarified by the Parties in Resolution VIII.8, 2002; Ramsar Convention 2005, Resolution IX.1 Annex B).

Ecological character is the combination of the ecosystem components, processes, benefits and services that characterise the wetland at a given point in time (Ramsar Convention 2005a, Resolution IX.1 Annex A). Changes to the ecological character of the wetland outside natural variations may signal that uses of the site or externally derived impacts on the site are unsustainable and may lead to the degradation of natural processes, and thus the ultimate breakdown of the ecological, biological and hydrological functioning of the wetland (Ramsar Convention 1996, Resolution VI.1).

The Australian Government is working with the state and territory governments to establish a more systematic and strategic approach to the management of Australia's Ramsar wetlands. This will ensure that Australia's responsibilities under the Ramsar Convention are discharged effectively and efficiently, with particular emphasis on the maintenance and improvement of the ecological character of Ramsar sites in Australia.

The ecological character description of a wetland provides the baseline description of the wetland at a given point in time and can be used to assess changes in the ecological character of these sites. Ecological character descriptions should be prepared for all existing Ramsar sites and for all proposed Ramsar nominations before the required documentation is forwarded to the Ramsar Secretariat.

The purpose of this document is to help wetland managers, consultants and researchers to describe the ecological character of their wetland. The framework is designed to establish a standard method for describing ecological character for wetlands in Australia. It was developed using the outcomes from a national workshop held in Canberra in May 2006, the *Framework for Describing Ecological Character of Ramsar Wetlands* (DSE 2005a) and substantial input from the Natural Resource Management Ministerial Council's (NRMMC) Wetlands and Waterbirds Taskforce, which includes representatives from Australian, state and territory government agencies.

The framework provides background information on ecological character, guidance on interpreting terms, the essential elements of an ecological character description, and a step-by-step guide to developing a description of ecological character for wetlands. The step-by-step guide is the preferred process for preparing an ecological character description; however, the exact order in which the information is presented can be altered slightly to suit the requirements of the site. If the process is varied, or an alternative method is used to prepare the description, the method used should be described in an appendix to the ecological character description.

Certain essential elements should be included in any ecological character description, whatever the method used to prepare it. These elements include an executive summary; acknowledgments; table of contents; site details; statement of purpose; relevant legislation or regulations; conceptual model; description of the components, processes, benefits and services of the site; limits of acceptable change; potential threats to the site; knowledge gaps; changes to ecological character; key monitoring needs; glossary; methods used for the description; and lists of community assemblages for the site. It is advisable that the Australian Government Department of the Environment, Water, Heritage and the Arts (DEWHA) be consulted during the development of the ecological character description.

Once completed to the satisfaction of the site manager and the relevant jurisdiction, the ecological character description should be forwarded to the department who will check the description to ensure it meets the minimum requirements of the framework. The ecological character description will be appended to the Ramsar Information Sheet and forwarded to the Ramsar Secretariat.

Dead tree trunk in saline billabong

1. Introduction

This document outlines a nationally agreed framework for describing the ecological character of Australia's Ramsar-listed wetlands. Such wetlands are considered internationally significant in terms of ecology, botany, zoology, limnology or hydrology. Understanding and documenting ecological character is central to maintaining and protecting the values of internationally and nationally important wetlands.

Wetland managers, consultants and researchers can use the framework in describing the ecological character of their wetland. The framework provides a step-by-step guide and outlines the essential elements (listed in Appendix 1) that should be included in an ecological character description.

Descriptions developed under this framework will be used to:

- provide the baseline description of ecological character of Ramsar wetlands
- assess the likely impacts of proposed actions on the ecological character of Ramsar wetlands
- guide development of management plans
- evaluate the results of monitoring.

Application of the framework at Ramsar sites may result in further refinement with the aim of reviewing the framework in five years.

1.1 The Ramsar Convention

The *Convention on Wetlands of International Importance Especially as Waterfowl Habitat* (Ramsar (Iran), 2 February 1971; www.ramsar.org) is commonly known as the Ramsar Convention. The broad aims of the convention are to halt and, where possible, reverse the worldwide loss of wetlands and to conserve those that remain through wise use and management. Australia is a contracting party to the Ramsar Convention.

The implementation of the Ramsar Convention is guided by its mission statement (Ramsar Convention 2002b, Resolution VIII.25), which is:

> The conservation and wise use of all wetlands through local, regional and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world.

This means ensuring that activities that might affect wetlands will not lead to the loss of biodiversity or diminish the many ecological, hydrological, cultural or social values of wetlands.

Contracting parties to the convention are required to designate a site or sites for the List of Wetlands of International Importance 'on account of their international significance in terms of ecology, botany, zoology, limnology or hydrology' (Ramsar Convention 1987, Article 2.2) and to 'formulate and implement their planning so as to promote the conservation of the wetlands included in the list, and as far as possible the wise use of wetlands in their territory' (Ramsar Convention 1987, Article 3.1).

The definition of wise use of wetlands was updated in 2005 to 'the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development' (Ramsar Convention 2005a, Resolution IX.1 Annex A).

Contracting parties are expected to manage their Ramsar sites so as to maintain the ecological character of each site (Ramsar Convention 2005b, Resolution IX.1 Annex B).

The Ramsar Convention defines ecological character as the combination of the ecosystem components, processes, benefits and services that characterise the wetland at a given point in time[1] (Ramsar Convention 2005a, Resolution IX.1 Annex A). This definition recognises that wetlands are complex systems and emphasises the links between the ecological components, their processes or interactions, and the benefits or services they support.

Each contracting party is expected to remain informed of any changes to the ecological character of Ramsar sites in its territory and on the list, and to notify the Ramsar Secretariat at the earliest opportunity if the ecological character of a site has changed or is likely to change (Ramsar Convention 1987, Article 3.2; further clarified in Resolution VIII.8, 2002).[2]

Change in ecological character is defined as the human-induced adverse alteration of any ecosystem component, process and/or ecosystem benefit or service (Ramsar Convention 2005a, Resolution IX.1 Annex A).

Changes to the ecological character of the wetland outside natural variations may signal that uses of the site or externally derived impacts on the site are unsustainable and may lead to the degradation of natural processes and thus the ultimate breakdown of the ecological, biological and hydrological functioning of the wetland (Ramsar Convention 1996, Resolution VI.1).

[1] The phrase 'at a given point in time' refers to Resolution VI.1 paragraph 2.1, which states that 'It is essential that the ecological character of a site be described by the Contracting Party concerned at the time of designation for the Ramsar List, by completion of the Information Sheet on Ramsar Wetlands' (as adopted by Recommendation IV. 7).

[2] Contracting parties are requested to verify the data that they have provided on information sheets on Ramsar Wetlands every six years (ie every second meeting of the conference) and to provide the Secretariat with updated sheets if necessary. During the intervening period, urgent information on changes at listed sites should be conveyed to the Secretariat using the existing mechanisms of regular, day-to-day contacts and the triennial national reports.

1.2 Background to development of the framework

The Ramsar Information Sheet (RIS), prepared at the time a site is designated, represents a description of the site (Ramsar Convention 1996). The RIS format has been modified on a number of occasions to increase the value of the information provided. However, the Scientific and Technical Review Panel reported to the 7th Conference of the Contracting Parties that the RIS did not provide sufficiently detailed and rigorous information for the purposes of describing 'ecological character'. They urged parties to supplement their RIS's with appropriate high-resolution benchmark data. However, no specific guidance was given at that time. Describing ecological character for Ramsar sites has proven challenging, particularly in relation to quantifying variables and identifying limits of acceptable change.

In Australia, Storey et al. (1997) provided advice to the Western Australian and Australian governments on the development and implementation of monitoring programs aimed at assessing whether or not the ecological character of a Ramsar site has changed, is changing or is likely to undergo change. The authors did not include an approach to defining ecological character but advised that the concept of ecological character be considered when designing site-specific assessment and monitoring programs.

Phillips et al. (2002) developed a comprehensive proforma for describing the 'biological, physical and chemical components' of a wetland system. The authors proposed a description of the components but no documentation of the links between the ecological components and processes and the ecosystem services.

The Victorian Department of Sustainability and Environment (DSE) developed a method for describing the ecological character of Ramsar wetlands, using funds from the Australian Government's Natural Heritage Trust (DSE 2005a). The DSE framework was used to develop ecological character descriptions at a number of Ramsar sites around the country including Barmah Forest (DSE 2005a), Hattah-Kulkyne Lakes (Cooling 2005), Wilgara Wetland (a private component of Macquarie Marshes, Taylor-Wood and Jaensch 2005), Ashmore Reef National Nature Reserve (Phillips and Hale 2005), and Elizabeth and Middleton Reefs Marine National Nature Reserve (Phillips et al. 2006).

In 2006, the Australian Government Department of the Environment, Water, Heritage and the Arts (DEWHA) commissioned independent reviews of the practical application of the DSE ecological character framework. The reviews (Davis and Sim 2006; Sorrell 2006; McGrath 2006) found that the framework was strictly implemented at some sites but was modified at others, and that an alternative approach was used to develop the ecological character description at some sites (e.g. Phillips et al. 2005). The reviewers suggested various improvements to the DSE framework.

Following the reviews, a national workshop was held in Canberra in May 2006 to progress the development of a nationally agreed framework for describing the ecological character of Australia's Ramsar-listed wetlands.

After the workshop, it was agreed that the DSE framework should be revised and a nationally agreed framework prepared for describing the ecological character of Ramsar wetlands. This framework has been developed by DEWHA using the outcomes of the workshop, the DSE Framework (2005a) and substantial input from the NRMMC Wetlands and Waterbirds Taskforce, which includes representatives from Australian, state and territory government agencies.

1.3 Australian policy relating to Ramsar sites

The Australian Government, through DEWHA, has direct responsibility for managing significant areas of Australian wetlands. DEWHA administers environmental programmes that affect wetland conservation around the country. The department also promotes the conservation, repair and wise use of all wetlands across Australia, in collaboration with all levels of government, industry, regional natural resource management organisations and community members.

The *Wetlands Policy of the Commonwealth Government of Australia*, developed in 1997, aims to ensure that the Australian Government's actions will be consistent with those expected under the Ramsar Convention and, in particular, to promote the adoption of the Ramsar Convention's 'wise use' principles for managing wetlands (Environment Australia 1997). The goal of the policy is to conserve, repair and manage wetlands wisely.

Australia addresses its Ramsar site obligations through:

- the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- the Environment Protection and Biodiversity Conservation Regulations 2000
- Australian, state and territory government wetland policies
- state, territory and local government legislation that contributes to wetland conservation (e.g. planning legislation and protected area legislation)
- Australian, state and territory government natural resource management (NRM) programs.

Regional NRM bodies across Australia prepare and coordinate the implementation of catchment-based strategies that are expected to recognise, amongst other things, the importance of Ramsar sites and to identify strategies that contribute to the maintenance of their ecological character.

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 1999 s 16(1)). An action that will have or is likely to have a significant impact on a Ramsar wetland is subject to environmental assessment and approval under the EPBC Act. An 'action' in this case includes a project, a development, an undertaking or an activity or series of activities.[3]

The EPBC Act establishes a framework for managing Ramsar wetlands, through the Australian Ramsar Management Principles (EPBC Act 1999 s 335), which are set out in Schedule 6 of the Environment Protection and Biodiversity Conservation Regulations 2000. These principles are intended to promote national standards of management, planning, environmental impact assessment (EIA), 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. The regulations also cover matters relevant to the preparation of management plans, environmental assessment of actions that may affect the site and the community consultation process.[4]

[3] http://www.environment.gov.au/epbc/index.html

[4] http://www.environment.gov.au/epbc/matters/ramsar.html

1.3.1 Management of Ramsar sites

In accordance with the Ramsar Convention, appropriate management of Ramsar wetlands includes describing and maintaining the ecological character of the wetland and implementing planning processes that promote conservation and wise use. An outline of Ramsar management requirements as they apply to individual sites is in Appendix 2.

Describing the ecological character of a Ramsar site is a fundamental management tool for site managers and other parties, and should form the baseline or benchmark for management planning and action, including site monitoring to detect negative impacts. Figure 1 shows, for Australia, some of the links between ecological character description and other planning and management processes and documents.

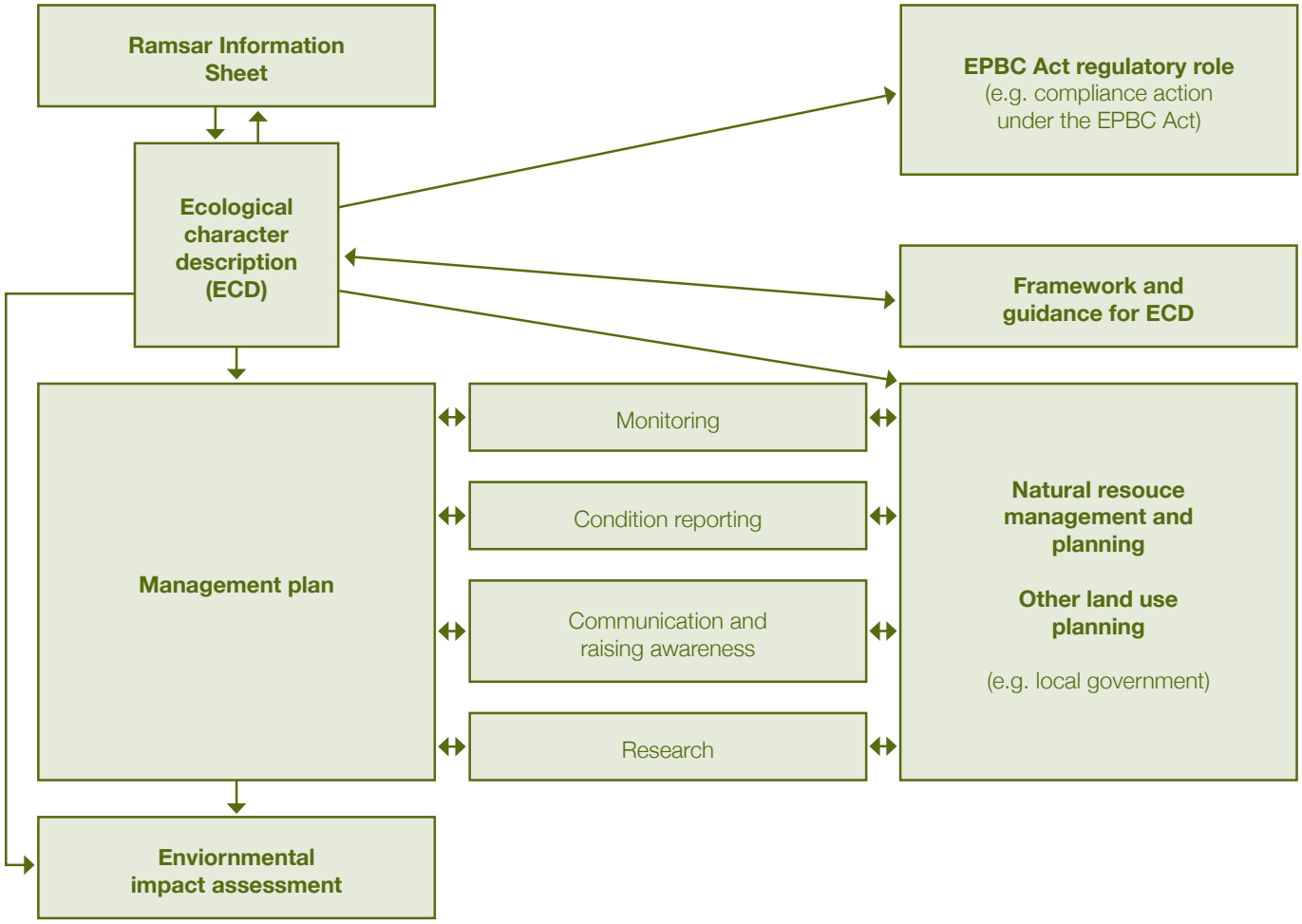


Figure 1. Relationship between the ecological character description and other documents

Source: Lambert and Elix (2006)

The ecological character description of a wetland provides the baseline description of the wetland at a given point in time, which can be used to assess change in the ecological character of these sites. It forms the reference for the following activities:

- development and implementation of a management plan designed to maintain the ecological character of the site
- design of a monitoring program to detect change in ecological character
- regular evaluation of the results of the monitoring program to assist onsite management
- assessment of the likely impact on ecological character of proposed actions, as required under the EPBC Act, including EIA
- reporting to the Australian Government and the Ramsar Convention about any changes in the ecological character of Ramsar sites.

A major component of the documentation provided when proposing a site for Ramsar listing is the RIS, which contains detail of the ecological character description. A RIS must be prepared for each Ramsar site at the time of listing and be updated every six years, if necessary (Ramsar Convention 1996, Resolution VI.1 paragraph 2.3). The ecological character description provides detailed supplementary information to an updated RIS and should be done at the same time.

Once completed, an ecological character description should be forwarded, with all relevant documents (e.g. RIS and maps), to the relevant state or territory governments for review. It will be checked by DEWHA, which will submit it to the Ramsar Secretariat for inclusion in the Ramsar Sites Database[5] (see Section 4 for more detail). It is also envisaged that the ecological character descriptions will be available on the department's website.[6]

As part of an improved framework for implementing the Ramsar Convention in Australia, the Australian Government (the Australian administrative authority for the Ramsar Convention) will require that, for new sites, ecological character descriptions are prepared for all proposed Ramsar wetlands and submitted with the RIS to the Australian Government Environment Minister for approval before nomination documentation can be forwarded to the Ramsar Secretariat. Previously, Australian sites could be added to the Ramsar list without an accompanying ecological description.

[5] http://www.ramsar.org/index_list.htm

[6] It is intended that ecological character descriptions will be made publicly available via the internet. This means that any information in the ecological character description, including contact details, published on the internet will be accessible to millions of users from all over the world; that their information can be searched for using an identifier such as the individual's name; and that their information can be copied and used by any web user. Once personal information has been published on the web, the department has no control over its subsequent use and disclosure.

1.4 Wetlands of national importance

Although the focus of the framework is developing ecological character descriptions for Ramsar wetlands, it can also be used to describe the ecological character of any wetland in Australia. Many of Australia's wetlands are unique and very distinct, but not all of the country's important wetlands are Ramsar listed.

A number of wetlands identified as nationally important have been listed in *A Directory of Important Wetlands in Australia* (DIWA) (Environment Australia 2001). To date, 904 wetlands have been included in the directory. These are often referred to as 'DIWA wetlands'. To be considered nationally important, a wetland must meet at least one of the six nationally agreed criteria covering the following areas:

- biogeographic representativeness
- important ecological or hydrological functions
- provision of habitat during times of vulnerability or adverse conditions
- support for more than 1% of the national populations of any species
- support for threatened taxa or communities
- historical or cultural significance.

Appendix 6 contains a list of the criteria for DIWA wetlands.

The preparation of descriptions, as outlined in this framework, may improve the understanding and management of these sites. Additional guidance has been provided in some sections to help managers apply the framework to these wetlands.

1.5 Ecological character

The Glossary provides definitions for ecological character and associated terms including ecosystems, ecosystem components, ecosystem processes, benefits and services. These definitions have changed over time, and the ninth meeting of the Conference of Contracting Parties in 2005 attempted to reduce the number of definitions and terms related to wetland ecosystems. A comparison of some of the terminology is outlined in Table 1.

Table 1. Comparative terminology for describing wetland ecosystems

Millennium Ecosystem Assessment terms to apply in Ramsar guidelines and other convention usages	Terms used in various previous Ramsar guidelines and other documents
Ecosystem components: physical; chemical; biological (habitats, species, genes)	'components', 'features', 'attributes', 'properties'
Ecological processes within and between ecosystems	'processes', 'interactions', 'properties'; 'functions'
Ecosystem services: provisioning; regulating; cultural; supporting	'services', 'benefits', 'values', 'functions', 'goods', 'products'

Source: Ramsar Convention 2005a

The core of an ecological character description is the description of the components, processes, benefits and services of the wetland and how they are linked at the time of listing. The components and processes of the wetland influence and determine the habitats, ecological communities and species that are found at a site and the criteria for which it was listed. These in turn influence the benefits and services provided by the site.

Climate and geomorphology determine the location of wetlands in the landscape, and they shape and influence a range of wetland characteristics (National Research Council 1995, Mitsch and Gosselink 2000, Figure 2). Through precipitation, evaporation and transpiration, climate influences surface and groundwater flows, and the hydrology and hydrological variability of wetlands. Geology influences the geomorphology of the site, which in turn influences the water source of a wetland; the size, shape and location of a wetland; physicochemical properties; and soils.

It is useful to consider how components and processes such as climate and geomorphology influence the ecological character of the wetland. It is also useful to consider land use within the catchment, as this may also influence the ecological character of the wetland.

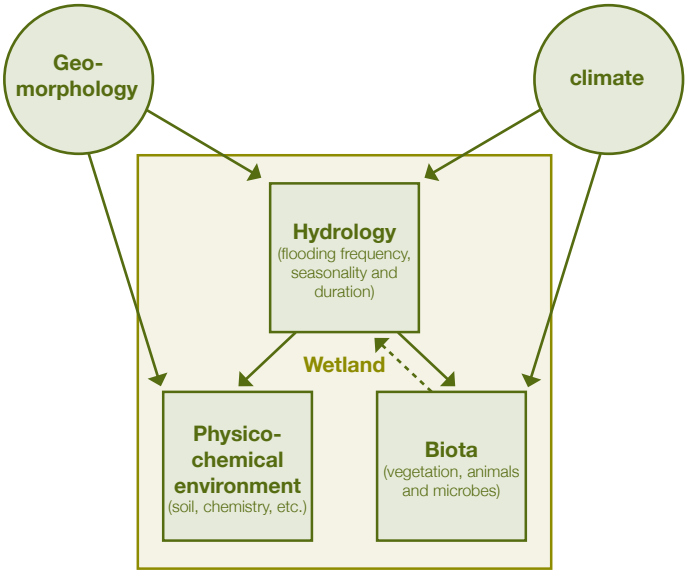


Figure 2. Conceptual diagram showing the relationships between the key characteristics of wetlands and the key drivers

Source: National Research Council 1995, DSE 2005a. Reprinted and adapted with permission from National Academies Press, Copyright (1995), National Academy of Sciences and the Victorian Department of Sustainability and Environment 2005.

Examples of ecosystem components, processes, benefits and services are provided later in the document in Tables 3, 4 and 5.

Yellow Water Lagoon

2. The national framework

2.1 Approach taken in this framework

Ideally, to assess change in ecological character at a Ramsar site, a description is required that establishes quantitative benchmarks. Managers also need to know how extensively ecosystem components, processes, benefits and services can vary without the ecological character changing. This information can then be used to identify indicators for monitoring and to set targets for management. However, resources are often insufficient to undertake the level of research and data collection required to describe ecological character comprehensively. Therefore, it may sometimes be necessary to take a strategic approach and limit the components and processes described.

Ramsar Convention guidance indicates that assessment of ecological character

> should be linked to the Ramsar criterion or criteria fulfilled by the site at the time of designation for the Ramsar List. Use of the criteria indicates certain benefits and values of the wetland which might be lost as a result of change in the ecological character. (Ramsar Convention 1996).

The guidance also indicates that, in the assessment of ecological character, it is important to consider additional ecosystem benefits and services as well 'since significant degradation of wetland functions and values might occur without any of the designated Ramsar criteria being contravened' (Ramsar Convention 1996). The description should flag those components, processes, benefits and services of particular importance to the Ramsar criteria, but should not be limited to them.

This framework emphasises the importance of describing and quantifying the ecosystem components, processes, benefits and services of the wetland and the relationship between these elements. Information on the benchmarks or ecologically significant limits of acceptable change is also needed to indicate when the ecological character has changed or is likely to change.

2.2 Applying the framework

The recommended approach for applying the framework is to document what is known about ecological character — focusing on the ecosystem components, processes, benefits and services for the site; the level of certainty of current knowledge; and key information gaps. This description of ecological character will serve as a blueprint to begin monitoring and to decide whether further research is required.

2.2.1 Users and skill requirements

This framework is designed for use by Ramsar or other wetland site managers, consultants, and researchers or students working with them to prepare ecological character descriptions. It is suitable for use at any Ramsar, DIWA or other wetland site. The framework describes the approach for developing ecological character descriptions for Ramsar sites unless otherwise specified.

Use of this framework requires a general understanding of wetland ecology, review of publications and documented information on the Ramsar site, and consultation with knowledgeable stakeholders and experts familiar with the site. For more complex wetland systems, it may be useful to have an expert panel develop the description; however, this is not always possible.

2.2.2 Knowledge and data gaps

Substantial knowledge gaps may exist in the information available for many wetlands around Australia. These knowledge gaps are an ongoing problem for describing ecological character and should be identified and summarised in the ecological character description. Additional information on knowledge gaps is provided in Section 4.5.

2.2.3 Selecting the appropriate baseline for descriptions

Guidance from the Ramsar Convention indicates that ecological character description should be made for the state of the wetland at the time of its listing as a Ramsar site, and that change in ecological character should be assessed against the baseline status at the time of listing (Ramsar Convention 1996).

> In some instances a contracting party may decide to restore a wetland to re-establish the ecological character that existed prior to the date of designation. In the case of such restoration programmes, a new Ramsar Information Sheet should be provided, to establish a new baseline for assessing any future change. Information should also be given concerning the target state that any restoration is aiming at. (Ramsar Convention 1996; Annex to Resolution VI.1).

For new Ramsar sites, the description can be prepared at the time of listing with current knowledge and data. Although the description will be prepared at one point in time, for wetlands with natural variability of ecological components, the description should document the range of natural variability typical for those components at the time of listing. For example, this may involve describing a prevailing hydrological cycle that spans many years and includes extremes such as droughts and floods. Therefore, the description of ecological character at the time of listing may describe a range of characters within the limits of acceptable change (see Section 4.5 for more information).

For many existing Ramsar sites in Australia, especially for those sites that were listed before 2005, no ecological character descriptions exist, and several years and even decades have elapsed since the sites were listed. For these sites, the ecological character may have changed since the time of listing. It is important to attempt to describe the ecological character at the time of listing because this is the appropriate time for setting the baseline. Useful sources of past information may include remote sensing, expert opinion, long-term data sets, Indigenous custodians and local studies. More recent ecological knowledge about the wetland may also assist in inferring the ecological character of the wetland at the time of listing. Knowledge about the stability of the wetland ecosystems since listing would help in deciding whether the use of more recent information is valid in a description of ecological character. Where several years have elapsed between listing and preparation of an ecological character description, it may be useful to include some information on the character of the site at the time of listing, to identify any changes since that time; this is discussed in Section 4.7.

Where it is impossible to assemble sufficient information to develop a baseline description of ecological character for the time of site listing, the manager will need to choose a baseline as close as possible to that time and provide justification for the baseline chosen.

For DIWA wetlands, the baseline description of ecological character should be prepared for the time the DIWA site was listed. For wetlands that are not listed under Ramsar or DIWA, the baseline should be pre-European condition reflecting natural variability. Where this is not possible, the baseline should be determined by the authors based on the purpose of preparing the ecological character description.

2.2.4 Updating the description of ecological character

The description of ecological character is the baseline reference for assessing change. Therefore, it is not appropriate to update that reference to describe the wetland in a more recent state if there is evidence that the wetland has undergone adverse change since listing. This applies to wetlands for any listing process (e.g. Ramsar, DIWA, or state and territory listings). An update to the description should be considered only in one or more of the following circumstances:

- Further substantial data, knowledge or resources are available to improve the original description. In such cases, the aim would be to expand on, clarify and refine the original baseline, not to establish a new baseline by describing a more recent, changed ecological state.
- The boundaries of the site are extended, reduced or modified; in which case the RIS and the ecological character description should be re-examined and updated where required.
- The wetland undergoes favourable human-induced changes as a result of a rehabilitation or restoration project, or the wetland undergoes natural evolutionary change. In such cases, the ecological character of the wetland may change to the extent that a new baseline is required for assessing impacts of proposed actions and for monitoring and evaluating future change. For example, if a wetland is used for water storage, the limits of acceptable change will be related to a water regime that is limited by its use as a water storage facility. If it was decided that the wetland was no longer required for water storage and was to be restored to a 'natural' state, the wetland would become quite different in nature (e.g. the water regime would be related to natural inflow) and the ecological character description should reflect this.

The original description should be retained and an updated version prepared.

For Ramsar sites, an updated RIS should be prepared at the same time as the ecological character description. The ecological character description will be appended to the RIS and submitted to the Ramsar Secretariat. When the RIS is updated in future, the ecological character description should remain the same unless one of the circumstances described above has occurred, in which case it should be updated with the RIS.

3. Content of an ecological character description — minimum requirements

This framework describes the preferred process for preparing an ecological character description. However, the exact order that the information is presented in can be adapted to some extent to suit the requirements of the site. If there are justifiable reasons for using an alternative process or method to prepare the description, this alternative method should be described in an appendix to the ecological character description. The following section should be used to ensure that the ecological character description contains the required minimum set of information. Appendix 1 provides a checklist for preparing an ecological character description. Appendix 3 lists resources to assist in developing an ecological character description.

An ecological character description should include, at a minimum, the elements listed below. Each of these is described in more detail in Section 4.

Executive summary: a plain English summary that synthesises the ecological character of the site to ensure that it can be understood by all potential users of the description, not just those with technical expertise on wetlands. The executive summary should set the scene for the ecological character description; summarise the data collected; summarise the most important components, processes, benefits, services and the limits of acceptable change; include the conceptual model for the site; summarise the threats and risks to the ecological character of the wetland; and, if applicable, state clearly whether the ecological character of the site has changed since listing.

Acknowledgments: a description or list of the people and organisations involved in developing or contributing to the ecological character description, including any funding bodies.

Table of contents: a clear table of contents to help users navigate around the ecological character description.

List of abbreviations: a summary of the abbreviations used in the description.

Introduction: that addresses the following components:

- **Site details.** This section should provide introductory details about the site and the preparation of the ecological character description (e.g. the name and location of the site, date the site was listed, date the ecological character description was made, name of the compiler, references to the Ramsar Information Sheet and management plans, and the name of the management authority responsible for managing the wetland).
- **Statement of purpose of the ecological character description:** The statement of purpose should clearly explain the intended legal status and role of the ecological character description. This will help the author(s) of the descriptions to be clear about what they are trying to achieve and readers to understand the description. For Ramsar wetlands, the reasons should include, at a minimum, those outlined in Section 4.1.

- **Relevant treaties, legislation or regulations.** This section should list any relevant legislation or treaties that may be relevant to the site or to species or communities that are present at the site. This might include international agreements or treaties; national, state or territory legislation; or local government regulations.

See Section 4.1 for more detail about the Introduction.

A detailed description of the site. This section should also provide an overview of the site to set the scene and provide context to the description of the site. It should include information on the Ramsar or DIWA criteria; wetland type; maps (including a map of the Ramsar site, clearly showing its location and the boundaries of the site), images and photographs of the wetland; land tenure; and any other general information about the site. See Section 4.2 for more detail about the site description.

A description of the components, processes and benefits or services of the wetland that most strongly influence or determine the ecological character of the site. The critical components, processes and benefits or services that support the Ramsar or DIWA criteria should be identified. See Section 4.3 for more detail about describing the site components and processes.

A conceptual model (or series of conceptual models) that provides information on the critical components, processes and benefits or services of the wetland and the linkages between them. See Section 4.4 for more detail about the conceptual model.

A quantitative description of the limits of acceptable change for the critical components, processes and benefits or services of the wetland. These limits are the range of variation in the components, processes and benefits or services that can occur without causing a change in the ecological character of the site. Where the information available is not comprehensive, this should be filled out as best as possible. Any knowledge gaps should be noted and included in the relevant section. See Section 4.5 for more detail about describing acceptable change.

Key actual or likely threats to the site: a summary of the actual or likely threats to the wetland helps to identify what aspects of the ecological character might be more likely to change and in some cases where to focus management effort. See Section 4.6 for more detail about describing potential threats.

If appropriate, changes in ecological character: information about the current ecological character of the site including a statement of whether the ecological character of the site has changed since the time of listing. This should include information on any changes in components, processes and benefits or services (e.g. are they outside their limits of acceptable change); whether they are adverse and the likely causes of those changes (e.g. human induced); and whether the Ramsar nomination criteria for which the site was listed are still being met. See Section 4.7 for more detail about describing changes in ecological character.

Knowledge gaps: a summary of the knowledge gaps identified during the development of the ecological character description. See Section 4.8 for more detail about describing knowledge gaps.

Key site monitoring needs: This section should not develop a monitoring program but should provide prompts or guidance bout on the critical components, processes, benefits or services, or threats to site that may require monitoring. The sites key monitoring needs may have been identified from the conceptual model, limits of ecological change, threats, or other parts of the ecological character description. Identifying the important monitoring requirements for the site helps to provide input to the monitoring program and ensures that the program is linked to the ecological character of the wetland. See Section 4.9 for more detail about identifying the key monitoring needs.

Communication, education and public awareness (CEPA) messages: A summary of the key ecological character messages for the site (e.g. critical ecological features, threats, management options) that may need to be communicated. These messages can serve as pointers and can be elaborated on in a management plan or CEPA action plan. See Section 4.10 for more detail about developing CEPA messages.

Glossary: The glossary should contain definitions of all the major terms used in the ecological character description and the sources of the definitions. Ramsar definitions should be used where possible, and the glossary to this framework can also be used. Depending on the description, additional definitions may need to be included. Where alternative definitions or words are used, the reasons for this should be described and included in the glossary.

References: This section should include a comprehensive reference list to ensure that scientific and technical researchers can find the original sources of information.

Appendices: The appendices provide additional information relevant to the ecological character description. The appendices should include information such as:

- a description of the methods used to prepare the description (including site visits) and how these methods differed, if at all, from this Framework
- a list of the community assemblages [presence or absence taxa lists, taxa counts, rapid biological assessment survey results, observed invertebrate sampled using Australian River Assessment System (AUSRIVAS), etc that are useful in providing information on the ecological character of the site] or other relevant data
- a one-page curriculum vitae for each author of the ecological character description
- For Ramsar-listed wetlands, a draft RIS and Ramsar site map should be prepared or updated at the same time as the ecological character description is being prepared. The draft RIS and map should be submitted as a companion document to the ecological character description.

4. Preparing an ecological character description

This section describes the main steps of the preferred process for preparing a description of the ecological character of a wetland (Figure 3). If an alternative process or method is used to prepare the description, it should be described in an appendix to the ecological character description. Whatever method is used, the elements listed in Appendix 1 must be included.

The ecological character description should consist of an executive summary, acknowledgments, a table of contents, a list of abbreviations, a glossary, references and any necessary appendixes in addition to the outputs from each of the steps in Figure 1. There may be some flexibility in the order the steps are undertaken, depending on the site. More detailed guidance on each step is given in Sections 4.1–4.12. Each subsection concludes with a summary of the expected documentation that should result from the step.

A list of useful resources for developing an ecological character description can be found in Appendix 3.

When the ecological character description has been completed, it should be forwarded to the site manager, the respective state or territory government agency responsible for Ramsar matters, and DEWHA.

Egret

Ecological character description

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

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

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

4. Develop a conceptual model for the wetland
Depict the critical components and processes of the wetland (e.g. hydrology, biogeochemical processes, biota and vegetation, and their relationships)

5. Set limits of acceptable change
Determine limits of acceptable change for critical components, processes and services of the site

6. Identify threats to the ecological character of the site
Use information from Steps 3–5 and other information to identify the actual or likely threats to the site

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

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

9. Identify site monitoring needs
Use information from steps 3–8 to identify monitoring needs

10. Identify communication and education messages
Identify any communication and education messages highlighted during the development of the description

11. Compile the description of ecological character

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

Figure 3. Key steps in preparing an ecological character description

4.1 Introduction to the description

Aim: To provide background information about the description of ecological character and some general details about the site.

Task: Develop an introduction for the site that includes information on site location, purpose of the description, and any legislation that is relevant to the site or to species and communities at the site.

4.1.1 Site details

Provide the basic details about the site and the preparation of the ecological character description. Include relevant descriptive site location information required by the Ramsar Secretariat and the Australian Ramsar Administrative Authority. An example is provided in Table 2.

Table 2. Example of site details for inclusion in an ecological character description

Site descriptor	Information to include
Name	Use the designated site name. Any alternative names should be included in brackets after the precise name; for example Gwydir Wetlands: Gingham and Lower Gwydir (Big Leather) Watercourses.
Location in coordinates	Provide the coordinates (latitude and longitude in degrees and minutes) of the approximate centre of the site or the limits of the site.
General location	Include a brief description of the location of the site. Include the part of the country and the location of the nearest town.
Area	Provide area in hectares (ha).
Date of Ramsar site designation	Provide date for Ramsar sites only.
Ramsar/DIWA criteria met	List criteria met (e.g. Ramsar criteria 1, 2, 3 or 4).
Management authority	List the authority or landholder(s) responsible for managing the site and their full contact details. NOTE: The authors need to be aware of the *Privacy Act 1988* (Cwlth) and should contact the managers to obtain permission to use their contact details in a document that is intended to be made publicly available.
Date the ecological character description applies	Date for which the description applies. If this date is not the same as the date of listing, include justification.
Status of description	Explain whether this is the first description or an update. If the description is an update, briefly explain why the description is being updated (e.g. substantial additional information is available).
Date of compilation	Date the description was made in month and year format (e.g. June 2006).
Name(s) of compiler(s)	Include the name and address of main compiler, organisation or consultant responsible for compiling the description. NOTE: Ecological character descriptions are likely to be made publicly available via the internet. Any information in the description, including contact details, will thus be accessible to millions of users from all over the world. Once personal information has been published on the internet, the department has no control over its subsequent use and disclosure.
References to the Ramsar Information Sheet (RIS)	Ramsar sites only: • Reference for the RIS (e.g. title, date, website) • Date the RIS was prepared or updated.
References to the management plan	Full reference for the plan or plans (e.g. name, date and title of site management plan). Include a website address for the plan if available.

4.1.2 Statement of purpose

Prepare a statement of the purpose of the ecological character description. The statement should give the reasons for describing the ecological character of the wetland and should clearly explain the intended legal status and role of the ecological character description. It will help readers and those writing the description to understand what they are trying to achieve.

For Ramsar wetlands, include in the statement of purpose the reasons listed below (outlined by McGrath 2006) as a minimum:

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 (Cwlth):
   a) to describe and maintain the ecological character of declared Ramsar wetlands in Australia
   b) to formulate and implement planning that promotes:
      i) conservation of the wetland
      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 Ramsar Information Sheet submitted under the Ramsar Convention for each listed wetland and, collectively, to 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.

Also include any other reasons for preparing the ecological character description.

4.1.3 Relevant treaties, legislation and regulations

In addition to the EPBC Act, list any international, state, territory or local government legislation, treaties or regulations relevant to the site or to species or communities that use or are present at the site. Examples include:

- 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* (JAMBA)[7]
- 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* (CAMBA)[8]
- the *Agreement between the Government of Australia and the Republic of Korea for the Protection of Migratory Birds and their Environment* (ROKAMBA)[9]
- the *Convention on the Conservation of Migratory species of Wild Animals* (the Bonn Convention)[10]
- state or territory legislation (e.g. threatened species legislation; National Parks and Wildlife legislation.)

Appendix 3 lists links to additional information about sources for legislation and treaties.

[7] http://www.austlii.edu.au/au/other/dfat/treaties/1981/6.html

[8] http://www.austlii.edu.au/au/other/dfat/treaties/1988/22.html

[9] http://www.austlii.edu.au/au/other/dfat/nia/2007/5.html

[10] http://www.cms.int/

Outputs for inclusion in the ecological character description

This section of the ecological character description should include:

- ❑ site details
- ❑ a statement of purpose for the description
- ❑ information on relevant legislation, treaties or regulations.

4.2 General description of the site

Aim: To provide more detailed information about the site at the time it was listed, explain why it was listed, set the scene and provide context for the description of the site. This information is also important for regulatory processes.

Task: Develop a description of the site. The description of the site should include, at a minimum, information about site location, maps and photographs, land tenure, Ramsar criteria and the wetland types at the site. Each of these aspects is described in more detail below.

4.2.1 Site location

Provide a detailed description of the location of the site, its boundaries and any relevant contextual information. For example, include information about the drainage division, catchment, climate and biogeographic region.

4.2.2 Maps, images and photographs of the site

Maps, images and photographs can help to place the wetland in context and provide a sense of its relationship to surrounding areas, providing much more information than a simple description. More information on mapping Ramsar wetlands can be found in the *Mapping Specifications for Australian Ramsar Wetlands* (Wetlands and Waterbirds Taskforce 2008).

Include maps of the Ramsar wetland, satellite images and aerial photographs showing the site's regional and local settings, clearly depicting the Ramsar site boundaries. Also include ground photographs showing the variety of ecosystem types in the wetland (McGrath 2006). Ensure that maps conform to the standards given in the *Mapping Specifications for Australian Ramsar Wetlands*. They should include a border, orientation (north), legend, title and scale, as well as key features, towns or other markers that help place the wetland in a broader context.

Accompany any photograph or image with a description, the date it was taken, where it was taken from (e.g. description or GPS coordinates and orientation) and the name of the person or organisation who owns the image (McGrath 2006). For satellite or aerial photographs, also mark the site boundary.

If there are numerous maps or photographs, these could be included in other relevant sections of the description or in the appendixes accompanying the description.

4.2.3 Land tenure

The land tenure of a wetland will influence who is responsible for managing the site. Wetlands on public land are generally the responsibility of the Australian, state or territory government agencies, whereas those on private land may be managed by private landholders, Indigenous custodians, community trusts or industry. Some wetlands may cross different land tenures and be managed jointly by different groups such as the landholders and the government agencies responsible for reserves and wildlife. Include a description of land tenure of the site in this section.

4.2.4 Ramsar criteria

This section helps to ensure that the description of ecological character is linked and refers to the Ramsar criteria under which the site was listed. At least one of the Ramsar criteria for identifying wetlands of international importance (listed in Appendix 4; Ramsar Convention 1999a and 2005b) must be met for a site to be Ramsar listed. Criteria were first adopted by the convention in 1974 and revised in 1990, 1996, 1999 and 2005, when the current criteria were adopted. Appendix 5 compares the pre-1999 and current criteria.

Assessment of ecological character:

> should be linked to the Ramsar criterion or criteria fulfilled by the site at the time of designation for the Ramsar List. Use of the criteria indicates certain benefits and values of the wetland that might be lost as a result of change in the ecological character. (Ramsar Convention 1996).

Also consider any additional ecosystem benefits and services, 'since significant degradation of wetland functions and values might occur without any of the designated Ramsar criteria being contravened' (Ramsar Convention 1996).

The RIS specifies the criteria for which individual sites are listed. However, for some sites, there may be criteria that apply since the site was listed. Therefore, in describing the wetland, list the Ramsar criteria under which the site was listed plus any relevant new criteria agreed since the listing. Describe the specific features of the site that meet these Ramsar criteria, and include any new criteria that apply to the site in the updated RIS.

For a site listed in DIWA, refer to the criteria for determining nationally important wetlands in Australia and to the site's inclusion in DIWA. The DIWA criteria are those agreed to by the Natural Resource Policies and Programs Committee in 2006 and used in the third edition (Appendix 6) of DIWA (Environment Australia 2001).

Ramsar sites are generally also on the DIWA list; therefore, some sites may have met more than one set of nomination criteria. Many of the DIWA criteria are similar to the Ramsar criteria, and it is possible to identify both the Ramsar and DIWA criteria that apply to a site in the ecological character description. However, the boundaries of the DIWA site may not match the Ramsar site; therefore, take care when identifying any DIWA criteria that apply within the boundaries of the Ramsar site.

4.2.5 Wetland types

List and map the wetland types that occur at the site and include estimates of their area, if possible, to provide important background information on the way the wetland functions. Different components, processes, benefits and services may operate in different wetland types, so it is important to identify these types and where they occur. For complex sites that have vastly different wetland types, it may be useful to subdivide the ecological character description to address the components, processes, benefits and services for these different wetland types.

Map the location of the wetland types and provide an estimate of the percentage or area of the wetland for each type.[11]

State and territory wetland agencies may have their own wetland classification and wetland mapping systems (such as habitat mapping or vegetation mapping); include these if desired.

[11] For wetland types for Ramsar sites, see http://www.ramsar.org/ris/key_ris.htm#type; for wetland types for DIWA sites, see http://www.environment.gov.au/water/publications/environmental/wetlands/directory.html

Giant rush beside Billabong

Outputs for inclusion in the ecological character description

This section of the ecological character description should include:

- ❑ a description of the site location
- ❑ maps, images and photographs of the site
- ❑ a description of the land tenure of the site
- ❑ the relevant listing criteria
- ❑ a list and map of the wetland types within the wetland.

4.3 Identification and description of critical components, processes, benefits and services

Aim: To identify and describe the ecosystem components, processes, benefits and services that are critical to the ecological character of the site.

Task: Identify and describe the components and subcomponents, processes, benefits and services of the wetland that most strongly determine the ecological character of the site that existed or operated at the time of its listing.

1. Identify as many components, processes, benefits and services of the wetland as possible, using Tables 3–5 (below), wetland experts and any relevant information available. The resulting list may be long, with some features repeated and interrelated; however, it can be narrowed down in the next step.

2. Identify and summarise the critical ecosystem components, processes, benefits and services that most strongly influence or determine the ecological character of the site. All aspects of the wetland ecosystem are important and each of the three components (hydrology, physicochemical and biota) will be critical for each wetland. However, some subcomponents or processes may be fundamental to determining the ecological character of the site. Provide the reasons for the selection of critical elements.

As a minimum, select for analysis and description those components, subcomponents, processes, benefits and services:

- that are important determinants of the site's unique character
- that are important for supporting the Ramsar or DIWA criteria under which the site was listed
- for which change is reasonably likely to occur over short or medium time scales (< 100 years)
- that will cause significant negative consequences if change occurs.

3. Provide more detailed descriptions and quantitative information about each of the critical elements.

Define each critical element in quantitative terms and provide a source of information. Include spatial and temporal information to allow comment on the natural variability of the site. If relevant, include maps or photographs of the site that show seasonal changes or other environmental conditions (e.g. drought). Pay particular attention to the requirements of site owners and local Indigenous groups.

4.3.1 Ecosystem components

Ecosystem components are physical, chemical and biological parts of a wetland, from large-scale to very small-scale (e.g. habitat, species and genes) (Ramsar Convention 2005a). Examples of ecosystem components and subcomponents are given in Table 3. Some components may be viewed as processes; therefore, identify which are important in terms of the ecological character of the specific site being described and whether they are components or processes.

Table 3. Ecological components of a wetland

Component	Examples
Physical form	Area of the wetland
	Wetland form (e.g. depth, shape and bathymetry [the study of underwater depth])
Wetland soils	Site and soil profile characterisation (e.g. using the Australian Soil and Land Survey Field Handbook McDonald *et al.* 1990).
	Soil profile classification (e.g. using Isbell 2002) – most profiles should fall into the Hydrosol Soil Order and classification to the Sub-Order or Great Group level will be sufficient in most cases.'
	Soil physical properties (e.g. structure, texture, consistency and profile)
	Soil chemical properties (e.g. organic content, nutrients, sulfides, acid neutralising capacity, salts and pH)
	Soil biological properties (e.g. soil organisms such as bacteria and fungi, invertebrates – shellfish, mites and worms)
Physicochemical water	Nutrients (e.g. nitrogen, phosphorus)
	Electrical conductivity
	Cations and anions
	Turbidity
	Temperature
	Dissolved oxygen
	pH
	Nutrient cycling
	Light attenuation
Biota	Wetland plants
	Vertebrate fauna (e.g. fish, amphibians, reptiles, waterbirds, mammals)
	Phytoplankton, including diatoms
	Aquatic macroinvertebrates

Source: after DSE (2005b)

4.3.2 Ecosystem processes

Ecosystem processes are the dynamic forces within an ecosystem. They include all those processes that occur between organisms and within and between populations and communities, including interactions with the nonliving environment, that result in existing ecosystems and bring about changes in ecosystems over time (Australian Heritage Commission 2002). They may be physical, chemical or biological (Ramsar Convention 1996, Resolution VI.1 Annex A). Examples of ecosystem processes are included in Table 4. Some processes may also be considered components or broken into subcomponents (e.g. for hydrology, consider frequency and duration of inundation); therefore, identify which are important in terms of the ecological character of the site and whether they are components or processes.

4.3.3 Ecosystem benefits and services

For the purposes of the Ramsar Convention, benefits and services are defined in accordance with the Millennium Ecosystem Assessment definition of ecosystem services as 'the benefits that people receive from ecosystems' (Ramsar Convention 2005a, Resolution IX.1 Annex A).

The Millennium Ecosystem Assessment definitions of benefits and services focus on the benefits that people receive from ecosystems[12]. However, in many cases the benefits people receive from ecosystems (economic, social and cultural) rely on the underlying ecological components and processes in the wetland. These components and processes provide ecological services that are very important even though they may not benefit humans directly.

The Millennium Ecosystem Assessment (2005a and b) identifies four main categories of ecosystem benefits and 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
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.

Consider the full range of ecosystem benefits and services (provisioning, regulating, cultural and supporting); see Table 5, which is designed to be used as a prompt. Appendix 7 provides a more comprehensive list of wetland ecosystem benefits and services, and Appendix 8 can be used as a guide in identifying ecosystem benefits and services that relate to Ramsar criteria.

[12] The Millennium Ecosystem Assessment Synthesis Report on *Ecosystems and Human Well-being: Wetlands and Water* defines 'ecosystem services as "the benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as regulation of floods, droughts, land degradation, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious, and other nonmaterial benefits." This term corresponds with the usage by the [Ramsar] Convention of the terms "products, functions and attributes" (as shown in the definition of ecological character). The classification of water as a provisioning service rather than a regulating service is debated, but this does not affect its general meaning within the context of this report.' (MA 2005b:v; also MA 2005a:v).

Table 4. Examples of ecological processes

Process type	Examples
Climate[a]	Precipitation Temperature Evaporation Wind
Geomorphology[a]	Topography/morphology Connectivity of surface waters Water source Soils Sedimentation Erosion
Hydrology[a]	Water balance (water flowing in, water flowing out) Groundwater infiltration and seepage Surface–groundwater interactions Tidal regime Inundation regime (volume, frequency, duration, height and seasonality [timing] of inundation)
Energy and nutrient dynamics	Primary production Nutrient cycling (nitrogen, phosphorus) Carbon cycling Decomposition Oxidation–reduction
Processes that maintain animal and plant populations	Reproduction Regeneration Dispersal Migration Pollination
Species interactions	Competition Predation Succession Herbivory Diseases and pathogens
Physical processes	Stratification Mixing Sedimentation Erosion Evaporation Infiltration

[a] For some wetlands these processes may be viewed as components or broken down into their components.

Source: after DSE (2005a)

Table 5. Wetland ecosystem benefits and services

Ecosystem benefit or service	Examples
Provisioning services — products obtained from the ecosystem such as food, fuel and fresh water	
Food	Sustenance for humans (e.g. fish)
Fresh water	Drinking water for humans Drinking water for livestock Water for irrigated agriculture Water for industry
Wetland products	Timber Fuel wood Peat Livestock fodder Commercial fishing
Biochemical products	Extraction of materials from biota
Genetic materials	Medicines Genes for tolerance of certain conditions (e.g. salinity) Genes for resistance to plant pathogens Ornamental species
Regulating services — benefits obtained from the regulation of ecosystem processes such as climate regulation, water regulation and natural hazard regulation	
Maintenance of hydrological regimes	Groundwater recharge and discharge Storage and delivery of water as part of water supply systems for agriculture and industry
Erosion protection	Retention of soils Prevention of physical changes such as coastal erosion and bank slumping
Pollution control and detoxification	Sediment deposition and retention Retention, recovery and removal of excess nutrients and pollutants
Climate regulation	Regulation of greenhouse gases, temperature precipitation and other climatic processes
Biological control of pests and diseases	Support of predators of agricultural pests (e.g. ibis feeding on grasshoppers)
Hazard reduction	Flood control Coastal shoreline and river bank stabilisation and storm protection
Cultural services — benefits people obtain through spiritual enrichment, recreation, education and aesthetics	
Recreation and tourism	Recreational fishing and hunting Water sports and activities Picnics, outings, touring Nature observation Nature-based tourism
Spiritual and inspirational	Inspiration Cultural heritage (historical and archaeological) Spiritual and religious significance Sense of place Existence value Appreciation of natural features
Scientific and educational	Educational activities and opportunities Scientific reference area or site Long-term monitoring site Major scientific study site Type and extant locality for a taxon
Supporting services — 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	
Biodiversity	Supports a variety of all lifeforms including plants, animals and microorganisms, the genes they contain and the ecosystems of which they form a part
Soil formation	Sediment retention Accumulation of organic matter
Nutrient cycling	Storage, recycling, processing and acquisition of nutrients Carbon sequestration

The critical components, processes, benefits and services should be assembled using all available existing information and expert advice. An example table of one component of hydrology is provided in Table 6.

Table 6. Description of the flood regime (a critical subcomponent of the hydrology) required to support successful breeding of colonially nesting waterbird species in Barmah Forest

Critical component, process or subcomponent	Aspect (of flood regime)	Requirements
Hydrological flood regime	Seasonality	A flood pulse is required in September or October (or, rarely, in November) to induce breeding. High stable water levels should continue for two months after the flood pulse with a gradual recession.
	Water depth	Breeding is induced provided nest sites are sufficiently inundated#. Rapid recession of floodwaters should be avoided. A sudden change in water depth of 0.3 metres under nest sites or in foraging areas is likely to lead to abandonment of breeding.
	Magnitude	Floods must inundate both nesting and foraging areas. Much higher flows are required for successful breeding of egrets than for ibis. A flood of at least 20 000 ML/day is considered necessary to induce breeding of colonially nesting waterbirds. However, in Barmah, ibis have bred successfully at specific locations (Boals Deadwoods) without widespread flooding. This was achieved by water being directed to the nesting area via a regulator at river flows of less than 11 000 ML/day.
	Duration of flooding	Flooding is required for up to 3.5 months after egg laying. A period before this is also required for birds to prepare behaviourally, hormonally and nutritionally. Nest sites and foraging areas need to be inundated for at least 5 months.
	Frequency	Frequency of flood events necessary to induce successful breeding events should reflect that which would occur under natural conditions. The opportunity for successful breeding must occur within the lifespan of a species (20–25 years in some species with mean wild survival of 8–10 years).

Source: DSE (2005a)

For some sites, quantitative information on ecological processes may be lacking; in this case, an expert panel may be able to make estimates. Where there are uncertainties about data or an estimate, the level of uncertainty should be stated. If a component or process cannot be described usefully in quantitative terms, this should be identified as a knowledge gap.

Outputs for inclusion in the ecological character description

This section of the ecological character description should include:

- ❑ a summary table of the critical components and subcomponents, processes, benefits and services of the wetland
- ❑ the reasons why these components, subcomponents, processes, benefits and services were chosen as critical
- ❑ descriptions and quantitative information of the critical components, subcomponents, processes, benefits and services of the site (descriptions and or tabular format).

4.4 Development of a conceptual model for the wetland

Aim: To develop a conceptual model of the wetland. This model can be used to understand and represent the relationships between the components, processes, benefits and services of the wetland that most strongly determine the ecological character of the site.

Task: Develop a conceptual model or series of conceptual models of the critical components, processes, benefits and services (where applicable) for the wetland. Tables 3–5 give examples of components, processes, benefits and services. Some resources to help you to create a conceptual model for your wetland are listed in Appendix 3.

The following examples of conceptual models are intended to serve as a guide only. Three examples are provided: a simple flow chart type conceptual model (Figure 4); a more detailed conceptual model for the Paroo wetland (Figure 5); and a more complex and detailed model for a general lacustrine wetland in the dry season (Figure 6). Decide on the type of conceptual model that should be developed for your wetland.

Once completed, the conceptual model may help to identify:

- the relationships and dependencies between the components, processes and, if possible, the benefits and services of the wetland
- threats to the wetland's critical values
- how, and in what ways, any changes in the objects or in their relationship to each other affect the functioning of the system.

It may be useful to include more information or descriptions about the relationships between critical ecosystem components, processes, benefits and services of the wetland following the conceptual model.

Conceptual models

Conceptual models can play an important role in describing ecological character of wetlands. For example, they can formalise understanding of the system processes and dynamics, identify linkages of processes, and identify the bounds and scope of the system (Gross 2003). Conceptual models are commonly visual diagrams that use symbols and/or drawings to represent the ecological system and/or communicate linkages between system components or processes.

They provide a useful and easy-to-understand tool with which to organise and communicate knowledge, help identify knowledge gaps, aid decision-making and planning, and facilitate wider participation among the community. Some conceptual models can help researchers and managers to predict what effects change might have on a wetland ecosystem.

Gross (2003) described two types of models that are commonly used to conceptually represent ecological systems. The first type is a **control model** that depicts the major system components, drivers and feedbacks of the system. It is intended to be an accurate representation of the system at a particular level of aggregation. The second is a **stressor model** that is an abstraction of a particular system or part of a system focused on the links between stressors, ecosystem responses, effects and, in some cases, indicators. The stressor model does not incorporate all relevant system components, feedbacks or interactions.

Conceptual models can be used to show the linkages between the chemical, physical and biological components of a wetland ecosystem as well as the ecological processes, benefits and services. One all-encompassing model may be too complex to draw and understand. In these cases, it may be useful to have a number of conceptual models of a system, each of which focuses on different parts, components or processes of the wetland.

The wide diversity and number of different wetland types makes it difficult to develop one overarching example conceptual model. Generic conceptual models should be viewed only as a base on which to develop a model more suited to a specific wetland ecosystem. It may be necessary to seek expert advice and to investigate any pre-existing management reports or research pertaining to the wetland.

A series of conceptual models for different wetland types were developed as part of the Queensland Wetlands Programme (Maher et al. 2006). These include models of a variety of palustrine and lacustrine wetlands that may be a useful starting point for developing a conceptual model for a specific wetland. One of these models is reproduced in Figure 6, and additional conceptual models for other wetland types can be found in the report by Maher et al. It is anticipated that these models will be made available on the Queensland Environment Protection Authority website (http://www.epa.qld.gov.au/).

A number of conceptual models that describe important wetland processes (e.g. dredging, infill, nutrient cycling, physical, sediment trapping and trophic structure) have been developed by the Coastal CRC and are reproduced in Appendix 9.

Outputs for inclusion in the ecological character description

This section of the ecological character description should include a conceptual model or a series of conceptual models for the wetland that depicts the critical components and processes of the site. In some cases it may be useful to identify the services or benefits of the wetland. Some sites may be easier to depict with conceptual models for different functional units or wetland types.

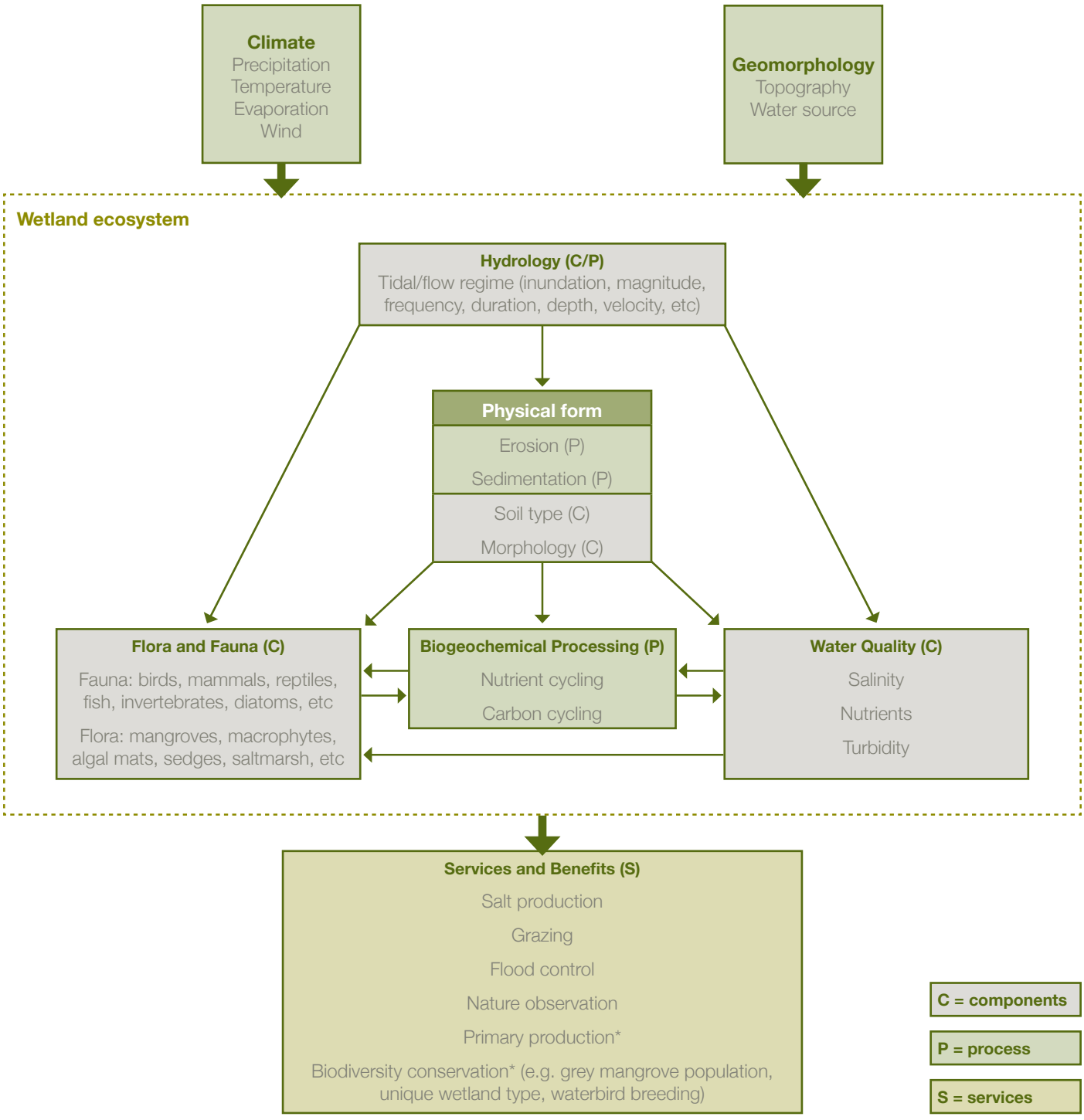


Figure 4. Simple conceptual model of a wetland ecosystem showing the components, processes and services

Those marked with an * may be considered as components or processes as well as ecosystem services or benefits.

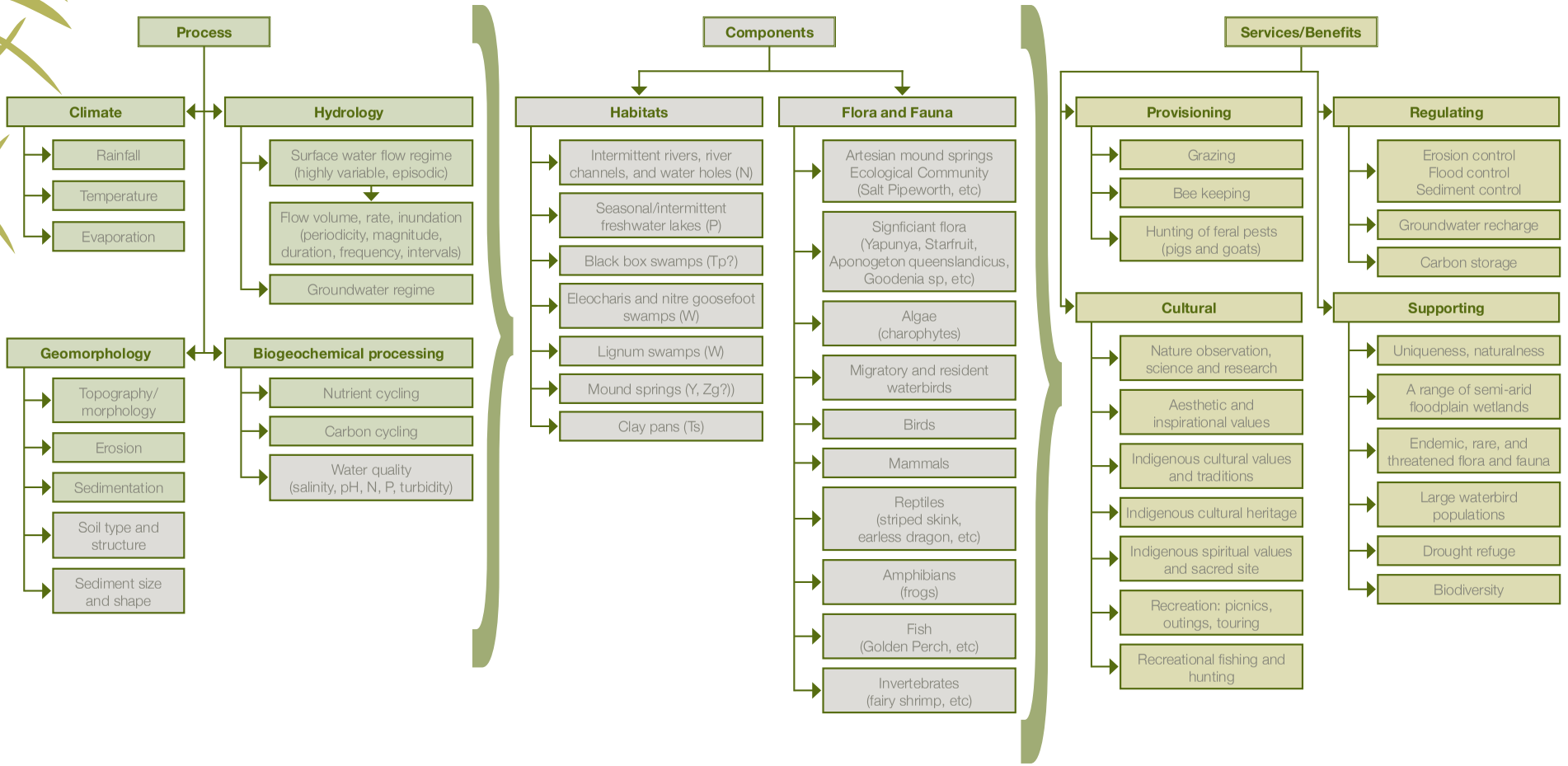


Figure 5. Draft conceptual model of the ecological character of the Paroo River Wetlands

A simplified conceptual model of the Paroo River Wetlands ecosystem, showing the main components, processes and benefits or services, and the linkages between them (Gray 2006 pers comm. after Philips et al. 2005)

N = seasonal/intermittent/irregular rivers/streams/creeks; P = seasonal/intermittent freshwater lakes (over 8 ha) — includes floodplain lakes; Tp = permanent freshwater marshes/pools — ponds (below 8 ha), marshes and swamps on inorganic soils — with emergent vegetation water-logged for at least most of the growing season; Ts = seasonal/intermittent freshwater marshes/pools on inorganic soils — includes sloughs, potholes, seasonally flooded meadows, sedge marshes; W = shrub-dominated wetlands; shrub swamps, shrub-dominated freshwater marshes, shrub carr, alder thicket on inorganic soils; Y = freshwater springs, oases; Zg = geothermal wetlands

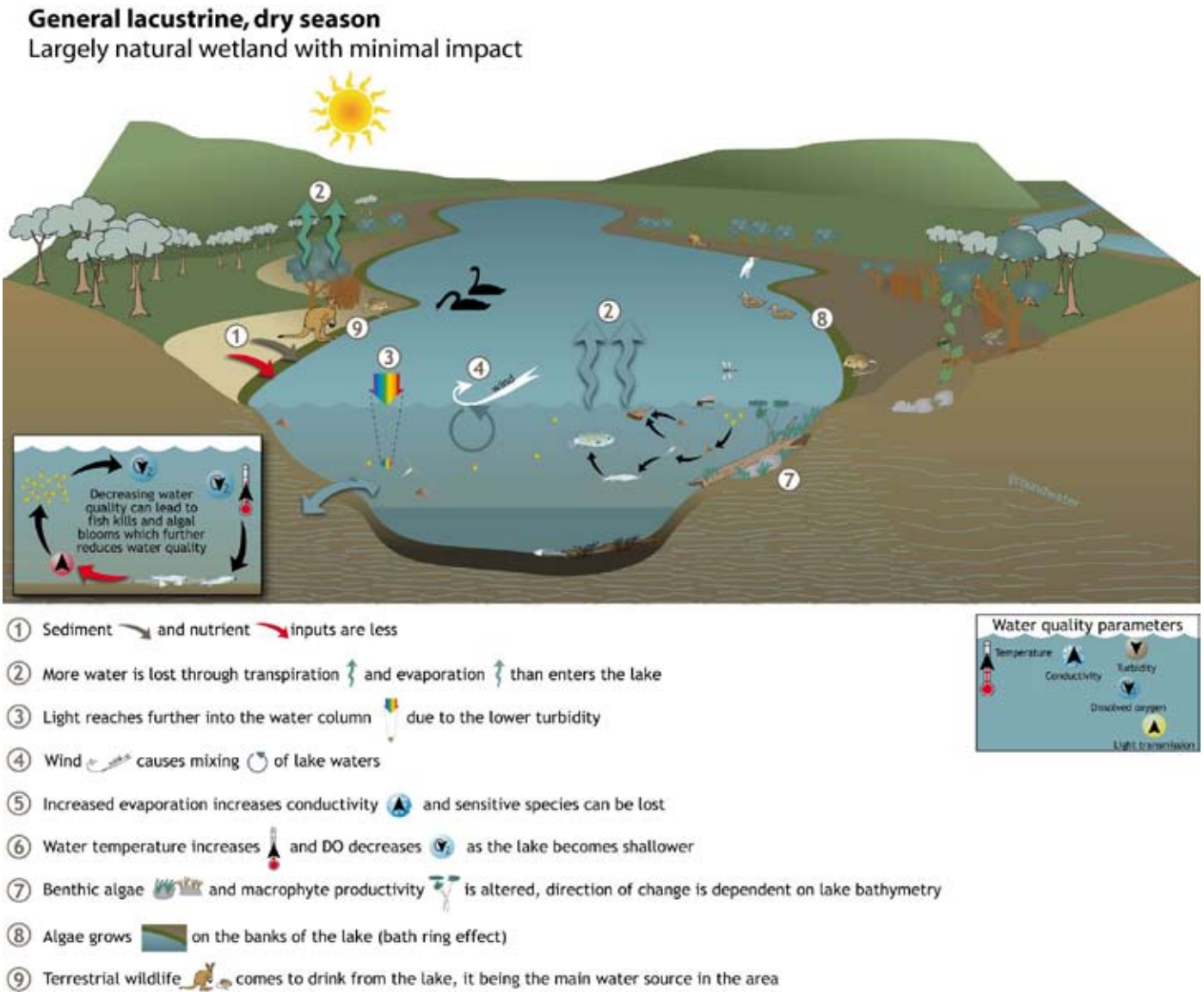


Figure 6. Example conceptual model for a general lacustrine wetland in the dry season

Source: Maher et al. (2007)

4.5 Setting limits of acceptable change for the critical components, processes, benefits and services of the wetland

Aim: To understand the range of natural variation in the components and processes of a wetland ecosystem and to set limits of acceptable change for the wetland. These limits make it easier to determine when the ecological character is likely to change or when it has changed as a result of technological development, pollution or other human interference.

This is particularly important for Australian wetlands given that they often have a large range in natural variability. Change in ecological character occurs when the critical parameters of the wetland ecosystem fall outside their normal range (Ramsar Convention 1996 Annex to Resolution VI.1).

This information can help site managers determine limitations to activities, monitor the site, and take action to maintain ecological character.

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 (Figure 7). In most cases, change is considered in a negative context, leading to a reduction in the values for which a site was listed.

Task: Describe the natural variability and limits of acceptable change for each of the critical components, processes, benefits and services of the wetland.

Quantify the typical range of variability for the critical components, processes, benefits and services and the limits of acceptable change beyond which the ecosystem component, process or service would be expected to move outside the limits specified and result in a change in condition of the wetland.

Where possible, describe the impact that exceeding the limits of acceptable change may have on these and other components, processes, or benefits or services.

The limits of acceptable change may equal the natural variability or may be set at some other value. Provide justification for the limits.

For some wetlands there may be a trend of change in the natural variation of the system over time, so it is important to review the limits of ecological change over time to ensure they still reflect the natural variability of the system. However, care should be taken to ensure that such changes reflect the natural variability or trend of the system and not a human-induced change in the system.

Where possible, the limits of acceptable change should be based on quantitative information from relevant monitoring programs, scientific papers, technical reports, or other publications and documented information on the wetland. Wetland experts, Indigenous leaders and oral histories may also provide information that can be useful in setting limits of acceptable change. In some cases the datasets may not be ideal, although they may contain enough information to set interim limits of acceptable change and to identify the need for further data.

For some components, processes or wetlands, there may be very little information available. Where available information is not comprehensive enough to set definite limits or interim limits of acceptable change, this lack of information should be described as a knowledge gap. Where possible, identify the information required to set the limits if that information is not available.

Limits of acceptable change can be provided as a description or in tabular form. An example of the natural variability and limits of ecological change for the most relevant ecosystem components, processes, benefits and services of a site is provided in Table 7.

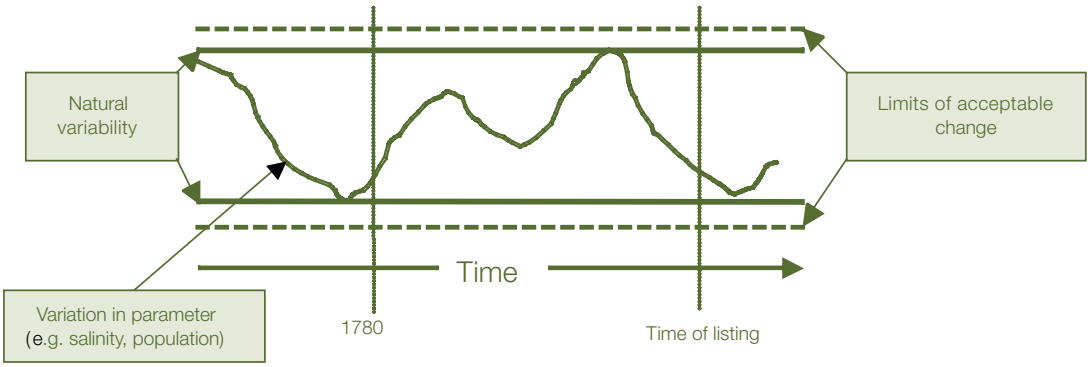


Figure 7. Example of natural variability and limits of ecological change

Source: Phillips (2006)

Table 7. Examples of limits of acceptable change for critical components, processes or services and benefits of a wetland

Critical ecological components and processes	Baseline condition[a] and range of natural variation where known	Interim limits of acceptable change[b] (Based on baseline and natural variability)	
		Short-term (1–2 years)	Long-term (5–20 years)
Significant species and communities components and processes			
Number of waterbird species recorded at site annually.	Up to 70 species have been recorded, but highly variable. Waterbirds respond to drivers at scales beyond that site.	Wetland species show marked variation between years and observed differences between years are difficult to interpret. There is insufficient data available yet.	An observed, estimated, inferred or suspected reduction of waterbird species 10 % or more over 10 years.
Numbers of waterbirds recorded in annual/ bi-annual surveys	20 000–120 000	Less than 15 000 birds recorded for two consecutive years, based on consideration of previous 24 months data.	No net reduction in waterbird numbers over 10 years.
Species observed present in numbers exceeding 1 % of flyway population (= notable species) Curlew sandpiper Banded stilt Red knot Red-capped plover Red-necked stint Red-necked avocet	Range of numbers observed between 1987 and 2003 (with mean) for each species: 8000–41 606 (30 194) 2042–53 098 (20 298) 8–2566 (816) 114–2110 (785) 2350–8312 (6530) 0–2401 (282).	No recording of notable species for any one year.	Advice required
Native fish species	Data insufficient at this time.	Data insufficient at this time.	No net reduction in native fish populations over 5 years.
Macroinvertebrates	The site has low numbers of insects, dominated by air breathers and dipterans. May have some molluscs, but salt tolerant crustacean species expected to be the dominant fauna. Expected range of number of species is 10–20. Phytoplankton driven system — plankton may be important food for waterbirds and fish.	No greater than 20% change in number of species of any of the classes of invertebrates present sustained for longer than two years.	No greater than 12% loss of species or taxa of any of the classes of invertebrates present over 5 years.
Grey mangrove community	Area: approximately 22.5 ha. Condition: generally good but significant dieback suffered after cyclone in 2000. Trend: recruiting success after the 2000 dieback is unknown.	No greater than 4 % mortality rate under stable climatic conditions. Loss of up to 90 % due to flooding or cyclone.	Advice is required on what constitutes a significant loss of area.
Sedges and saltmarshes	Area: not known. Condition: not known. Trend: not known.	Once area determined, % mortality rate to be specified. Loss of up to 90% due to flooding or cyclone.	No greater than 5% change in area of community over 10 years. Advice is required on what constitutes a significant loss of area.

Critical ecological components and processes	Baseline condition[a] and range of natural variation where known	Interim limits of acceptable change[b] (Based on baseline and natural variability)	
		Short-term (1–2 years)	Long-term (5–20 years)
Biophysical and hyrdological components and processes			
Tidal inputs, seawater discharge — hydraulic head through vents	3–4 metres of head.	Advice needed.	Advice needed.
Freshwater inputs	Areal extent limited to littoral marshes unless significant rainfall.	Advice needed.	Advice on the limits of change for the timing, duration, and frequency of freshwater inputs required.
pH	Changes in pH are both a direct and an indirect ecological stressor (pH affects the availability of toxicants). pH has a high natural variability and is influenced by the effect of algal growth on dissolved CO2. Suggests the need for site-specific limits.	To be defined.	To be defined.
Sedimentation	Natural rate of sedimentation for this closed system is unknown at present.	To be defined.	To be defined.
Turbidity	Turbidity can be expected to vary with freshwater inflows, wind and tidal actions: < 50 TU preflood < 200 NTU postflood.	ANZECC (2000) trigger values 2–200 NTU. Once sufficient data have been collected, site-specific trigger values based on 80th percentile of the median should be calculated and adopted.	No significant change in median concentrations from baseline.
Salinity	Hypersaline range = 40–100 g/L Measured as saline to hypersaline in October 2000. 38.4–49.5 ppt Insufficient data at this time. Salinity may vary dramatically over seasonal water regime cycles.	Trigger value based on site-specific data and the salinity tolerance of significant biota.	No significant change in median concentrations from baseline.

[a] The quantitative measures used to gauge whether or not management is acting to retain this ecological attribute.

[b] The tolerance that is considered acceptable without indicating a change of 'ecological character' is occurring. Use of this concept requires good knowledge of natural variations, the boom-and-bust cycles that can occur naturally in these species or communities. Where this is lacking, the precautionary principle will be applied.

Source: Examples adapted from Phillips et al. (2006)

Outputs for inclusion in the ecological character description

This section of the ecological character description should include:

- ❑ the limits of acceptable change for each of the critical components, processes, benefits and services
- ❑ sources of information
- ❑ notes regarding any identified knowledge gaps.

4.6 Identification of threats to the ecological character of the site

Aim: To identify actual or likely threats to the wetland and what aspects of the ecological character might be impacted or changed.

The threats to the wetland can be used as pointers for areas of focus under the management plan and as initial guidance in assessing the likely impacts of potential development proposals under the EPBC Act.

Task: Identify the actual or likely threats to the ecological character of the wetland. This is not meant to be a detailed threat assessment but should, at a minimum, identify:

- the likely threats to ecological character
- the likely impacts or potential effects of the threat on the ecological character
- the likelihood and likely timing of the threat (if possible).

In identifying the threats, focus on the components, processes, benefits and services that were identified as most strongly influencing the ecological character of the wetland. The site manager, conceptual model, activities within the catchment, actions around the wetland that have been referred under the EPBC Act, any compliance and enforcement action that may have been taken, and any existing management or natural resource management plans or other publications about the wetland may be useful in identifying the threats to the ecological character of the wetland.

Summarise the threats in a table (e.g. Table 8) and describe them in more detail following the summary. Identify any knowledge gaps for inclusion in a later section. It may also be useful to update the conceptual model, where appropriate, to include some of the threats and risks to the wetland.

Include any specific threats to threatened species of plants or animals at the site in the description. Possible threats or risks should be further explored for management and monitoring in the management plan for the wetland.

Risk assessment

A *Wetland Risk Assessment Framework* was developed by van Dam et al. (1999) to provide an additional framework for assessing the threats or risks to wetlands (Ramsar Convention 1999c, Resolution VII.10; van Dam et al. 1999). The framework provides guidance on how to predict and assess change in the ecological character of wetlands and promotes, in particular, the use of early warning systems (Ramsar Convention 1999c, Resolution VII.10; van Dam et al. 1999). A detailed risk assessment should be part of the management plan for the site.

The *Wetland Risk Assessment Framework* identified five categories of causes of adverse change to the ecological character of a wetland (Ramsar Convention 1999c, Resolution VII.10):

1. changes to the water regime — such as magnitude, timing and frequency of flooding from increased water extractions or diversions upstream of the site, drought or climate change
2. water pollution — such as changes to land use and land cover in the catchment,e.g. increased urban areas and urban runoff that cause increased turbidity and sedimentation, increased nutrients and other pollutants
3. physical modification — such as loss of habitat from clearing or draining for urban development, altered fire regimes and firewood depletion
4. exploitation of biological products — such as overfishing or overgrazing
5. introduction of exotic species — such as introduced animals (e.g. foxes, goats, pigs and cats) may result in predation of wildlife or overgrazing; weed invasion may cause loss of suitable habitat or changes to wetland communities.

These categories may be a useful starting point for identifying threats to ecological character of a Ramsar wetland. The type of change may be seen as biological, chemical or physical (Ramsar Convention 1999c, Resolution VII.10; van Dam et al. 1999).

To develop a more systematic approach to cataloguing environmental threats and management actions at the international level, the International Union for the Conservation of Nature (IUCN) and the Conservation Measures Partnership (CMP) have developed a standardised hierarchical classification of commonly encountered environmental threats and conservation/management actions (IUCN-CMP[13] 2006).

Using the IUCN's threat classification hierarchy, the Australian Government undertook a review in 2007 of all RISs, any existing ECDs, and the Ramsar site management plans for each of Australia's 64 Ramsar sites. The review identified the threats recorded at each site and classified them using the IUCN threats classification hierarchy. The list of threats from the review is listed in Appendix 10.

[13] www.iucn.org/themes/ssc/sis/classification.htm

Table 8. Example table of threats to a wetland

Actual or likely threat or threatening activities	Potential impact(s) to wetland components, processes and/or services	Likelihood	Timing of threat
Water extractions/diversions upstream that lead to: • altered hydrological regimes • altered temperature regimes	• Altered hydrological regimes — timing, magnitude and frequency of flows • Changes to water depth • Changes to habitat availability from changes in area, frequency and flooding • Changes to water temperature regimes • Impacts on flora and fauna (e.g. breeding events, vegetation distribution)	Certain/high	Immediate
Introduction and/or poor control of invasive species	• Reduced habitat (e.g. choking of wetlands, changes in vegetation structure) • Competition with native flora and fauna • Loss of native species	Certain	Immediate– medium term (5 years)
Agricultural activities adjacent to wetland such as: • clearing of native vegetation • livestock grazing • cropping/ horticultural activities	• Sediment deposition and increased turbidity • Nutrient enrichment • Salinisation • Changes to hydrology • Establishment of weeds • Reduced habitat quality	Certain	Immediate– medium term (5 years)
Urban development may lead to activities such as • land filling • wetland draining excavation • changes to runoff • disturbance of acid sulfate soils	• Increased urban runoff resulting in increased sedimentation and pollutants • Increased turbidity • Impacts of flora and fauna that are impacted by light levels and sedimentation • Loss of wetland habitat • Changes in wetland depth • Disturbance to flora and fauna • Changes in hydrology • pH changes	Medium	Medium term (5 years)
Climate change may result in: • changed rainfall patterns • changed temperature and wind regimes • More frequent and severe water events	• Altered hydrological regimes — timing, magnitude and frequency of flows • Reduced water depth • Impacts on flora and fauna (e.g. breeding events, vegetation distribution) • Impacts on habitat condition and availability • increased erosion and habitat destruction	Medium	Medium–long term (5 years to decades)

Outputs for inclusion in the ecological character description

This section of the ecological character description should include:

- ❑ the likely threats to the ecological character of the site
- ❑ the likely impacts or potential effects of the threat on the ecological character
- ❑ the likely timing of the threat, if possible.

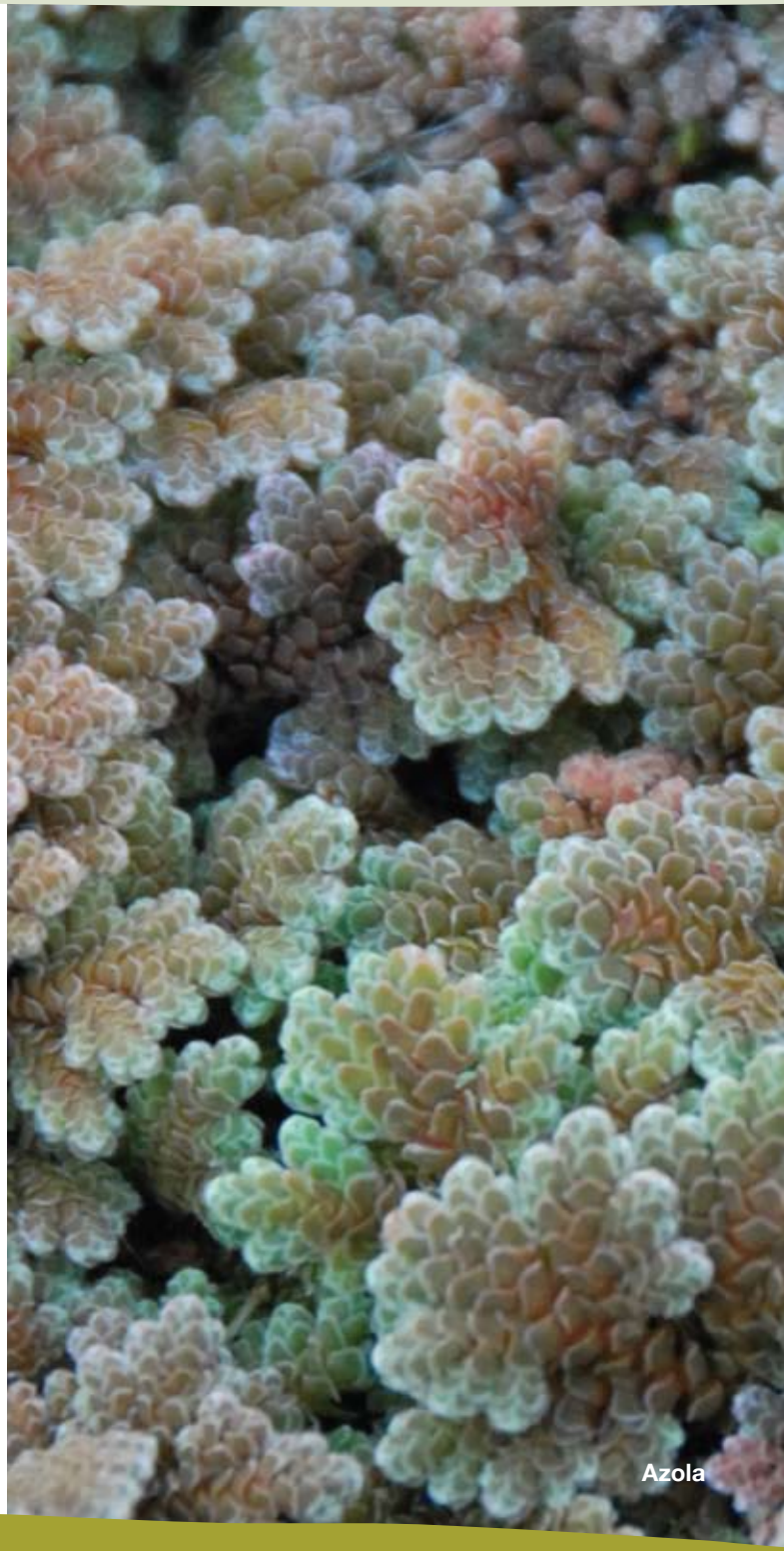
4.7 Description of the current ecological condition and identification of any changes in ecological character of the site

Aim: To determine if the ecological character of a wetland has changed.

Task: Briefly describe the current ecological character of the site and identify any changes in ecological character since site listing. These may be positive or negative changes.

This section should not be an extensive assessment of the current ecological character but should include whether there have been any quantitative or qualitative changes in any of the critical components, processes, benefits and services of the sites; whether they are within or outside their limits of change; the likely cause of the changes; and whether the site still meets the Ramsar nomination criteria that the site was listed for.

The ecological character description should include information about these changes so that they can then be taken into account in the monitoring, management and evaluation of the site. The management plan can use these findings to identify actions to maintain or restore the site, or to put in place actions to address any further negative changes.



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Outputs for inclusion in the ecological character description

Documentation for this section of the ecological character description should include:

- ❑ a brief description of the current ecological character of the site
- ❑ an outline of any quantitative or qualitative changes in the critical components, processes, and/or benefits/services
- ❑ whether these change(s) were beyond the bounds of normal seasonal (within years) or inter-annual variation (between years) and/or exceeded specified limits of environmentally acceptable change
- ❑ whether these changes were adverse and human induced
- ❑ a clear, quantified statement of the whether the site still meets the Ramsar nomination criteria the site was listed for
- ❑ whether the site meets any Ramsar criteria that may have been included since the site was listed.

4.8 Summarising the knowledge gaps

Aim: To list the knowledge gaps identified during the preparation of the ecological character description.

Task: Use steps 4.3–4.6 and other relevant information, to summarise the knowledge gaps for determining the ecological character of the site.

Summarise the knowledge gaps that were identified during development of the ecological character description. Where appropriate, describe any issues associated with data availability and accessibility, and how these affect the development of the ecological character description for the site. Knowledge gaps may be identified at multiple stages throughout the description, for example, during identification of components, processes, benefits and services, and when describing limits of acceptable ecological change. The information could be presented as a description or as a summary table, for example Table 9.

The identified knowledge gaps can be used to help target resources to address these priority gaps in knowledge and help in the management of the wetland.

Table 9. Example of some knowledge gaps and recommended monitoring or actions to address the gaps

Component	Specific component/ subcomponent/or process	Identified knowledge gaps	Recommended monitoring or other action to address the gap
Hydrology	Volumes and timing of inundation	Inundation records for wetland not available	Remote sensing or aerial photos of wetland extent over time Gauge information
	Groundwater input	Contributions from groundwater are not yet quantified	Monitor groundwater levels
Physical/ chemical	Water quality	Baseline water quality data needed for x and y	Sample water quality during flood events
Biota	Vegetation	Vegetation distribution has not been mapped	Remote sensing or aerial photos of vegetation types and distribution and ground truthing
	Fish	Fish diversity and abundance is not known	Fish surveys

4.9 Identification of site monitoring needs

Aim: To identify which aspects of the wetland's ecological character or which threats should be targeted for monitoring. The aim is not to devise a monitoring program, which would be undertaken in the site management plan or monitoring plan.

Task: Summarise any monitoring needs for the site in relation to determining or maintaining the site's ecological character.

This section should outline:

- recommended components, processes, benefits and services or threats that need to be monitored
- specific objective of monitoring of components, processes, services or threats (e.g. to fill a knowledge gap, to set limits of acceptable change, to detect changes in ecological character)
- priority for the monitoring
- recommended indicator or measure to be used
- recommended monitoring frequency.

Examples of monitoring activities are outlined in Table 10.

Outputs for inclusion in the ecological character description

This section of the ecological character description should include:

- ❑ a summary of the identified knowledge gaps
- ❑ pointers to potential future data sources, management actions or monitoring to address the gaps.

Identifying the important monitoring requirements for the site helps to provide input to the management and monitoring program, and ensures that these programs are linked to the ecological character of the wetland. The monitoring requirements may also provide further information that can be used to improve the understanding and description of the ecological character of the wetland.

This section should provide prompts or guidance as to the critical components, processes, benefits or services, or threats to the site that may require monitoring. There may be a number of different reasons for monitoring at the site in relation to the ecological character. For example, monitoring can be used to establish baseline information, set limits of acceptable change, address knowledge gaps, or to detect change in the ecological character. It may also be useful to monitor to establish relationships between components, processes, benefits or services, and threats so that in future, only one of them may need to be measured.

Some of the monitoring needs may have been identified after describing the components, processes, benefits and services of the wetland; setting limits of ecological change; identifying the risks and threats to the ecological character; or identifying knowledge gaps.

Table 10. Examples of monitoring actions that may be identified in an ecological character description

Overarching component, process, benefit or service	Specific component, process, benefit or service	Objective of the monitoring	Indicator/measure	Frequency	Priority
Hydrology	Magnitude, duration, frequency of inflows	Establish limits of change	• depth gauges • water meter	Monthly	High
Biota	Waterbirds	Establish benchmarks and limits of change	• presence/absence of waterbird species • presence/absence of target species • numbers of breeding pairs • number of nests	Bi-annual surveys Weekly within critical periods for species-specific information	High
	Native fish	Establish benchmarks and limits of change	• total species richness • proportion of native abundance • proportion of species richness • total abundance	Annually	Medium
	Macroinvertebrates	Detection of change	• presence/absence of families • total numbers of families • observed/expected score (if available)	Quarterly	Medium
	Vegetation — salt marshes	Establish benchmarks and limits of change	• mapping extent of main vegetation types	Bi-annual surveys	Medium
	Non-native species — weed invasion	Detection of change — likely threat to native vegetation	• extent • rate of spread over or within habitat	Bi-annual surveys	Medium
Water quality	Physicochemical parameters — turbidity, nutrients, salinity	Ongoing condition	• turbidity • nutrients • salinity	Monthly	Medium

Outputs for inclusion in the ecological character description

This section of the ecological character description should include suggested:

- ❑ monitoring for the critical components, processes, benefits or services most important to maintaining the ecological character of the site; this may include suggested monitoring to address the likely threats to ecological character of the site
- ❑ objectives of the monitoring
- ❑ indicators or measures to monitor
- ❑ monitoring frequencies
- ❑ priorities for monitoring.

4.10 Identification of important communication, education and public awareness messages

Aim: To highlight any important messages which may need to be addressed in a management or Wetland Communication, Education and Public Awareness (CEPA) action plan.

Task: Identify important communication, education and public awareness messages that may have been identified during the preparation of the description.

The important messages might include the following:

- why the site is important
- the Ramsar criteria that the site meets
- the species that are present at the site
- the threats to the site
- the status of the site.

This section is not intended to provide a comprehensive list of messages or an action plan. However, communication and public awareness activities can play an important role in wetland conservation, wise use and management. Under the Ramsar Convention, a Program of Communication, Education and Public Awareness 2003–2008 was established to help raise awareness of wetland values and functions. The program calls for coordinated international and national wetland education, public awareness and communication.

In response to this, Australia has established the Wetland Communication, Education and Public Awareness (CEPA) National Action Plan 2001–2005. This plan provides an umbrella for coordinated activities across Australia. It is an evolving plan that will document and provide guidance towards the collaboration of effectively delivered CEPA activities.

4.11 Compilation of the description of ecological character

Task: Using the information and outputs from steps 4.1–4.10, compile the description of ecological character. To reduce repetition, it may be necessary to combine information from steps 4.3 and 4.5. For some complex wetlands, it may be useful to divide the description into different sections based on major wetland types or functional units.

In addition to the information from these steps, include the following in the description:

- Executive summary
- Acknowledgments
- Table of contents
- A list of abbreviations
- A glossary
- References
- Appendixes

More detailed information on what to include under each of these headings can be found in Section 3.

Outputs for inclusion in the ecological character description

This section of the ecological character description should include a list or description of any key communication, education or public awareness activities identified during the development of the ecological character description that could be elaborated on in a management plan or CEPA action plan.

Compiling the ecological character description

To compile the ecological description:

- ❑ use the outputs from steps 3.1–3.10 to compile the ecological character description
- ❑ include an executive summary, acknowledgments, table of contents, abbreviations used, a glossary, references and appropriate appendixes.

4.12 Preparation of the Ramsar Information Sheet

Aim: To update the RIS for listed sites or prepare a RIS for a site to be listed.

Task: prepare (or update) a draft RIS and Ramsar site map at the same time as the ecological character description is being prepared. The draft RIS and map should be submitted as a companion document to the ecological character description.

The Ramsar Convention identifies the RIS as the place to describe ecological character. Therefore, the ecological character description will be appended to and regarded as a critical part of the RIS.

A RIS must be prepared for each Ramsar site at the time of listing and must be updated every six years, if necessary (Ramsar Convention 1996, Resolution VI.1 paragraph 2.3). The ecological character description should provide detailed input to a RIS (or an updated RIS), which should be done at the same time as the development of the ecological character description.

The format of the RIS changes periodically, so the Ramsar Convention website[14] should be checked to ensure the most current version of the RIS template is used. Associated explanatory notes for completing the sheet are also available here.

RISs are not required for non-Ramsar wetlands. For these sites the ecological character description should stand alone.

Outputs for submission with the ecological character description

For new Ramsar sites:

- ❏ a RIS to be submitted with the ecological character description.

For existing Ramsar sites

- ❏ an updated RIS to be submitted with the ecological character description.

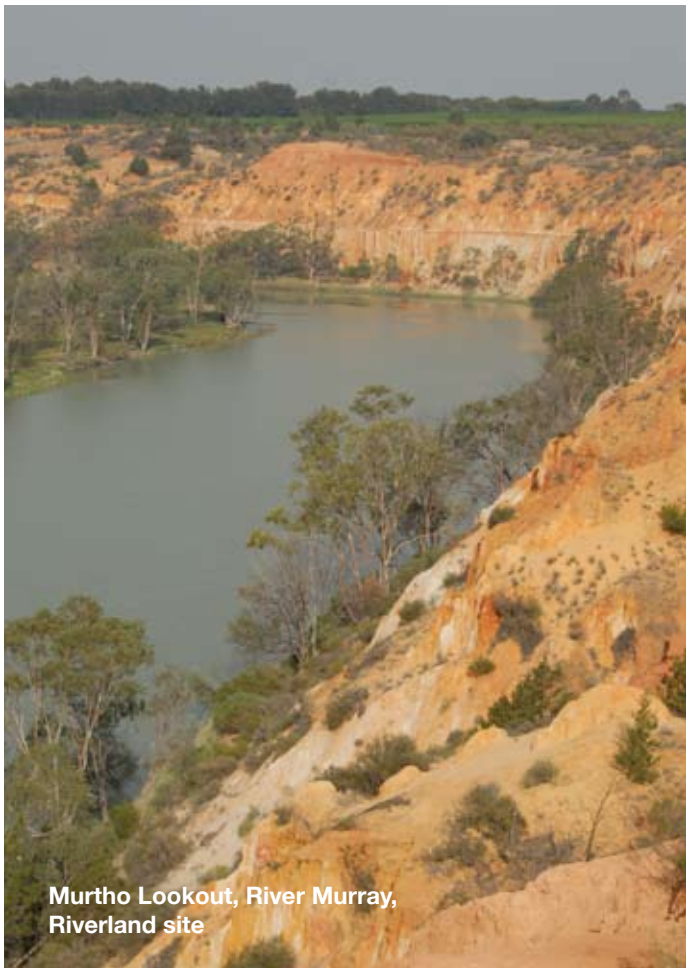
5. Submission of the ecological character description

During the development of the ecological character description, site managers and jurisdictions should consider consulting with DEWHA.

Once completed, the ecological character description, a new or revised RIS (for Ramsar wetlands) and Ramsar site map(s) should be forwarded to the state or territory government that will review it and provide comments. Once the state or territory government is satisfied with the description, it will be forwarded to DEWHA and checked to ensure that it meets the minimum requirements of the framework. For new sites, DEWHA will append the ecological character description to the RIS; this will form part of the nomination documentation that is provided to the Australian Government Environment Minister. If approved the nomination documentation will be submitted to the Ramsar Secretariat.

For existing sites, DEWHA will append the ecological character description to the RIS and forward them to the Ramsar Secretariat.

This information is noted by the Secretariat and copied to Wetlands International for inclusion in the Ramsar Sites Database.[15]



Murtho Lookout, River Murray, Riverland site

[14] http://ramsar.org/ris/key_ris.htm
[15] http://www.ramsar.org/index_list.htm

Appendix 1: Checklist for preparing an ecological character description

The following checklist outlines the required information as part of an ecological character description. The checklist should be completed and sent to the Australian Government Department of the Environment, Water, Heritage and the Arts with the ecological character description for the wetland.

- ❑ Executive summary of the ecological character of the site
- ❑ Acknowledgments
- ❑ Table of contents
- ❑ Abbreviations
- ❑ Introduction including:
  - ❑ Site details
  - ❑ Statement of purpose
  - ❑ Relevant legislation
- ❑ Detailed description of the site location including:
  - ❑ Maps, images and photographs of the site (including a map of the Ramsar site, clearly showing its location and the boundaries of the site). Maps should include border, orientation, legend, title and scale. Wetland boundaries should be drawn onto maps and satellite photographs.
  - ❑ Description of the land tenure
  - ❑ The relevant listing criteria (e.g. Ramsar or DIWA)
  - ❑ A list and map of the wetland types within the wetland
- ❑ A summary of the critical components, processes, benefits and services of the wetland
- ❑ A description of the critical components, processes, benefits or services of the site, and the relationships between them; include the reasons why they were chosen
- ❑ A conceptual model for the site
- ❑ A quantitative description of the limits of acceptable change for the key components, processes, benefits or services of the site
- ❑ The likely threats or risks to the ecological character of the site; the likely timing and impacts or potential effects of the threat on the ecological character
- ❑ Identification of any changes in ecological character (e.g. any changes in components, processes, or benefits or services of the site). If possible state whether these changes were adverse and human induced, and whether they were beyond the bounds of normal seasonal variation or specified limits of acceptable change. This should include information about the Ramsar criteria that the site met at the time of listing and meets at present
- ❑ Summary of the knowledge gaps
- ❑ Recommendations for monitoring including frequency, type, and priorities
- ❑ Communication, education and public awareness messages identified during preparation of the ecological character description
- ❑ References and sources of information
- ❑ Glossary
- ❑ Appendices, including the following:
  - ❑ Methods used to compile the description
  - ❑ List of community assemblages for the site
  - ❑ Short curriculum vitae for each author
- ❑ Companion material to be submitted with the ecological character description
- ❑ Updated RIS

Appendix 2: Ecological character and other requirements for Ramsar sites

This appendix summarises the main requirements and activities that relate to Ramsar sites and shows the context of the ecological character description in relation to these activities. The eight main activities that relate to Ramsar sites are listed below, and the outputs of each activity are identified.

Activity	Output
Ramsar site listing	Criteria for identifying wetlands of international importance met by the wetland Stakeholder support and management agreement for listing Ramsar information sheet Description of ecological character
Management plan	Consultation requirements and plan General wetland description Ecosystem services (including Ramsar criteria) and risks Wetland risk assessment Management objectives and strategies Implementation program ≤ 6 yearly review of RIS, ecological character and maps Monitoring program
Implementation of management plan	Annual works program
Environmental impact assessment (EIA)[a]	Conditions for approved actions
Monitoring	Results and conclusions
Evaluation	Status of ecological character Recommendations for review of management plan Effectiveness of conditions to minimise environmental impact of actions
Reporting	National reports to each Conference of Contracting Parties Notification to Ramsar Secretariat by Contracting Parties of change in ecological character
Communication, education and public awareness activities	Communication Education Public awareness raising

[a] EIA is required for controlled actions (actions likely to have a significant impact on the ecological character of the wetland) requiring approval under the Commonwealth of Australia *Environment Protection and Biodiversity Conservation Act 1999*. These may include actions or anticipated actions in a management plan that are likely to have a significant impact on the ecological character of the wetland.

Source: after DSE (2005a)

Appendix 3: Useful resources

The following section describes some suggested resources and links that might be useful in developing an ecological character description of the site.

General background information about the site

- The Ramsar Information Sheet for the site — see the Australian Wetlands Database for a copy. This also provides a description of DIWA wetlands in a similar format. http://www.environment.gov.au/water/publications/environmental/wetlands/database/index.html
- *A Directory of Important Wetlands in Australia*, 3rd edition, Environment Australia 2001. http://www.environment.gov.au/water/publications/environmental/wetlands/directory.html.
- The Ramsar List of Wetlands of International Importance for designation date of sites. http://ramsar.org/sitelist.pdf.
- Explanatory notes and guidelines for completing the Information Sheet on Ramsar Wetlands (RIS). http://ramsar.org/ris/key_ris.htm
- Ramsar criteria (Appendix 4) or DIWA criteria (Appendix 6).
- Wetland types for Ramsar sites. http://www.ramsar.org/ris/key_ris.htm#type.
- Wetland types for DIWA sites. http://www.environment.gov.au/water/publications/environmental/wetlands/directory.html.
- Publications and documented information on the wetland.
- Site manager or other stakeholders.
- Oral histories.
- *Mapping Specifications for Australian Ramsar Wetlands*. Module outlining the standards for delineation of boundaries, data capture and management and map production for Ramsar wetlands. This is intended to provide guidance to managers of Ramsar wetlands and agencies that have a role in the preparation and approval of documentation for Ramsar wetlands.
- State or territory environmental, natural resource or planning departments or agencies.

Treaties, legislation and regulations

International

- Information on the Ramsar Convention. www.ramsar.org

National

- *Environment Protection and Biodiversity Conservation Act 1999* and Environment Protection and Biodiversity Conservation Regulations 2000. http://www.environment.gov.au/epbc/about/index.html

State and territory

- The Australian Legal Information Institute website can be used to find relevant legislation for each state or territory http://www.austlii.edu.au
- Australian Capital Territory http://www.legislation.act.gov.au/
- New South Wales http://www.legislation.nsw.gov.au/
- Northern Territory http://www.nt.gov.au/dcm/legislation/current.html.
- Queensland http://www.legislation.qld.gov.au/OQPChome.htm.
- Tasmania http://www.thelaw.tas.gov.au/index.w3p.
- Victoria http://www.dms.dpc.vic.gov.au/.
- Western Australia http://www.slp.wa.gov.au/statutes/swans.nsf.

Fivebough

Threatened, endangered and migratory species

- Information on threatened species or ecological communities: http://www.environment.gov.au/biodiversity/threatened/index.html
- Information on the listings of threatened species, communities and threatening processes since commencement of the EPBC Act: http://www.environment.gov.au/cgi-bin/sprat/public/publiclistchanges.pl
- Information on migratory species: http://www.environment.gov.au/biodiversity/migratory/index.html
- Information on the *East Asian–Australasian Shorebird (or wading bird) Reserve Network* launched in 1996 and which now falls under the *Asia-Pacific Migratory Waterbird Conservation Strategy 2001–2005*. The strategy aims to establish a network of the most important wetland sites used by migratory wading birds along the East-Asian Australasian Flyway. The flyway spread from the nonbreeding sites in New Zealand and Australia through southeast Asia, China and Japan, to the main breeding sites in Siberia and Alaska: http://www.environment.gov.au/biodiversity/migratory/waterbirds/2001–2005/index.html
- State and territory websites may have additional information about state and territory specific threatened species or communities.

More detailed site information

The following may be useful in preparing an ecological character description for your wetland:

- Results of relevant monitoring programs (e.g. water quality, bird surveys, diatom work, vegetation mapping)
- National or state guideline documents (e.g. ANZECC and ARMCANZ (2000a) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Document 4). These provide default water quality guidelines for a range of water quality parameters. If specific water quality objectives have not been set for your water body, consult http://www.environment.gov.au/water/quality/nwqms/index.html
- Publications and documented information on the wetland
- Site manager, wetland experts and other knowledgeable stakeholders
- Oral histories
- Conceptual model developed for the site
- Tables 3–5
- Activities and land uses occurring within the wetland catchment
- Existing management plan(s)
- Natural resource management plan(s) for the area

Developing conceptual models

Information on developing conceptual models can be found at the following sites:

- *Queensland Wetlands Programme Wetland Indicators Scoping Study Project*. A series of conceptual models for different wetland types were developed as part of the Queensland Wetland Programme (Maher et al. 2007). These include models of a variety of palustrine and lacustrine wetlands. These models may be a useful starting point for developing a conceptual model for a specific wetland.
- *Build a Conceptual Model, Oz Coast*, Coastal CRC. This site allows you to create simple conceptual models for estuarine wetlands. It provides templates of estuary types as well as specific Australian estuaries on which to base your model. http://www.ozcoasts.org.au/conceptual_mods/cm_build.jsp
- Geomorphic conceptual models have been developed for each of the seven types of Australian estuaries and coastal waterways on the Ozestuaries website. http://www.ozcoasts.org.au/conceptual_mods/cm_build.jsp#0
- *Integration and Application Network, University of Maryland, Center for Environmental Science*. This site contains over 1500 custom-made vector symbols, over 100 custom swatches, ecosystem landscapes and an interactive multimedia tutorial. The libraries Are available to download free of cost and are royalty free. http://ian.umces.edu/symbols/.
- *Conceptual Diagrams — Tools for Science, Integration and Application Network University of Maryland, Center for Environmental Science*. This site provides background material on developing conceptual models and provides links and resources for developing conceptual models. http://ian.umces.edu/conceptualdiagrams_page.php.
- *Conceptual Models, Centre for Marine Studies, Marine Botany Laboratory, University of Queensland.* This site provides some example conceptual models such as benthic algae. http://www.marine.uq.edu.au/marbot/marineplants/benticmicroalgae.htm
- *Australian Natural Resources Atlas: Understanding Estuary Processes*, Department of the Environment, Water, Heritage and the Arts. The site includes some generic 3D-conceptual models that illustrate the general characteristics of wave- and tide-dominated estuaries and deltas, and the way they transport sediment and cycle nitrogen. http://audit.deh.gov.au/ANRA/coasts/coasts_frame.cfm?region_type = AUS&region_code = AUS&info = process.
  The site also includes some simple conceptual models for various estuary uses and their impacts on estuarine ecology. Each diagram shows examples of good and poor estuary management practices. http://audit.deh.gov.au/ANRA/coasts/coasts_frame.cfm?region_type = AUS&region_code = AUS&info = condition

- Ryan DA, Heap AD, Radke L and Heggie DT (2003). Conceptual models of Australia's estuaries and coastal waterways: applications for coastal resource management. Geoscience Australia, record 2003/09, 136 pp. *(Geoscience Australia)* http://dbforms.ga.gov.au/pls/www/npm.ozest.show_mm?pBlobno = 10277.
- *Developing Conceptual Models for Monitoring Programs* (Gross 2003) provides a guide to the development of conceptual models, in particular for the design of wetland monitoring programs. http://science.nature.nps.gov/im/monitor/docs/Conceptual_Modelling.pdf.

Ramsar Convention manual and handbooks

- The Ramsar Secretariat prepared *The Ramsar Convention Manual, a Guide to the Convention on Wetlands (Ramsar, Iran, 1971), fourth edition* (Ramsar Convention 2006) to provide information about the Ramsar Convention and its processes. http://www.ramsar.org/lib/lib_manual2006e.htm
- The Ramsar Secretariat has also prepared a series of handbooks that cover a range of topics such as wetland conservation and wise use, communication and education, wetland management, wetland inventory and a number of other topics. The handbooks are listed below:

Wise use of wetlands

1. Handbook 1 Conceptual Framework for the wise use of wetlands.

Wetlands policies and legislation

2. Handbook 2 National Wetland Policies. Developing and implementing National Wetland Policies.
3. Handbook 3 Laws and institutions. Reviewing laws and institutions to promote the conservation and wise use of wetlands.

Wetlands and people

4. Handbook 4 Wetland CEPA. The Convention's Programme on communication, education and public awareness (CEPA) 2003–2008.
5. Handbook 5 Participatory skills. Establishing and strengthening local communities' and indigenous people's participation in the management of wetlands.

Wetlands and water

6. Handbook 6 Water-related guidance. An integrated framework for the Convention's water-related guidance.
7. Handbook 7 River basin management. Integrating wetland conservation and wise use into river basin management.
8. Handbook 8 Water allocation and management. Guidelines for the allocation and management of water for maintaining the ecological functions of wetlands
9. Handbook 9 Managing groundwater. Managing groundwater to maintain ecological character.

Wetlands and spatial planning

10. Handbook 10 Coastal management. Wetland issues in Integrated Coastal Zone Management.

Wetland inventory, assessment and monitoring

11. Handbook 11 Inventory, assessment and monitoring. An integrated framework for wetland inventory, assessment and monitoring.
12. Handbook 12 Wetland inventory. A Ramsar framework for wetland inventory.
13. Handbook 13 Impact assessment. Guidelines for incorporating biodiversity-related issues into environmental impact assessment legislation and/or processes and in strategic environmental assessment.

Wetlands of international importance

14. Handbook 14 Designating Ramsar Sites. Strategic Framework and guidelines for the future development of the List of Wetlands of International Importance.
15. Handbook 15 Addressing change in ecological character.

Managing wetlands

16. Handbook 16 Managing wetlands. Frameworks for managing Wetlands of International Importance and other wetlands.

International cooperation

17. Handbook 17 International cooperation. Guidelines for international cooperation under the Ramsar Convention on Wetlands.

The handbooks can be downloaded from the Ramsar Convention Website:
http://www.ramsar.org/lib/lib_handbooks2006_e.htm

Other sources of information

- Information on environmental allocations and water requirements can be found in *Environmental Water Requirements to Maintain Wetlands of National and International Importance* (Davis et al. 2001). http://www.environment.gov.au/water/publications/environmental/rivers/nrhp/wetlands.html
- *Australian Guidelines for Water Quality Monitoring and Reporting* (ANZECC and ARMCANZ 2000b) http://www.environment.gov.au/water/publications/quality/index.html#nwqmsguidelines
- *Recommended Methods for Monitoring Floodplains and Wetlands* (Baldwin et al. 2005). http://publications.mdbc.gov.au/ This document includes information and references to methods for monitoring surface water, groundwater, soil and sediment, birds, fish, frogs, macroinvertebrates, vegetation and phytoplankton.
- The *National Framework for Natural Resource Management Standards and Targets* and the *National Natural Resource Management Monitoring and Evaluation Framework* provide information to assist with setting targets, monitoring, evaluation and reporting on natural resource management. http://www.nrm.gov.au/publications/frameworks/standards-targets-framework.html http://www.nrm.gov.au/publications/frameworks/me-framework.html

Appendix 4: Ramsar criteria for identifying wetlands of international importance

Group A of the criteria; 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 of the criteria. Sites of international importance for conserving biological diversity	
Criteria based on species and ecological communities	**Criterion 2:** A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities. **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. **Criterion 4:** A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.
Specific criteria based on waterbirds	**Criterion 5:** A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds. **Criterion 6:** A wetland should be considered internationally important if it regularly supports 1 per cent of the individuals in a population of one species or subspecies of waterbird.
Specific criteria based on fish	**Criterion 7:** 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:** 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.
Specific criteria based on other taxa	**Criterion 9:** A wetland should be considered internationally important if it regularly supports 1 per cent of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species.

Source: Ramsar Convention (1999a); Ramsar Convention (2005b).

Appendix 5: Comparison table for pre-1999 and current Ramsar criteria for identifying wetlands of international importance

Current criteria (2005)	Pre-1999 criteria
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.	1(a) it is a particularly good representative example of a natural or near-natural wetland, characteristic of the appropriate biogeographical region 1(b) it is a particularly good representative example of a natural or near-natural wetland, common to more than one biogeographical region 1(c) it is a particularly good representative example of a wetland which plays a substantial hydrological, biological or ecological role in the natural functioning of an major river basin or coastal system, especially where it is located in a trans-border position 1(d) it is an example of a specific type of wetland, rare or unusual in the appropriate biogeographical region.
Criterion 2: A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.	2(a) it supports an appreciable assemblage of rare, vulnerable or endangered species or subspecies of plant or animal, or an appreciable number of individuals of any one or more of these species.
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.	2(b) 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 2(d) it is of special value for one or more endemic plant or animal species or communities 3(b) it regularly supports substantial numbers of individuals from particular groups of waterfowl, indicative of wetland values, productivity or diversity.
Criterion 4: A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.	2(c) it is of special value as the habitat of plants or animals at a critical stage of their biological cycle.
Criterion 5: A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.	3(a) it regularly supports 20,000 waterfowl.
Criterion 6: A wetland should be considered internationally important if it regularly supports 1 per cent of the individuals in a population of one species or subspecies of waterbird.	3(c) where data on populations are available, it regularly supports 1 per cent of the individuals in a population of one species or subspecies of waterfowl.
Criterion 7: 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.	4(a) 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: 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.	4(b) 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: A wetland should be considered internationally important if it regularly supports 1 per cent of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species.	None.

Source: after DSE (2005a)

Appendix 6: Criteria for determining nationally important wetlands

The criteria for determining nationally important wetlands in Australia are those agreed to by the Natural Resource Policies and Programs Committee in 2006, and included in the third edition of *A Directory of Important Wetlands in Australia* (Environment Australia 2001).

A wetland may be considered nationally important if it meets at least one of the following criteria:

1. It is a good example of a wetland type occurring within a biogeographic region in Australia.
2. It is a wetland which plays an important ecological or hydrological role in the natural functioning of a major wetland system/complex.
3. It is a wetland which is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail.
4. The wetland supports 1 per cent or more of the national populations of any native plant or animal taxa.
5. The wetland supports native plant or animal taxa or communities which are considered endangered or vulnerable at the national level.
6. The wetland is of outstanding historical or cultural significance.

Many of the sites in the directory meet more than one of the criteria. Application of the criteria to individual wetland sites involves a degree of subjectivity. Not only may certain aspects of a site's significance be interpreted differently by different investigators, but information gaps often exist that make it difficult to judge whether or not a site meets a particular criterion.

The Interim Biogeographic Regionalisation for Australia is used as the framework for applying Criterion 1, which identifies wetlands that are unique or representative within a biogeographic region in Australia.

Egret Fishing

Appendix 7: Typical wetland ecosystem benefits or services

Category of ecosystem benefit or service	Wetland ecosystem service or benefit	Description
Provisioning services Human uses and direct benefits for humans *The material products provided directly from wetland ecosystems, including food, fresh water, fibre and fuel, biochemicals, and genetic material (Millennium Ecosystem Assessment 2005b:2).*	Water supply	Role of ecosystems in storage, retention, processing and release of water that can be used as a water supply.
	Drinking water	Suitable raw drinking water supply. This assumes minimal treatment of water is required — for example, coarse screening and/or disinfection.
	Domestic farm water supply	Suitable domestic farm water supply other than drinking water — for example, *water quality* and quantity suitable for use for laundry and produce preparation.
	Stock watering	Suitable water supply and quantity for production of healthy livestock.
	Irrigation	Suitable water supply for irrigation, for example, irrigation of crops, pastures, parks, gardens and recreational areas.
	Industrial uses	Suitable water supply for industrial use — for example, food, beverage, paper, mining and power industries. Industries usually treat water supplies to meet their needs.
	Aquaculture	Suitable water supply for the health of *aquaculture* species and humans consuming cultured foods (such as fish, mollusks, and crustaceans).
	Provision of aquatic foods for human consumption	Suitability of a wetland to ensure the health of humans consuming aquatic foods — such as fish, crustaceans, shellfish, and seaweeds.
	Wetland products, such as animal and plant material	Provision of species or populations of flora, fauna and other resources that can be used by humans either directly or indirectly. For example, wetlands may provide fish, brood stock for aquaculture, salt, stock fodder (e.g. grazing), timber, fuel wood, peat or other products.
	Biochemical products	Presence of species or abiotic components with potential useful chemicals that can be used, for example, for medicinal or industrial uses.
	Genetic resources	Role in preserving a natural reservoir for biological diversity and providing genetic resources that can support colonisation, contribute to maintaining intra-species diversity, and allow for research and development such as selective breeding. Includes the provision of genetic resources for resistance to pathogens, or tolerance to environmental conditions, and the development of new medicines.
	Ornamental species	Presence of species or abiotic resources with ornamental use such as aquarium fish and plants.

Category of ecosystem benefit or service	Wetland ecosystem service or benefit	Description
Regulating Services Human uses and benefits *The material benefits obtained from the regulation of wetland ecosystem processes, including climate regulation, the regulation of surface and groundwater flows, water purification and waste water treatment, erosion regulation, natural hazard mitigation, and pollination (Millennium Ecosystem Assessment 2005b:2). These may include material benefits wetlands provide to humans as well as non-material services.*	Maintenance and regulation of hydrological cycles and regimes	Capacity of wetlands to regulate hydrological processes and cycles, including retaining and retarding flows, maintaining groundwater–surface water balances through recharge and discharge processes, and providing habitats and refugia for wetland-dependent species
	Maintenance and regulation of air quality	Capacity of wetlands to regulate air quality, for example, by extracting chemicals and particles from the atmosphere.
	Maintenance and regulation of climate	Regulation of greenhouse gases, temperature, precipitation and other climatic processes. Role in mitigating the *enhanced greenhouse effect* and the impacts of *climate change*, for example, by sequestering and storing carbon dioxide from the air.
	Maintenance and regulation of local climate	Influence on local climatic affects, for example, through evaporation of water that can help to form mist, fog and rain and provide a local cooling effect.
	Coastal shoreline stabilisation and storm protection	Role in reducing *coastal hazards* and maintaining *coastal processes*, due to the physical structures provided by wetland and its biota. For example, stabilisation of the substrate and provision of shelter from the impacts of wind, wave action and currents.
	Bank stabilisation and erosion protection	Role in stabilizing banks, substrate and retaining soils, and in preventing erosion and slumping.
	Biological control of pest species and diseases and support of predators of agricultural pests	Provision of habitat for animals that can control pests and diseases. For example, some frogs and fish that live in wetlands reduce the abundance of disease vectors by eating mosquitoes or their larvae. Some wetlands provide habitat for predators that control agricultural pests, for example, ibis feeding on grasshoppers.
	Pollution control and detoxification through trapping, storage and/or treatment of contaminants	Role of a wetland in slowing flow, trapping and assimilating sediments, nutrients and other contaminants, and 'buffering' the amount of contaminant transfer that may occur during flow events. Contaminants may arise from natural or anthropogenic sources. Diffuse sources of pollution include stormwater runoff from urban or agricultural land, irrigation areas, degraded landscapes or urban stormwater management systems. Point sources include discharges from sewage treatment plants or industry.
	Natural hazard reduction	Role in reducing floodwater impacts (for example, reducing peak levels and velocity), storm protection, shoreline and riverbank stabilisation, and reduction in fire intensity and frequency.

Category of ecosystem benefit or service	Wetland ecosystem service or benefit	Description
Cultural Services Human uses and benefits *The benefits people obtain through spiritual and inspirational enrichment, recreation, education, and aesthetic experiences, including recreational, spiritual, religious, and other non-material benefits (Millennium Ecosystem Assessment 2005:v and 2). There may be places or objects that have anthropological, archaeological, historical, scientific, spiritual, visual or sociological significance or value, including such significance or value under Aboriginal tradition or Torres Strait Island custom.*	Recreation	Provision of areas for people to undertake recreational and nature-based activities. Activities may include some contact with water such as wading, swimming, canoeing, rafting, boating, rowing, sailing, hunting and fishing. They may also include activities that involve no contact with water such as walking and picnicking adjacent to a wetland and nature observation such as bird watching.
	Tourism	Provision of areas for people to undertake activities associated with tourism. For example, ecotourism, camping, and tourists using the wetland for activities such as fishing or tours.
	Science and education	Presence of features with educational and scientific interests, for example, learning about wetlands.
	Aesthetic amenity (including unique or representative land and waterscapes)	Provision of 'iconic' natural scenery, for example, attractive landscapes and environment that people can view, enjoy, or otherwise appreciate. It may also display the 'typical' wetland features or characteristics, usually relating to a type or class of wetlands. It may be representative of a combination of geomorphic, ecological and hydrological wetland features, and may also represent individual features of high value such as particular fish communities. Representative examples may or may not be common, so some examples may also have rarity value.
	Cultural heritage and identity	The wetland provides culturally important landscape features or species. For example the wetland may contain historical structures or sites that use wetland derived products, tools for hunting wetland-dependent biota. There may also be sites of spiritual significance such as burial sites.
	Spiritual and inspirational	The wetland may provide a source of inspiration for religion and art. The wetland may represent a place of significant nonmaterial culture such as though folklore, music, customs and traditional knowledge, and may also include species of cultural and religious significance, including family and totem species.
Supporting Services Wetland ecosystem services *Those services necessary for the production of all other ecosystem services, and include soil formation and nutrient cycling (Millennium Ecosystem Assessment 2005b:2). They include the intrinsic environmental value of wetland ecosystem components, processes, and services/benefits that provide environmental benefits. These services often provide indirect human benefits by supporting other environmental services or benefits (Millennium Ecosystem Assessment 2005).*	Hydrological processes	The wetland supports the cyclic movement of water through the surface, subsurface, and atmospheric compartments associated with a wetland, and the resultant variation of the spatial and temporal distribution of the water and its properties and characteristics. Variation in a wetland's hydrological processes can affect many ecological aspects of the wetland itself and can also influence aspects of global, aquifer and catchment-scale hydrological cycles. For example, a wetland may allow localised groundwater recharge, evaporation that increases the amount of atmospheric moisture, and storage and delivery of water.
	Food webs	The wetland supports a network of living things in a wetland that depend on each other for food. Food webs involve a complex network of interactions and pathways that transfer energy and nutrients from one species to another.
	Physical habitat	Supports physical features (biotic and abiotic) that are important for proper function of wetland ecosystems and processes, including providing habitat for part or parts of the lifecycle of wetland organisms (e.g. for migration, feeding, breeding, hibernation). For example, riparian areas provide habitat for aquatic macroinvertebrates, trap sediment, shade the waterway, and reduce erosion. Some waders have specific physical habitat characteristics when feeding. Some fish require specific physical habitat to spawn.

Category of ecosystem benefit or service	Wetland ecosystem service or benefit	Description
	Nutrient cycling	Uptake, transformation, processing, storage, movement and reuptake of compounds that promote biological growth or development in a wetland ecosystem, including repeated pathways of particular nutrients or elements from the environment through one or more organisms back to the environment. This includes primary production and the carbon, nitrogen and phosphorus cycles.
	Primary production (for economic based primary production see Provisioning Services)	Green plants and certain bacteria are able to convert inorganic matter into biomass using energy from solar radiation or chemical energy. They are the first link in the food chain and are therefore called the primary producers (autotrophs). All other life depends on the energy fixed by these primary producers. Wetlands can provide a suitable location and resources for primary production. This supports other activities such as aquaculture, grazing, and fisheries production.
	Sediment trapping, stabilisation and soil formation	Processes of trapping and stabilisation of sediment and accumulation of organic matter that occur as a function of the physical features of a wetland and its biotic communities. These processes can affect the rate and temporal aspects of sediment movement to downstream areas and reduce the likelihood of erosion in and around a wetland.
	Biodiversity	Supports a variety of wetland species, communities, habitats, and geomorphic features.
	Special ecological, physical or geomorphic features	Supports special ecological features, generally uncommon in the landscape, that arise from a combination of features such as uncommon species, habitat, geomorphic features or ecological functions (including acting as refuge in terms of drought, supporting species at a vulnerable or particular stages of their life cycle, or supporting high productivity).
	Distinct or unique wetland species	Supports species that may be common but are also notable or otherwise important, such as keystone or indicator species. These may also include iconic species such as those species that are especially important to a community, often in a symbolic sense, or by association (such as platypus, sea eagles, brolgas, freshwater cod, barramundi, etc).
	Threatened wetland species, habitats and ecosystems	Supports listed threatened species, ecosystems or habitats in association with a wetland. For example, the presence of a listed rare or threatened wetland type or endangered habitat such as an endangered regional ecosystem or an endangered, threatened or rare community.
	Priority wetland species and ecosystems	Supports wetland species, ecosystems, habitat, or processes that have been identified for special management (e.g. species or species subject to a recovery or management plan, or sites listed under *A Directory of Important Wetlands in Australia, JAMBA, CAMBA,* or ROKMBA).
	Natural or near-natural wetland ecosystems	Supports a natural or near-natural wetland. Lack of human-induced disturbance, incorporating consideration of the ecological integrity and resilience (e.g. the capacity of the wetland ecosystem to sustain a community of organisms and habitats over time and to be resilient to natural forms of disturbance). Wetlands that have been disturbed by humans often have lower ecological integrity than natural wetlands.
	Ecological connectivity	Supports another wetland or wetland aggregation, terrestrial ecosystem, or species transfer or movement, including supporting another wetland's hydrological processes, providing a pathway for seed dispersal, or interconnected habitat for migratory birds.

Millennium Ecosystem Assessment (2005a). *Ecosystems and Human Wellbeing — Synthesis*, Island Press, Washington, DC.
Millennium Ecosystem Assessment (2005b). *Ecosystems and Human Wellbeing: Wetlands and Water — Synthesis*, Island Press, Washington, DC.

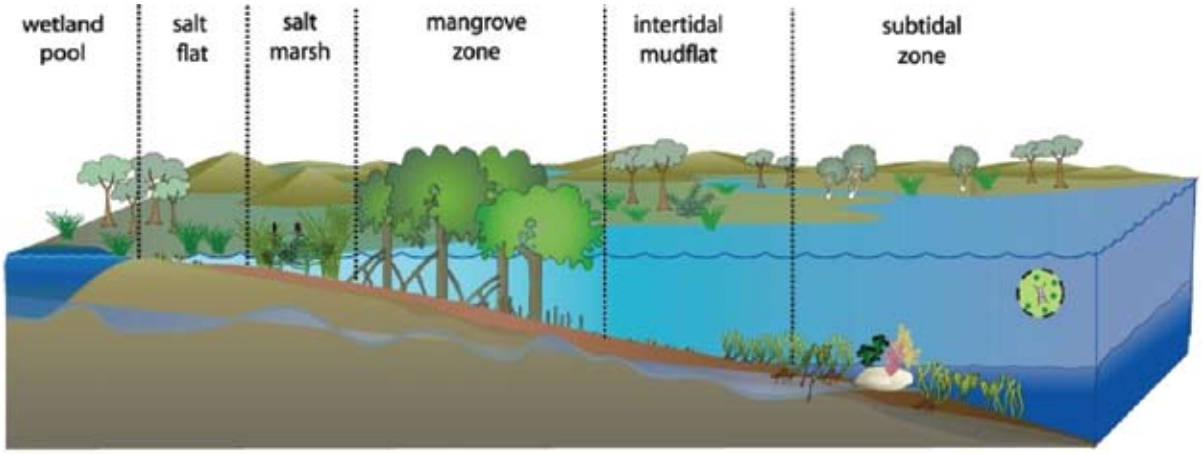
Appendix 8: Guide to identifying ecosystem benefits or services that relate to the Ramsar criteria for identifying wetlands of international importance

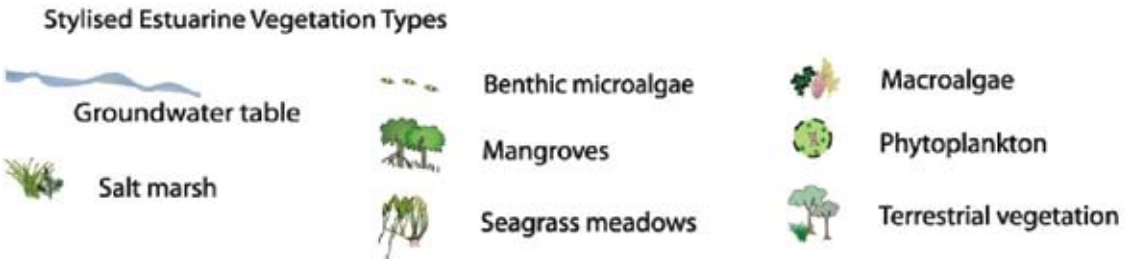
Criterion	Ecosystem services relating to criterion
Group A of the Criteria; sites containing representative, rare or unique wetland types	
Criterion 1: A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.	If the Ramsar site meets this criterion, the relevant ecosystem services should relate to: • representativeness based on wetland types (using the Ramsar classification system for wetland type) within biogeographic regions • rarity or uniqueness of wetland types in the Ramsar site • naturalness making the Ramsar site a good examples of the wetland type or types • the natural control, amelioration or prevention of flooding • seasonal water retention for wetlands or other areas of conservation importance downstream • recharge of aquifers • being part of karst or underground hydrological or spring systems that supply major surface wetlands • being major natural floodplain systems • having a major hydrological influence in the context of at least regional climate regulation or stability (for example, certain areas of cloudforest or rainforest, wetlands or wetland complexes in semi-arid, arid or desert areas, tundra or peatland systems acting as sinks for carbon, etc) • having a major role in maintaining high water quality standards.
Group B of the Criteria; sites of international importance for conserving biological diversity	
Criteria based on species and ecological communities	
Criterion 2: A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.	If the Ramsar site meets this criterion, the relevant ecosystem services should relate to: • supporting threatened species, including mobile species at different stages of their lifecycle or along a migratory pathway, species taking refuge during adverse conditions, and dispersed sedentary threatened species that occupy a restricted habitat type • enhancing the viability of threatened species' populations by increasing the size of habitat that is protected adjacent to or in close proximity to other protected wetlands • supporting rare or threatened ecological communities, particularly where these are of high quality or particularly typical of the biogeographic region.
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.	If the Ramsar site meets this criterion, the relevant ecosystem services should relate to: • supporting a high level of biodiversity in the biogeographic region • supporting significant numbers of endemic species • supporting the range of biological diversity (including habitat types) occurring in a biogeographic region • supporting a significant proportion of species adapted to special environmental conditions (such as in temporary wetlands in semiarid or arid areas) • supporting particular elements of biodiversity that are rare or particularly characteristic of the biogeographic region.
Criterion 4: A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles or provides refuge during adverse conditions.	If the Ramsar site meets this criterion, the relevant ecosystem services should relate to: • supporting particularly high proportions of mobile or migratory species populations gathered in relatively small areas at particular stages of lifecycles (for example, eating, resting, moulting) • supporting nonmigratory species during dry periods.

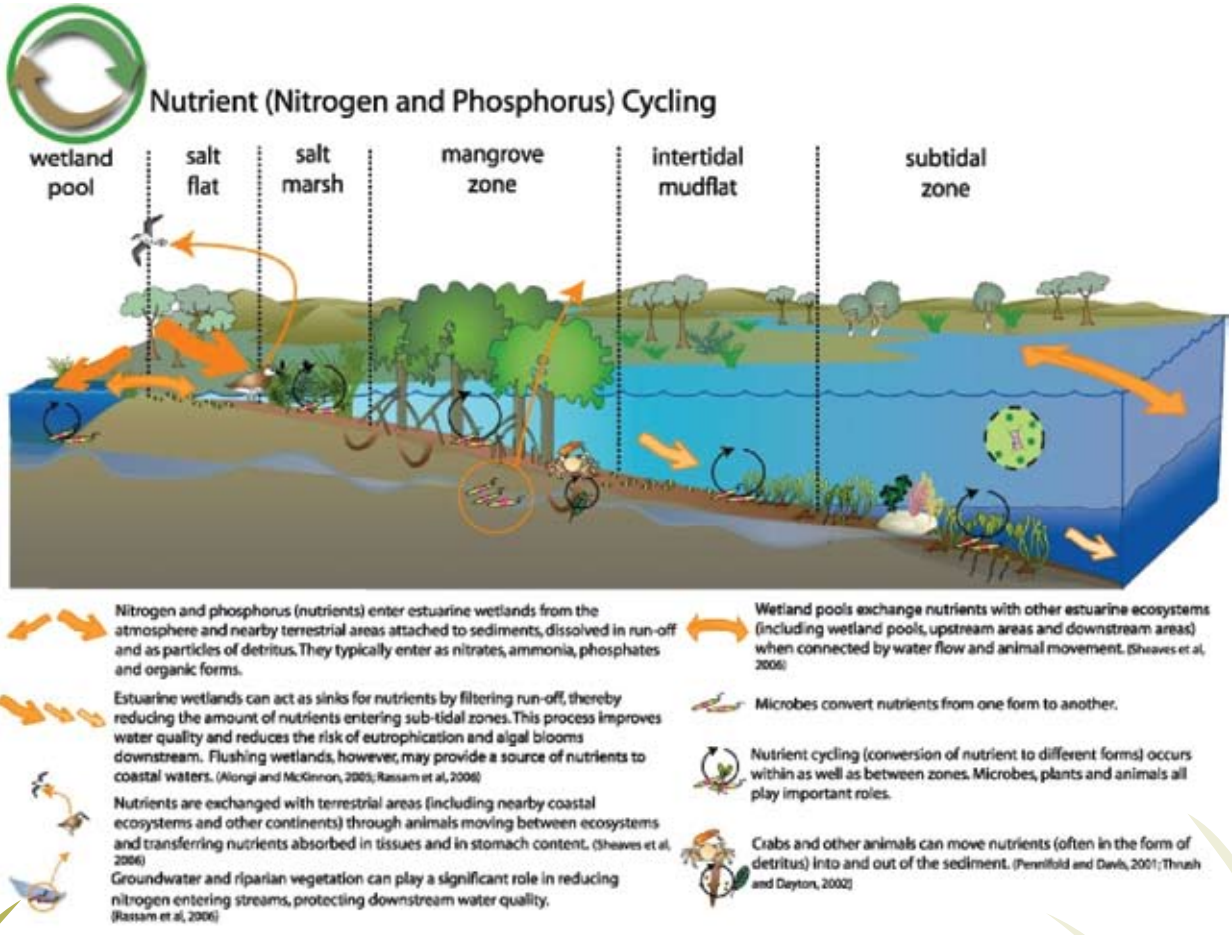
Criterion	Ecosystem services relating to criterion
Group B of the Criteria; sites of international importance for conserving biological diversity	
Specific criteria based on waterbirds	
Criterion 5: A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.	If the Ramsar site meets this criterion, the wetland should regularly support 20,000 or more waterbirds.
Criterion 6: A wetland should be considered internationally important if it regularly supports 1 per cent of the individuals in a population of one species or subspecies of waterbird.	If the Ramsar site meets this criterion, the wetland should regularly support 1 per cent of the individuals in a population of one species or subspecies of waterbird based on the international population estimates and 1 per cent thresholds published and updated every three years by Wetlands International (Wetlands International 2002).
Specific criteria based on fish	
Criterion 7: 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.	If the Ramsar site meets this criterion, the relevant ecosystem services should relate to: • supporting a high diversity of fishes and shellfishes related to several factors: number of taxa; different life-history stages; species interactions; and the complexity of interactions between the taxa and the external environment • supporting significant numbers (at least 10 per cent) of endemic species or genetically distinct infraspecific categories such as geographical races • supporting a community that demonstrates high biodisparity (ie a large range of morphologies and reproductive styles).
Criterion 8: A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.	If the Ramsar site meets this criterion, the relevant ecosystem services should relate to: • providing areas that are essential for the completion of a fish's life cycle • supporting essential ecological processes for fish stocks, even if they do not necessarily harbour large adult fish populations themselves • provide habitat for spawning.
Specific criteria based on other taxa	
Criterion 9: A wetland should be considered internationally important if it regularly supports 1 per cent of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species.	If the Ramsar site meets this criterion, the wetland should regularly support 1 per cent of the individuals in a population of a species or subspecies of wetland-dependent animal, and it should be recognised that in many cases the biogeographic range of the population is larger than the territory of one contracting party. For each population listed under Criterion 9, the name of the biogeographic population, as well as the number of individuals of this population regularly occurring in the site, should be listed. In the application of this Criterion, it is not sufficient simply to restate the Criterion, that the site supports >1 per cent of a population, nor is it a correct justification to list populations with numbers in the site >1 per cent of their *national* population, except when the population is endemic to that country.

Adapted from Ramsar Convention (1999c) Criterion 9 added in 2005.
Source: DSE (2005a)

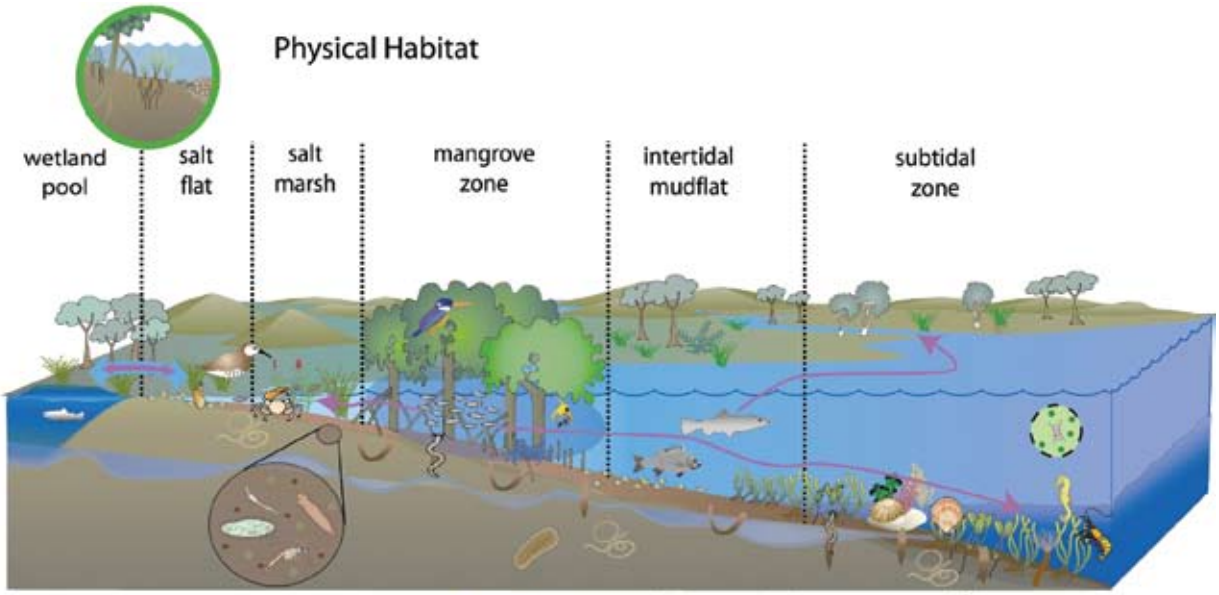
Appendix 9: Example conceptual models







Physical Habitat



Estuarine wetlands provide a variety of habitats for fish. Small fish move with the tides to access mangrove areas, where they find protection, and to the saltmarsh, where some feed. (Connolly et al, 2006). Some fish move upstream and downstream to freshwater and marine habitats at different stages of their life cycles to breed and spawn. (Robins et al, 2006).

Water flow between wetland pools and estuaries during very high tides, floods or run-off events allows fish to move between these habitats. (Sheaves 2006).

Mangroves shade water and sediment, buffering temperature and blocking UV radiation, providing a habitat for other organisms. (Hsieh, 1995)

Mangroves are important nursery areas for some juvenile fish and crustacean larvae. (Blaber, 2000, Beck et al, 2001)

Many organisms in estuarine wetalnds live in or on the sediment, including worms and microbes.

Prawns

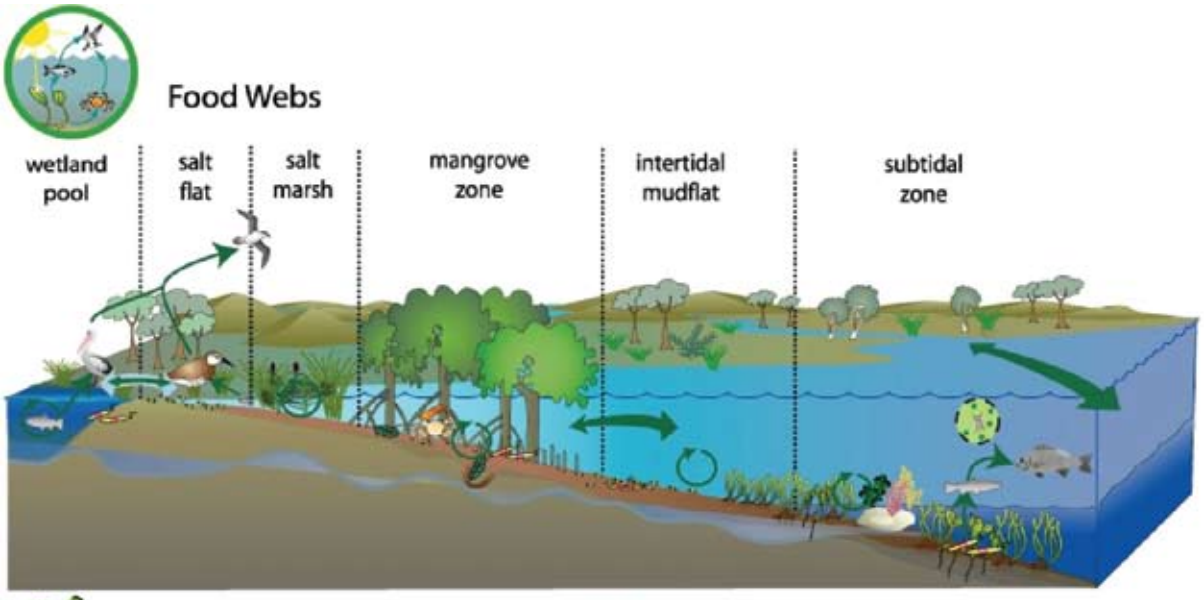
Shellfish

Fish

Migratory and resident birds

Crabs

Food Webs



Plants convert carbon from the atmosphere into plant matter that can then be consumed by animals. Thus forming the basis of many estuarine food webs.

Flow of carbon

Carbon cycling occurs in food webs within and between zones

Microbes decompose detritus and recycle carbon (Dennison and Abal, 1999)

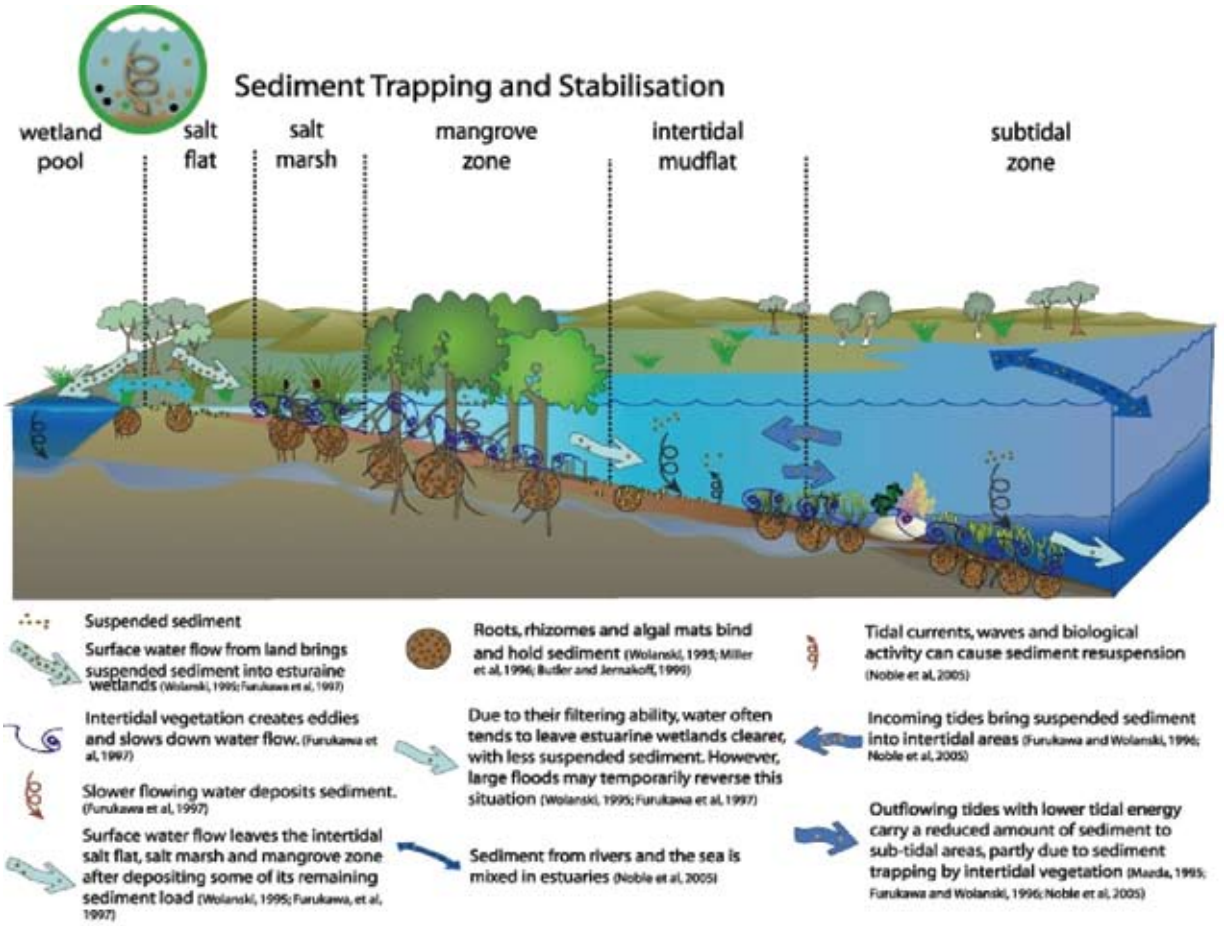
Food web linkages between wetland pools and the estuary occur when water connections allow the transfer of debris and organisms between these areas (Sheaves et al, 2006)

'Trophic relay' - carbon tends to move from high intertidal zones out into the estuary through a series of predator-prey interactions (Connolly et al, 2006)

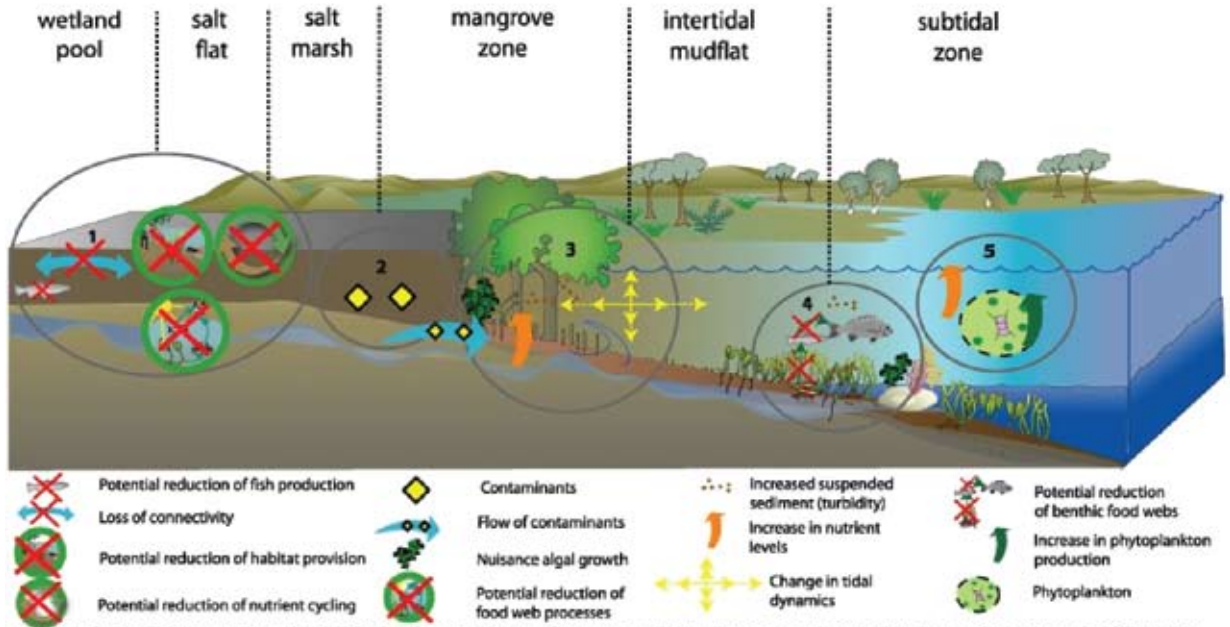
Carbon is exchanged between freshwater and marine sources within an estuary and some is exported off shore

Birds connect estuaries, wetland pools and terrestrial coastal ecosystems by moving carbon between the different locations (Sheaves et al, 2006)

Fish obtain their carbon from different sources depending on the availability of vegetation types in each system. For example, fish in Port Curtis tend to derive carbon from theabundant seagrass in this region (Connolly et al, 2006; Sheaves et al, 2006)

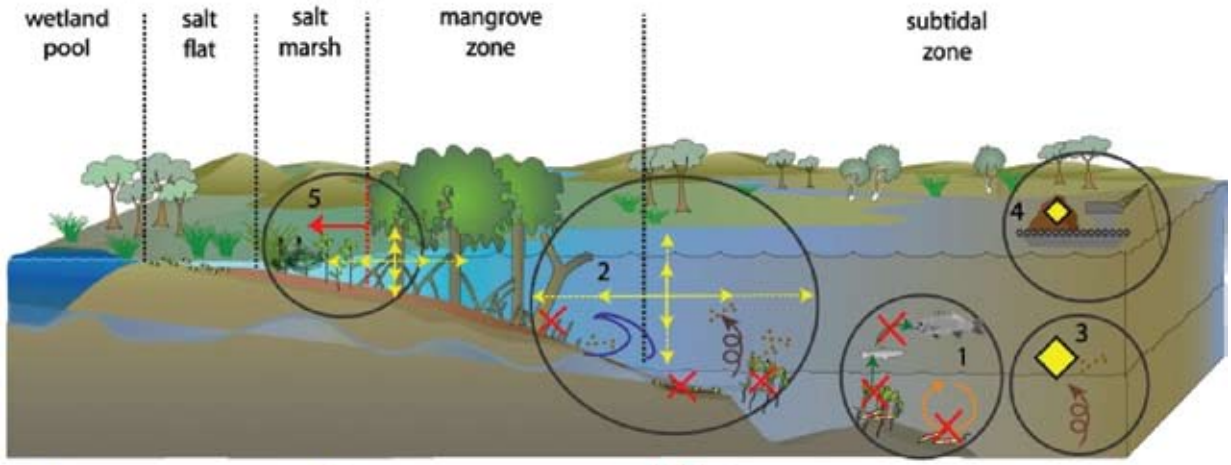


Some Impacts of Draining and Infilling



1. Removal of wetlands and vegetation will lead to the loss of associated habitat, food webs and nutrient cycling processes. Hydrological connectivity and therefore fish migration between the estuary and floodplain wetland pools will be reduced. This may impact on fish production. (Adam, 2002; Kennish, 2002; Sheaves, 2006)
2. Reclamation can disturb acid sulphate and contaminated soils, allowing toxic levels of leachate to enter waterways. (Blech and Taylor, 1999; Russel and Helmke, 2002; Clark and McConchie, 2004)
3. The construction of hard surfaces over estuarine banks can cause changes in tidal dynamics. Clearing of riparian vegetation can result in a decline in water quality through increased turbidity, nutrient inputs and water flow. This modified hydrology and water and habitat quality can disrupt remaining wetland vegetation resulting in a decline of some species and the growth of other species that are suited to hard substrates (for example algae). (Munro et al, 1967; Edyvane, 1999; Davis and Froend, 1999; Kennish, 2002; Connolly, 2003; Lee, 2006)
4. Turbidity can negatively impact on benthic vegetation and the food webs they support. (Davis and Froend, 1999; Dennison and Abal, 1999; Hemminga and Duarte, 2000; Kennish, 2002)
5. With more nutrients entering the system and less riparian and benthic vegetation to sequester them eutrophication may result, increasing the risk of harmful algal blooms (Prastka et al 1998; Edyvane, 1999; Davis and Froend, 1999; Dennison and Abal; 1999; Rassam, 2006)

Some Impacts of Dredging



Changes in tidal area and height

Potential loss of nutrient cycling

Potential loss of benthic food webs

Dredge boat

Mangrove seedling

Erosive wave action

Increased resuspension

Contaminants

1. Dredging results in the short term degradation of animals, vegetation and microbial communities that live in the dredged sediment. This reduces the estuary's capacity for nutrient cycling, primary production and habitat provision and can have flow on effects up the food web. Though these effects tend to be short lived, in some cases they may trigger long-term changes. (Larkum and West, 1990; Lewis et al. 2001; Thrush and Dayton, 2002; Lohrer and Wertz, 2003; da Silva et al. 2004; Waycott et al, 2004; Ohimain et al; 2005)

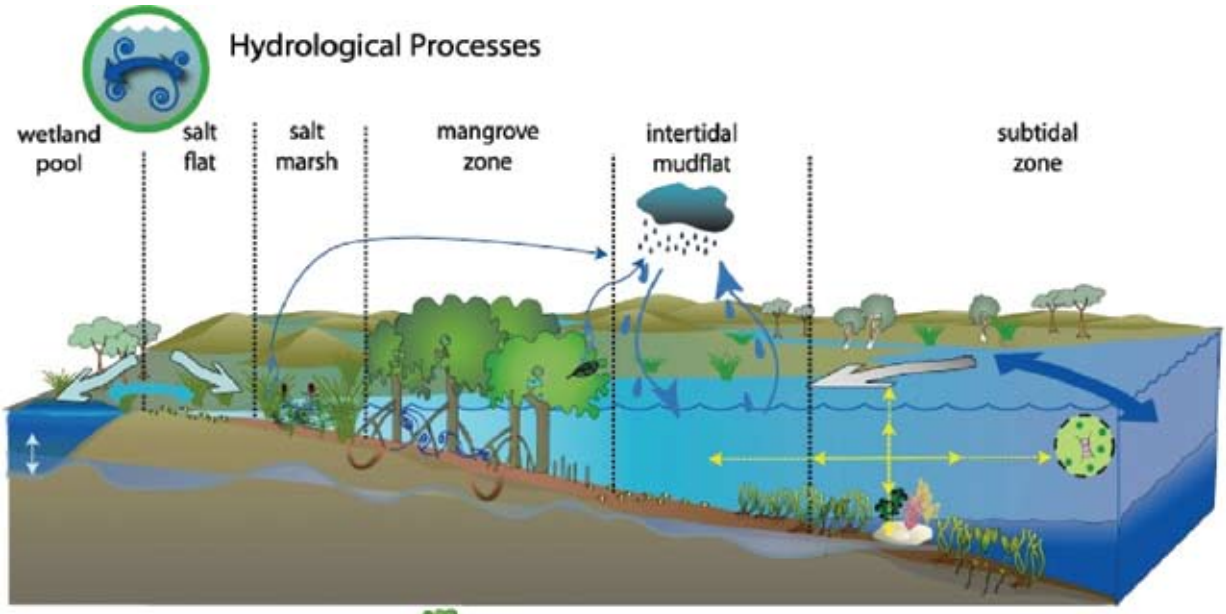
2. Changes in channel profile caused by dredging can alter tidal area, wave height and water velocity. Bank erosion can result, threatening mangroves and other mudbank communities and increasing turbidity. Suspended sediment in the water column blocks light, reducing benthic primary productivity. (Pringle, 1989; Larkum and West, 1990; Lewis et al, 2001; Rasheed and Balchand; 2001; Lohrer and Wertz, 2003; Sampson et al, 2005)

3. Dredging can expose and disturbs toxic sediments, releasing contaminants. This has implications for water quality. (Linkov et al, 2001; Thibodeaux and Duckworth, 2001; Van Den Berg, 2001; Nayar et al, 2004)

4. Dredge spoil is often deposited in deeper waters and can smother existing habitats. Spoil can also introduce marine pests, nutrients and contaminants to the area it is dumped. The impacts of dredge spoil disposal can range from short term to long term. (Linkov et al, 2001; Smith and Rule, 2001; National Ocean Disposal Guidelines for Dredged Material, 2002; Fredette and French, 2004)

5. Dredging may increase tidal flow, allowing increased upstream and lateral movement by tides which in turn may assist inland encroachment by mangroves and other wetland vegetation. (Saintilin and Williams, 1999; Harty, 2004)

Hydrological Processes



Surface water flow runs off the catchment into wetland pools and the estuary.

Groundwater - surface water exchange often occurs in wetlands. (Winter, 1999)

High tides, storm surges, floods and run-off events connect wetland pools to estuaries. (Shoreset al, 2006)

Crab burrows and vegetation alter water flows. (Ridd, 1996)

Evapotranspiration from vegetation. (Hughes et al, 1998)

Evaporation from water bodies.

Precipitation

Wind can play an important role in estuarine water circulation.

Tides, including spring and neap tidal ranges.

Freshwater and marine water are mixed and exchanged in estuaries.

Source: Reproduced with permission from the Coastal CRC http://www.coastal.crc.org.au/wetlands/conceptual.html.
Symbols for diagrams courtesy of the Integration and Application Network (ian.umces.edu/symbols), University of Maryland Centre for Environmental Science.

Appendix 10: Generic wetland threats

To develop a more systematic approach to cataloguing environmental threats and management actions at the international level, the International Union for the Conservation of Nature (IUCN) and the Conservation Measures Partnership (CMP) have developed a standardised hierarchical classification of commonly encountered environmental threats and conservation/management actions (www.iucn.org/themes/ssc/sis/classification.htm).

Using the IUCN's threat classification hierarchy, the Australian Government undertook a review in 2007 of all RISs, any existing ecological character descriptions, and the Ramsar site management plans for each of Australia's 64 Ramsar sites (a similar exercise was also conducted for other matters of National Environmental Significance listed under the EPBC Act). The review identified the following threats, which were then classed using the IUCN threats hierarchy.

Threat theme (threat class: level 1)	Threat activity (threat class: level 2)	Threat agent (threat class: level 3)
Agriculture and aquaculture	Agriculture and aquaculture	clearing
		unspecified
	Annual and perennial nontimber Crops	cropping
		irrigated pastures and cropping
	Livestock farming and grazing	grazing
		trampling
	Marine and freshwater aquaculture	unspecified
	Wood and pulp plantations	timber plantation
Biological resource use	Fishing and harvesting aquatic resources	aquarium trade
		bait
		commercial
		illegal take
		recreational
		trawling
		unspecified
	Gathering terrestrial plants	commercial
	Hunting and collecting terrestrial animals	illegal take
		recreational
	Logging and wood harvesting	firewood
		timber
		other management
Climate change and severe weather	Climate change and severe weather	unspecified includes 'global warming'
	Habitat shifting and alteration	coral bleaching
		loss of surface water sources
		erosion
		habitat change
		sea-level rise
	Storms and flooding	cyclones
	Temperature extremes	water temperature change
		climate change

Threat theme (threat class: level 1)	Threat activity (threat class: level 2)	Threat agent (threat class: level 3)
Ecosystem/community stresses	Ecosystem degradation	erosion
		unspecified
Energy production and mining	Energy production and mining	unspecified
	Mining and quarrying	unspecified
Human Intrusions and Disturbance	Human intrusions and disturbance	inappropriate conservation measures
		unspecified
	Recreational activities	bushwalking
		camping
		ecotourism
		horse riding
		hunting
		off-road vehicles
		unspecified
		water sports
	War, civil unrest and military exercises	military training
Invasive and other problematic species and taxa	Invasive nonnative/alien species	*Acanthaster planci* — crown-of-thorns starfish
		Achatina fulica — giant African snail
		Acridotheres tristis — common myna
		algae
		Alternanthera philoxeroides — alligator weed
		animal
		Anoplolepis gracilipes — yellow crazy ant
		Asparagus asparagoides — bridal creeper
		Avena fatua — wild oats
		Axis porcinus — hog deer
		Bassia salsola kali — soft roly-poly
		Bassia sclerolaena muricata — black roly-poly
		bees
		birds
		Bos javanicus — Bali cattle
		Bos taurus — cattle
		Bubalus bubalis — feral water buffalo
		Bufo marinus — cane toad
		Camelus dromedarius — Dromedary camel
		Canis familiaris — dog

Threat theme (threat class: level 1)	Threat activity (threat class: level 2)	Threat agent (threat class: level 3)
		Capra hircus — goat
		Carassius auratus — goldfish
		Carcinus meanus — European shore crab
		Carduus nutans — nodding thistle
		Cervus dama — fallow deer
		Cervus elaphus — red deer/elk
		Cervus unicolor — Sambar (deer)
		Cherax quadricarinatus — red claw
		Chrysanthemoides monilifera — Bitou bush/boneseed
		Cirsiun vulgare — black thistle
		Cortaderia spp. — pampas grass
		Cuscuta campestris — golden dodder
		Cyprinus carpio — carp
		Echium plantagineum — Paterson's curse
		Eichornia crassipes — water hyacinth
		Emilia sonchifolia — red tasselflower
		Equus caballus — horse (feral)
		Euphorbia paralis — sea spurge
		Felis catus — cat
		fish
		Gambusia holbrooki — mosquitofish
		Hydrocotyle bonariensis — pennywort
		Hypericum perforatum — St. John's wort
		Jatropha gossypifolia — jatropha (bellyache bush)
		Juncus acutus — sharp/spiny rush
		Lantana camara — lantana
		Lepus capensis — brown hare
		Leucaena Leucocephala — leucaena
		Lycium ferocissimum — boxthorn
		Lycodon aulicus capucinus — Southeast Asian wolf snake
		Mimosa pigra — mimosa
		Mus musculus — house mouse
		Nassella trichotoma — serrated tussock

Threat theme (threat class: level 1)	Threat activity (threat class: level 2)	Threat agent (threat class: level 3)
		Oncorhynchus mykiss — rainbow trout
		Opuntia stricta — prickly pear
		Oryctolagus cuniculus — European rabbit
		Parkinsonia aculeata — Parkinsonia
		Passiflora suberosa — corky passionfruit
		Perca fluviatilis — redfin perch
		Phalaris aquatica — Phalaris
		Pheonix dactylifera — date palms
		Phyla canescens — Lippia
		Phytophthora cinnamomi — dieback fungus
		Populus spp. — poplar
		Rattus norvegicus — brown rat
		Rattus rattus — black rat
		Rosa rubiginosa — sweet briar
		Rubus fruticosus agg. — blackberry
		Rumex spp. — dock
		Salix spp. except S.babylonica, S.X calodendron & S.X reichardtiji — willows
		Salvinia molesta — salvinia
		Silybun marianum — variegated thistle
		Spartina spp. — cord grass
		Stenotaphrum secondatum — buffalo grass
		Sturnus vulgaris — common starling
		Sus scrofa — pig
		Tamarix aphylla — Athel pine
		Typha spp.
		Ulex europaeus — gorse
		unspecified
		Vulpes vulpes — European red fox
		weeds
		Xanthium occidentale — Noogoora burr
		Xanthium pungens — Noogoora burr
		Xanthium spinosum — Bathurst burr
		Zantedeschia aethiopica — arum lily

Threat theme (threat class: level 1)	Threat activity (threat class: level 2)	Threat agent (threat class: level 3)
	Problematic native species	animal
		birds
		insects
		kangaroos/wallabies
		plant
	Invasive and other problematic species and taxa	algae
		animal
		disease
		toxic algae
		toxic phytoplankton
		toxic dinoflagellates
		unspecified
		weed(s)
Natural system modifications	Dams and water management/use	change
		dams/barriers
		drainage
		flooding
		general
		ground water extraction
		irrigation salinity
		levee
		revetment wall
		salinity
		stream redirection
		surface water extraction
		water storage
	Fire and fire suppression	natural fire
		unspecified
	Other ecosystem modifications	dieback
		dryland salinity
Pollution	Agricultural effluents	herbicides
		nutrients
		pesticides
		sediments
		toxins
		unspecified

Threat theme (threat class: level 1)	Threat activity (threat class: level 2)	Threat agent (threat class: level 3)
	Airborne industrial/commercial pollutants	toxins
	Excess energy	noise
	Garbage and solid waste	inland waters debris
		marine debris
		terrestrial debris
	Household sewage and urban waste water	septic tank
		stormwater
		unspecified
		waste treatment plant discharge
	Industrial and military effluents	leakage
		sediments
		spillage
	Pollution	acid sulphate soils
		nutrients
		pesticides
		salinity
		sedimentation/siltation
		soil contamination
		spillage
		unspecified
		water
Residential and commercial development	Commercial and industrial areas	commercial/industrial development
		landfill
		unspecified
	Housing and urban areas	urban development
		unspecified
		canal development
	Residential and commercial development	unspecified
		land reclamation
	Tourism and recreation areas	unspecified
		resorts
Species stresses	Indirect species effects	hybridisation
	Species mortality	unspecified
Transportation and service corridors	Shipping lanes	dredging
		unspecified
	Roads and railroads	roads
Uncategorised	Uncategorised	threats not specified

Glossary

Administrative authority	The agency within each contracting party charged by the national government with oversight of implementation of the Ramsar Convention within its territory. http://www.ramsar.org/about/about_glossary.htm
Adverse conditions	Ecological conditions unusually hostile to the survival of plant or animal species, such as those that occur during severe weather like prolonged drought, flooding, cold, etc (Ramsar Convention 2005b).
Assessment	The identification of the status of, and threats to, wetlands as a basis for the collection of more specific information through monitoring activities (as defined by Ramsar Convention 2002a, Resolution VIII.6).
Baseline	Condition at a starting point. For Ramsar wetlands, it will usually be the time of listing of a Ramsar site (Lambert and Elix 2006).
Benchmark	A standard or point of reference (ANZECC and ARMCANZ 2000b). A predetermined state (based on the values that are sought to be protected) to be achieved or maintained (Lambert and Elix 2006).
Benefits	Benefits here refer to the economic, social and cultural benefits that people receive from ecosystems (Ramsar Convention 2005a, Resolution IX.1 Annex A). These benefits often rely on the underlying ecological components and processes in the wetland. 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 2005b).
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 based largely on the one contained in Article 2 of the Convention on Biological Diversity (Ramsar Convention 2005b).
Catchment	The total area draining into a river, reservoir, or other body of water (ANZECC and ARMCANZ 2000a).
Change in ecological character	Human-induced adverse alteration of any ecosystem component, process, and/or ecosystem benefit/service (Ramsar Convention 2005a, 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 2000a).
Community composition	All the types of taxa present in a community (ANZECC and ARMCANZ 2000a).
Community structure	All the types of taxa present in a community and their relative abundances (ANZECC and ARMCANZ 2000a).
Conceptual model	Wetland conceptual models express ideas about components and processes deemed important for wetland ecosystems (Manlet et al. 2000, Gross 2003).
Contracting Parties	Countries that are Member States to the Ramsar Convention on Wetlands; 154 as at April 2007. Membership of the convention is open to all states that are members of the United Nations (UN), one of the UN specialised agencies, or the International Atomic Energy Agency, or are a Party to the Statute of the International Court of Justice. http://www.ramsar.org/key_cp_e.htm
Critical stage	Stage of the life cycle of wetland-dependent species (e.g. breeding, migration stopovers, moulting) that, if interrupted or prevented from occurring, may threaten long-term conservation of the species (Ramsar Convention 2005b).
Ecological character	The combination of the ecosystem components, processes, and benefits and services that characterise the wetland at a given point in time. Within this context, ecosystem benefits are defined in accordance with the variety of benefits to people (ecosystem services). The phrase 'at a given point in time' refers to Resolution VI.1 paragraph 2.1, which states that 'It is essential that the ecological character of a site be described by the Contracting Party concerned **at the time of designation for the Ramsar List**, by completion of the Information Sheet on Ramsar Wetlands (as adopted by Recommendation IV. 7).'

Ecological communities	Any naturally occurring group of species inhabiting a common environment thatinteracts with each other, especially through food relationships, and that is relatively independent of other groups. Ecological communities may be of varying sizes, and larger ones may contain smaller ones (Ramsar Convention 2005b).
Ecosystems	Within the Millennium Ecosystem Assessment, ecosystems are described as the complex of living communities (including human communities) and nonliving environment (ecosystem components) interacting (through ecological processes) as a functional unit, which provides, inter alia, a variety of benefits to people (ecosystem services) (Ramsar Convention 2005a, Resolution IX.1 Annex A).
Ecosystem components	Include the physical, chemical and biological parts of a wetland (from large scale to very small scale,e.g. habitat, species and genes) (Ramsar Convention 2005a, Resolution IX.1 Annex A).
Ecosystem processes	Dynamic forces within an ecosystem. They include all those processes that occur between organisms and within and between populations and communities, including interactions with the nonliving environment, that result in existing ecosystems and that bring about changes in ecosystems over time (Australian Heritage Commission 2002). They may be physical, chemical or biological.
Ecosystem services	Benefits that people receive or obtain from an ecosystem (Ramsar Convention 2005a, Resolution IX.1 Annex A). The components of ecosystem services include (Millennium Ecosystem Assessment 2005): • *provisioning* services — such as food, fuel and fresh water • *regulating* services — the benefits obtained from the regulation of ecosystem processes such as climate regulation, water regulation and natural hazard regulation • *cultural* services — the benefits people obtain through spiritual enrichment, recreation, education and aesthetics • *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 in the long term. See also 'Benefits'.
Ecologically sustainable development	Development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends (ANZECC and ARMCANZ 2000a).
Fluvial geomorphology	Study of water-shaped landforms (Gordon et al. 1999)
Indicator species	Species whose status provides information on the overall condition of the ecosystem and of other species in that ecosystem; taxa that are sensitive to environmental conditions and which can therefore be used to assess environmental quality (Ramsar Convention 2005b).
Indigenous species	Species that originates and occurs naturally in a particular country (Ramsar Convention 2005b).
Introduced (nonnative) species	Species that does not originate or occur naturally in a particular country (Ramsar Convention 2005b).
Limits of acceptable change	Variation that is considered acceptable in a particular component or process of the ecological character of the wetland without indicating change in ecological character that may lead to a reduction or loss of the criteria for which the site was Ramsar listed (modified from definition adopted by Phillips 2006).
List of wetlands of international importance ('the Ramsar List')	Wetlands that 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. http://www.ramsar.org/about/about_glossary.htm
Monitoring	Collection of specific information for management purposes in response to hypotheses derived from assessment activities, and the use of these monitoring results for implementing management (Ramsar Convention 2002a, Resolution VIII.6).
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' http://www.ramsar.org/about/about_glossary.htm

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. http://www.ramsar.org/about/about_glossary.htm
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 used more commonly. http://www.ramsar.org/index_very_key_docs.htm
Ramsar Information Sheet (RIS)	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. http://www.ramsar.org/about/about_glossary.htm
Ramsar List	List of Wetlands of International Importance. http://www.ramsar.org/about/about_glossary.htm
Ramsar Sites	Wetlands designated by the Contracting Parties for inclusion in the List of Wetlands of International Importance because they meet one or more of the Ramsar Criteria. http://www.ramsar.org/about/about_glossary.htm
Ramsar Sites Database	Repository of ecological, biological, socio-economic, and political data and maps with boundaries on all Ramsar sites, maintained by Wetlands International in Wageningen, the Netherlands, under contract to the Convention. http://www.ramsar.org/about/about_glossary.htm
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 assessment	Identification of the status of, and threats to, wetlands as a basis for the collection of more specific information through monitoring activities (Finlayson et al. 2001; Ramsar Convention 2002a).
Wetland ecological risk assessment	Quantitative or qualitative evaluation of the actual or potential adverse effects of stressors on a wetland ecosystem.
Wetland types	As defined by the Ramsar Convention's wetland classification system. http://www.ramsar.org/ris/key_ris.htm#type
Wise use of wetlands	Maintenance of their ecological character, achieved through the implementation of ecosystem approaches[1], within the context of sustainable development[2]" (Ramsar Convention 2005a Resolution IX.1 Annex A). 1. Including inter alia the Convention on Biological Diversity's "Ecosystem Approach" (CBD COP5 Decision V/6) and that applied by HELCOM and OSPAR (Declaration of the First Joint Ministerial Meeting of the Helsinki and OSPAR Commissions, Bremen, 25–26 June 2003). 2. The phrase "in the context of sustainable development" is intended to recognise that whilst some wetland development is inevitable and that many developments have important benefits to society, developments can be facilitated in sustainable ways by approaches elaborated under the convention, and it is not appropriate to imply that 'development' is an objective for every wetland.

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