Australian Government

MURRAY–DARLING BASIN AUTHORITY

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Chowilla Floodplain

Environmental Water Management Plan

February 2012

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Murray–Darling Basin Authority

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Contents

About this plan

This environmental water management plan consists of:

i. A long-term strategic plan, (per Clause 117 of the TLM Business Plan), which outlines the icon site's environmental water requirements and how to broadly achieve them with a combination of environmental water and works and measures.

ii. Schedules detailing operational information about the icon site such as Operating, Condition Monitoring, Risk Management and Communication Plans. These Schedules will be added to the environmental water management plan as they become available and updated to reflect learnings from the operation of works, the results of environmental waterings and the latest science.

The environmental water management plans provide context for an icon site's water planning, delivery, monitoring and consultation processes. While the environmental water management plans include proposed operating strategies, annual water planning and implementation will be responsive to changing water resource conditions, opportunities and environmental priorities throughout the season and from year to year.

This environmental water management plan and associated schedules have been prepared by TLM partner governments in consultation with the relevant stakeholders. The MDBA would like to acknowledge the significant contribution of all those involved in the development of the environmental water management plans.

Summary

The Chowilla Floodplain and anabranch system is a significant ecological asset of the Murray–Darling Basin. Listed under the Ramsar Convention on Wetlands of International Importance (the Ramsar Convention), the Chowilla Floodplain is part of The Living Murray (TLM) Chowilla Floodplain and Lindsay–Wallpolla Islands icon site. This environmental water management plan focuses on the Chowilla Floodplain (including Kulcurna) component of the larger icon site.

The Chowilla Floodplain straddles the South Australia – New South Wales border; it covers a total area of 17,781 ha, 74% of which lies in South Australia, with the remaining 26% in New South Wales (including Kulcurna).

In recent years, the Chowilla Floodplain has undergone a severe decline in environmental condition because of river regulation and low inflows due to the prolonged drought. Despite this, it still retains much of its natural character and values (SA MDB NRM Board 2009a). Chowilla has highly diverse terrestrial and aquatic habitats; supports populations of rare, endangered and nationally threatened species; and contains heritage-protected sites of cultural significance. The floodplain is also important for its recreational and economic values.

In recognition of its ecological value, the South Australian portion of the Chowilla Floodplain was listed in 1987 as part of the Riverland Wetland Complex under the Ramsar Convention (Newall et al. 2009). The area is also listed on national and state directories of important wetlands and is incorporated into the Riverland Biosphere Reserve (previously known as the Bookmark Biosphere Reserve), which is part of the network of international biosphere reserves coordinated by the United Nations Educational, Scientific and Cultural Organization (UNESCO) Man and the Biosphere program.

The key threats to the Chowilla Floodplain are altered flow regimes, an elevated and altered groundwater regime, obstruction to fish passage, and pest plants and animals. Flow regulation and diversions in particular have reduced flooding frequencies and durations, as well as elevating saline groundwater levels, which have significantly affected native fauna and flora. In particular, the health of the icon site's river red gum (*Eucalyptus camaldulensis*) and black box (*E. largiflorens*) woodlands is rapidly declining.

It is anticipated that this ecological decline will continue in the absence of recovered water combined with significant intervention and continued low-flow conditions.

As part of TLM's First Step Decision, three broad ecological objectives were identified for maintaining the high biodiversity values of the Chowilla Floodplain and Lindsay–Wallpolla Islands icon site:

- high value wetlands maintained
- current area of river red gum maintained
- at least 20% of the original area of black box vegetation maintained.

To enable these objectives to be adequately measured, more specific objectives and targets have been developed.

To achieve the objectives and targets, in 2010 work began on constructing an environmental regulator on Chowilla Creek and ancillary structures; this work is expected to be completed in 2012. The operation of these structures will enable large areas of Chowilla Floodplain to be inundated when the flows in the River Murray would otherwise be insufficient to wet the floodplain naturally. This will help achieve the ecological objectives and preserve the significant environmental, social and cultural heritage values of the icon site.

This environmental water management plan documents the site's water requirement and outlines how the regulator and other measures will be used to meet those needs. The plan describes the preferred operation, water use, potential risks and benefits of operation, and the monitoring required to support the icon site's future management.

Monitoring results from Chowilla clearly indicate that, with the exception of sites that have received environmental water on multiple occasions, the condition of floodplain vegetation continues to decline (MDBC 2008). Virtually no healthy river red gums remain in floodplain areas away from permanent watercourses, and river red gums on the outer anabranches (e.g. Punkah Creek) are now among the most rapidly declining tree populations on the floodplain.

Environmental watering began at Chowilla in 2004, when Monoman Island Horseshoe was inundated using environmental water supplied by the South Australian Government. Environmental water has been provided by TLM, the Australian Government and state governments to 28 sites across the Chowilla Floodplain, with many sites being watered three or four times. In 2009–10, 13.5 gigalitres (GL) was delivered to the icon site, watering 5% of the floodplain.

Given the scale of intervention associated with the Chowilla environmental regulator and ancillary structures, a large-scale monitoring program is essential to ensure that environmental benefits are maximised through adaptive management. The Chowilla monitoring program and operation plan will cover the potential risks associated with the Chowilla environmental regulator for risk mitigation and control.

In addition to the ongoing scientific monitoring program, successful achievement of this icon site's ecological objectives will require the continued engagement and support of the broader community. This will be achieved by continued consultation with established committees, including project working groups, community groups (e.g. Aboriginal groups and agency stakeholders) and through activities conducted under the communications plan.

The outcomes achieved by implementing the Chowilla environmental water management plan will be documented in a range of reports, including the annual TLM implementation report and the annual icon site condition report. All operations on Chowilla Floodplain will be conducted within an adaptive management framework to ensure that key lessons learned are captured and reflected within revisions of this plan.

1. Introduction

The Chowilla Floodplain and anabranch system is a significant ecological asset of the Murray–Darling Basin. Listed under the Ramsar Convention on Wetlands of International Importance (the Ramsar Convention), the Chowilla Floodplain is part of The Living Murray (TLM) Chowilla Floodplain and Lindsay–Wallpolla Islands icon site. This environmental water management plan focuses on the Chowilla Floodplain (including Kulcurna) component of the larger icon site.

Although the Chowilla Floodplain is currently undergoing a severe decline in environmental condition because of river regulation and prolonged periods of low in-flows, it still retains much of its natural character. Discrete areas of floodplain have benefited from an environmental watering program that has been conducted since 2004. Construction of the Chowilla Creek environmental regulator is now underway; when complete, this regulator will enable regular watering of significant areas of floodplain under a range of flow conditions.

The Living Murray

The Living Murray Initiative is one of Australia's most significant river restoration programs. Established in 2002, TLM is a partnership of the Australian Government and the governments of New South Wales, Victoria, South Australia and the Australian Capital Territory; it is coordinated by the Murray–Darling Basin Authority (MDBA). The long-term goal of this program is to achieve a healthy working River Murray system for the benefit of all Australians.

The Living Murray aims to improve the environmental health of six icon sites chosen for their significant ecological, cultural, recreational, heritage and economic values:

- Barmah–Millewa Forest
- Gunbower–Koondrook–Perricoota Forest
- Hattah Lakes
- Chowilla Floodplain and Lindsay–Wallpolla islands (including Mulcra Island)
- River Murray Channel
- Lower Lakes, Coorong and Murray Mouth.

Through its First Step water recovery initiative, TLM has acquired a water portfolio consisting of environmental water entitlements. As of May 2011, there was 478.97 gigalitres long-term Cap equivalent (LTCE), with another 7.1 GL to be recovered in 2011–12. The actual volume of water available against these entitlements depends on the allocations.

This portfolio will be used to achieve environmental objectives at the icon sites. Regulating structures, water delivery channels and fishways, known as works and measures, will deliver and manage the environmental water at the icon sites. On-ground works for each icon site will be progressively constructed from 2010 to 2012. The success of the environmental watering against the objectives will be monitored using fish, birds and vegetation as an overall indicator of the icon site's health.

The Living Murray will seek to align itself to the requirements of the Basin Plan Environmental Watering Plan, once finalised.

Further information on TLM is available on the MDBA website at ←**www.mdba.gov.au/programs/tlm**→.

Figure 1.1: Location of The Living Murray icon sites

The Living Murray icon site environmental water management plans

The Chowilla environmental water management plan establishes priorities for the use of TLM water within the icon site and identifies environmental objectives and targets (where appropriate), water delivery options and regimes for the site that can use TLM water portfolio.

Development of the environmental water management plans has been coordinated by the MDBA in consultation with the Environmental Watering Group to ensure a consistent approach to planning and management across the icon sites.

This revision builds on previous iterations of the Chowilla–Lindsay–Wallpolla icon site environmental water management plan (previously known as 'environmental management plans'), and incorporates consultation, research into icon site key species, learning from water behaviour modelling and outcomes from previous environmental watering. The Chowilla environmental water management plan reflects the larger volume now held in The Living Murray water portfolio, and uses TLM works and measures (as construction is completed) and monitoring information gathered at the icon site.

This environmental water management plan is for the Chowilla Floodplain (including Kulcurna) component of the icon site. The Lindsay–Wallpolla Islands portion of the icon site has been addressed in a separate environmental water management plan that has been primarily developed by Victoria.

Planning context and legislation framework

The Australian Government and the jurisdictions of Victoria, New South Wales and South Australia have comprehensive legislative frameworks addressing natural resource and environmental management. For activities associated with management of TLM icon sites, including construction of works under TLM, the principal pieces of legislation and planning strategies are detailed below.

Agreements

Ramsar Convention on Wetlands of International Importance

The Ramsar Convention on Wetlands of International Importance (the Ramsar Convention) is an international treaty with the broad aim of halting the worldwide loss of wetlands and to conserve, through wise use and management, those that remain. For wetlands to be listed as Ramsar wetlands, they need to be representative, rare or unique in terms of their ecological, botanical, zoological, limnological or hydrological importance. Ramsar-listed wetlands can be natural, artificial, permanent or temporary swamps, marshes, billabongs, lakes, salt marshes or mudflats classified as wetlands.

Signatories to the Ramsar Convention, including Australia, are required to formulate and implement their planning so as to promote the conservation of wetlands included in the Ramsar list, and as far as possible the wise use of all wetlands in their territory. Ramsar wetlands in Australia are protected under the *Environment Protection and Biodiversity Conservation Act 1999* as a matter of national environmental significance (Department of Sustainability, Environment, Water, Population and Communities 2011a).

Bilateral migratory bird agreements

Over the past 30 years Australia has signed three bilateral migratory bird agreements in an effort to conserve migratory birds in the east Asian and Australian regions: China–Australia Migratory Bird Agreement (signed in 1986); Japan–Australia Migratory Bird Agreement (signed in 1974); and the Republic of Korea – Australia Migratory Bird Agreement (came into effect in 2007).

These agreements protect terrestrial, water and shorebird species that migrate from Australia to Japan or China. The Japan–Australia Migratory Bird Agreement also provides for cooperation on the conservation of threatened birds, while the Republic of Korea – Australia Migratory Bird Agreement ensures conservation of migratory birds and collaboration on the protection of migratory shorebirds and their habitat (Department of Sustainability, Environment, Water, Population and Communities 2011b).

Murray–Darling Basin agreements

The Murray–Darling Basin Ministerial Council established TLM in 2002. In 2004, the Australian Government and the governments of New South Wales, Victoria, South Australia and the Australian Capital Territory signed the Intergovernmental Agreement on Addressing Water Over-allocation and Achieving Environmental Objectives in the Murray–Darling Basin, which gave effect to a funding commitment (made in 2003) of $500 million over five years for TLM. The Living Murray program's First Step aimed to recover 500 GL of water for the River Murray and focused on improving the environment at the six icon sites. A supplementary Intergovernmental Agreement was signed in 2006 which provided increased funding of $200 million to The Living Murray.

The role of the Intergovernmental Agreement on Murray–Darling Basin Reform, signed by the Council of Australian Governments, is to:

- promote and co-ordinate effective planning and management for the equitable, efficient and sustainable use of the water and other natural resources of the Murray–Darling Basin (Council of Australian Governments 2008).

This Agreement was the foundation for the Water Act 2007, which established the MDBA whose role is to manage the Basin's water resources through the development of a Basin plan.

Commonwealth legislation

Water Act 2007

The Intergovernmental Agreement on Murray–Darling Basin Reform was the foundation for the federal *Water Act 2007*, which established the MDBA, whose role is to manage the water resources of the Murray–Darling Basin in an integrated, consistent and sustainable manner. The Water Act requires the MDBA to prepare and oversee a Basin Plan, which will be a legally enforceable document that provides for the integrated and sustainable management of water resources in the Basin.

The Basin Plan's Environmental Watering Plan will provide a strategic framework for coordinated environmental water planning and environmental watering throughout the Murray–Darling Basin. In the future, TLM will align with the Environmental Watering Plan with the development of Basin states' annual and long-term environmental watering plans through the annual environmental water prioritisation processes.

Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act) provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places (including natural, historic or Indigenous places)—defined in the EPBC Act as matters of national environmental significance. There are eight matters of national environmental significance to which the EPBC Act applies.

The EPBC Act aims to balance the protection of these crucial environmental and cultural values with our society's economic and social needs by creating a legal framework and decision-making process based on the guiding principles of ecologically sustainable development (Department of Sustainability, Environment, Water, Population and Communities 2011c).

Native Title Act 1993

Section 24KA of the *Native Title Act 1993* requires that native title claimants are notified of any future act consisting of the grant of a lease, licence, permit or authority under legislation that relates to the management or regulation of surface or subterranean water.

South Australian legislation

National Parks and Wildlife Act 1972

The *National Parks and Wildlife Act 1972* provides for the establishment and management of reserves for public benefit and enjoyment; to provide for the conservation of wildlife in a natural environment.

River Murray Act 2003

Under the *River Act 2003*, the Riverland Wetlands Complex Ramsar site, as part of the Murray–Darling Basin, is recognised as an area of great environmental and economic significance to South Australia.

Natural Resources Management Act 2004

The *Natural Resources Management Act 2004* was established to help achieve ecologically sustainable development in South Australia by establishing an integrated scheme to promote the use and management of natural resources.

Native Title (South Australia) Act 1994

The Native Title Act provides the legal recognition that Indigenous people have rights and interests to their land that comes from their traditional laws and customs.

Aboriginal Heritage Act 1988

Under the *Aboriginal Heritage Act 1988* all Aboriginal sites, objects and remains in South Australia with significant traditional, archaeological, anthropological and historical importance are protected.

New South Wales legislation

Water Management Act 2000

The *Water Management Act 2000* provides for the protection, conservation and ecologically sustainable development of the water sources in New South Wales, and for other purposes.

Water Management Amendment Act 2005

The *Water Management Amendment Act 2005* amends the Water Management Act in relation to plans of management, environmental water and compensation and amends other legislation consequentially.

Fisheries Management Act 1994

The *Fisheries Management Act 1994* relates to the management of fishery resources in New South Wales.

Threatened Species Conservation Act 1995

The purpose of the *Threatened Species Conservation Act 1995* is the conservation of threatened species, populations and ecological communities of animals and plants in New South Wales. This Act amends other New South Wales legislation, including the *National Parks and Wildlife Act 1974* and the *Environmental Planning and Assessment Act 1979*.

National Parks and Wildlife Act 1974

The *National Parks and Wildlife Act 1974* consolidates and amends New South Wales law relating to the establishment, preservation and management of national parks, historic sites and certain other areas; it also protects certain fauna, native plants and cultural heritage sites in New South Wales.

Governance and planning arrangements

The Living Murray is a joint initiative and is managed collaboratively by partner governments. The Murray–Darling Basin Intergovernmental Agreement on Addressing Water Overallocation and Achieving Environmental Objectives in the Murray–Darling Basin (Council of Australian Governments 2004) outlines the governance arrangement for implementing TLM. The 2004 intergovernmental agreement is complemented by The Living Murray Business Plan, which provides operational policies to guide TLM implementation.

The groups with a direct role in TLM governance are the Murray–Darling Basin Ministerial Council, Murray–Darling Basin Authority (MDBA), Basin Officials Committee, TLM Committee and the Environmental Watering Group (see **Figure 1.3** for The Living Murray governance structure)

While MDBA plays a key coordination role at a TLM-wide level, management and delivery of TLM activities at the icon sites are primarily undertaken by relevant agencies in the jurisdictions where the icon sites are located.

Management of the Chowilla Floodplain icon site

While the MDBA plays a key coordination role, management and delivery of TLM activities at the icon sites are primarily undertaken by relevant agencies in the jurisdictions where they occur. The ultimate responsibility to ensure the icon sites are successfully governed lies with the icon site manager.

Management of the Chowilla Floodplain is undertaken by a number of organisations with different responsibilities. MDBA is required to equitably and efficiently manage and distribute the water resources of the River Murray in accordance with the Murray–Darling Basin Agreement. The MDBA works cooperatively with partner governments, committees and community groups to develop and implement policies and programs aimed at the integrated management of the Murray–Darling Basin.

The South Australian Department for Water is the Chowilla Floodplain icon site manager, and is responsible for developing policies, plans and actions that focus on improving the health of the River Murray (including the Chowilla Floodplain icon site) through improved operations and management of the river.

While the South Australian Department for Water is the icon site manager, management of the Kulcurna portion of the floodplain is the responsibility of the New South Wales Government and is vested in the Water Administration Ministerial Corporation. The land is managed by the New South Wales Office of Water. The NSW Office of Water has prepared a land and water management plan for Kulcurna (Jaensch 2010).

As part of The Living Murray Initiative, a number of structures have been approved to better deliver environmental water at the site. The MDBA manages the structures for and on behalf of the states and the Australian Government under provisions of the Murray–Darling Basin Agreement contained within the *Water Act 2007* (Cwlth). As the nominated construction authority, SA Water is responsible for operating and maintaining all current and proposed flow management structures on the Chowilla Floodplain. Operations are conducted at the direction of the MDBA.

The South Australian Department for Environment and Natural Resources is the landowner and manager for the Chowilla Game Reserve and Regional Reserve. These areas are managed in accordance with the *National Parks and Wildlife Act (SA)* and the park management plan (1995). The department has primary responsibility for the management of natural, historical and cultural features as well as visitors. The Chowilla Regional Reserve and Game Reserve has an existing lease over the property, which allows for grazing over a limited area by Robertson Chowilla Pty Ltd.

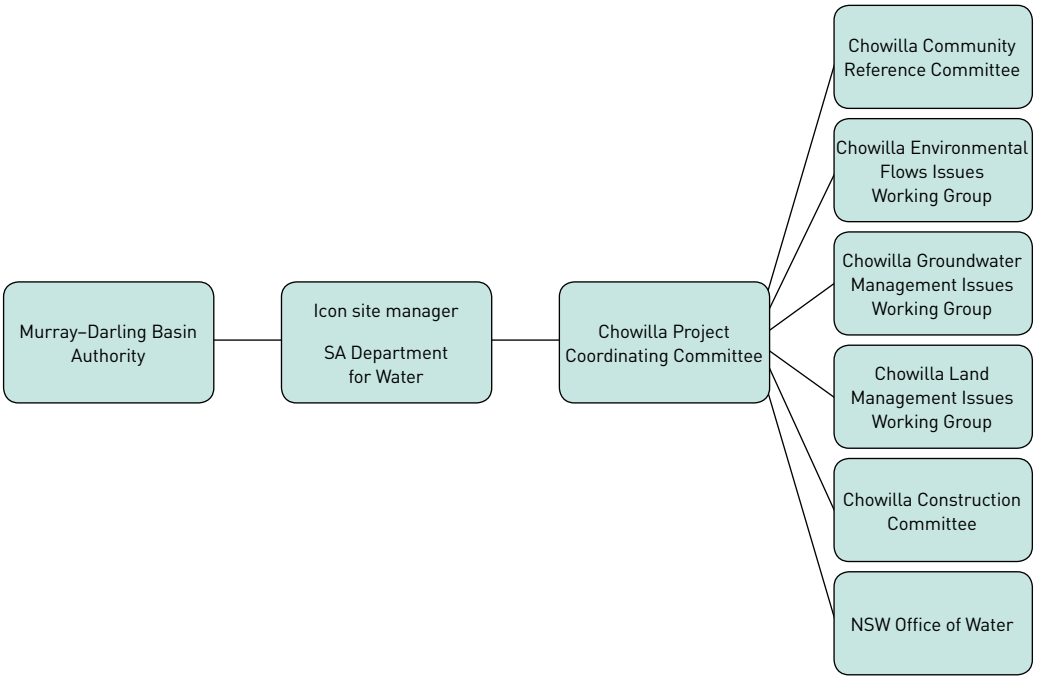

Figure 1.2: Chowilla governance structure

Committees and groups that contribute to the planning and integration of management actions at the icon site are listed below.

Chowilla Project Coordinating Committee

The Chowilla Project Coordinating Committee comprises program leaders responsible for delivering the primary components of the Chowilla environmental regulator project and provides the strategic direction for this project. The committee is chaired by the icon site manager who is accountable to the Chief Executive of the South Australian Department for Water. The committee is also responsible for ensuring that stakeholders are informed about the Chowilla environmental regulator project, including providing advice to the MDBA, the Department of Sustainability, Environment, Water, Population and Communities (formerly the Department of Environment, Water, Heritage and the Arts) and the South Australian Government. Specific technical working groups have been established to progress each key component.

Chowilla Construction Committee

The Chowilla Construction Committee comprises representatives from federal and state government agencies. The committee is responsible for providing technical oversight of design and construction of the Chowilla environmental regulator, and ensuring works provide the agreed environmental outcomes. This group reports to the Coordinating Committee through the icon site manager.

Chowilla Environmental Flows Issues Working Group

The Chowilla Environmental Flows Issues Working Group is responsible for developing the environmental water management plan for the Chowilla Floodplain. The working group identifies objectives and priorities for environmental flows, implements staged trials and determines appropriate assessments for management actions.

Chowilla Community Reference Committee

The Community Reference Committee provides a forum for discussion, input and advice to the Chowilla Project Coordinator and the Coordinating Committee on planning and management initiatives for the Chowilla Floodplain icon site. The committee membership includes representatives from the lessees of the Chowilla Floodplain and neighbouring properties; the Aboriginal community; irrigation and tourism industries; recreational users; natural resource management and local action planning groups; the Lower Murray–Darling and the Mallee catchment management authorities; conservation interests; the Murray Darling Association; and the South Australian Department of Environment and Natural Resources.

The committee plays an important role by providing a range of community views on management of the icon site, and giving advice on community engagement processes. It also makes an important contribution through disseminating information through their networks to the local community on environmental management activities.

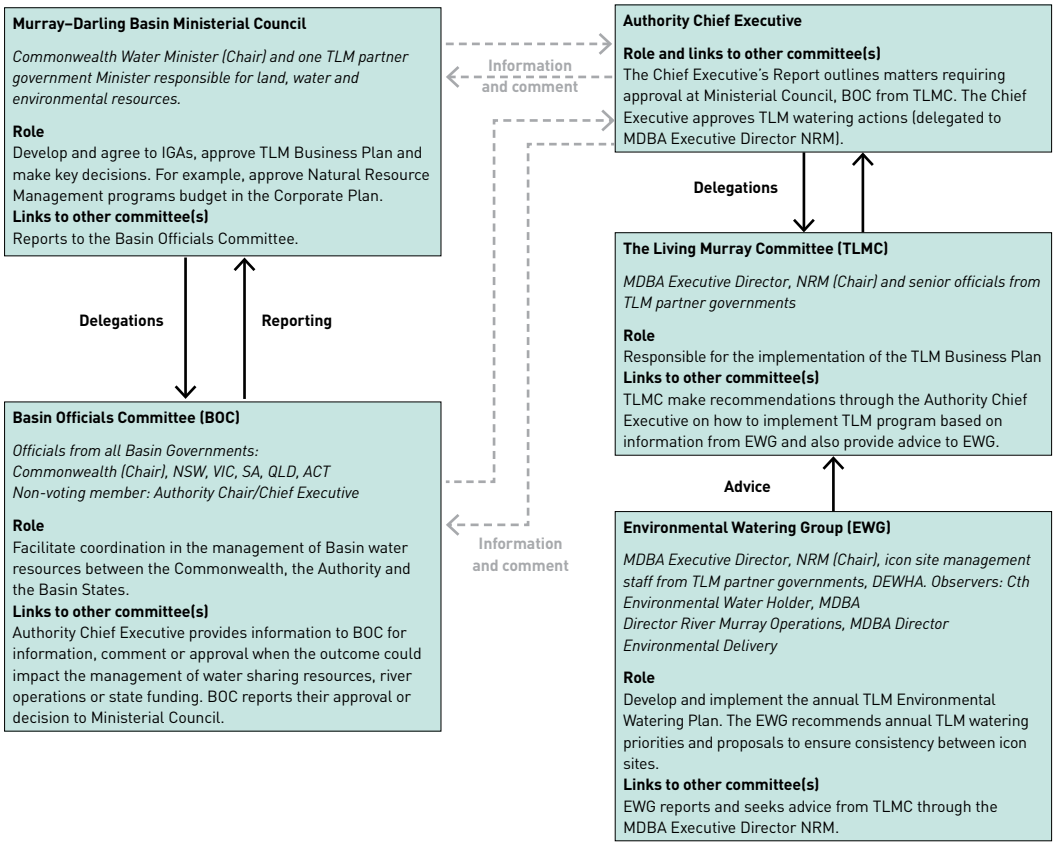

Figure 1.3: The Living Murray governance structure

2. Icon site description

The Chowilla Floodplain forms part of the Chowilla and Lindsay–Wallpolla Islands icon site, which covers a total area of 43,856 ha. The icon site comprises four main components: Chowilla (including Kulcurna), and the Lindsay, Mulcra and Wallpolla islands.

The Chowilla Floodplain straddles the South Australia – New South Wales border; it covers a total area of 17,781 ha, 74% of which lies in South Australia, with the remaining 26% in New South Wales (known as Kulcurna for the purposes of this environmental water management plan).

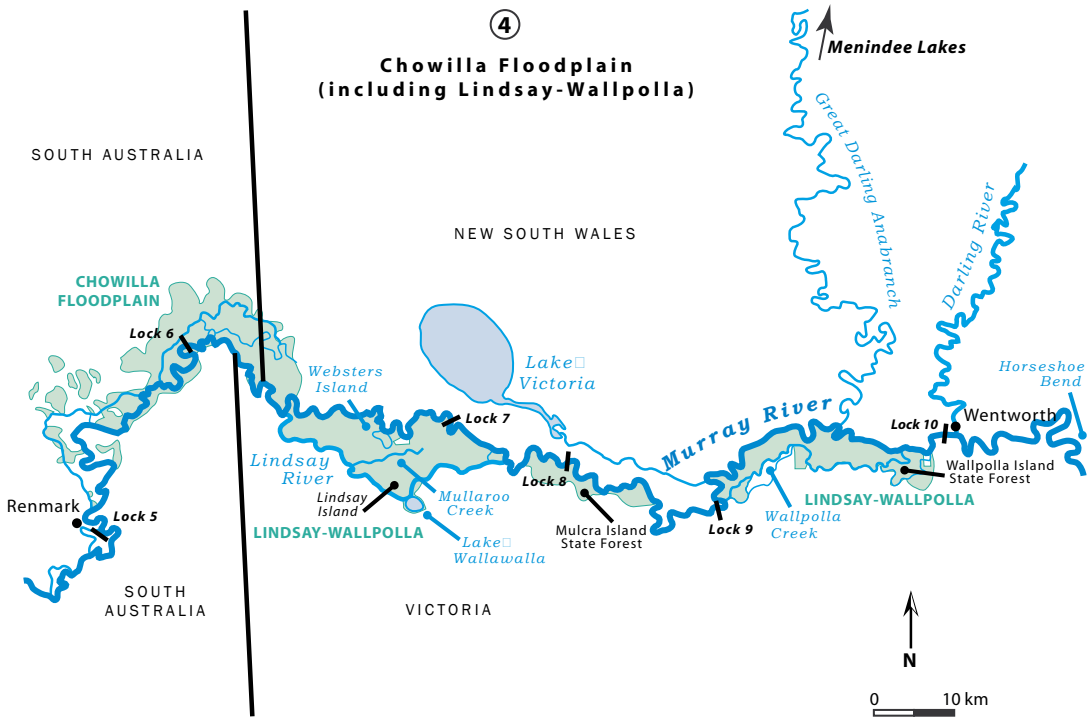

Figure 2.1: The Chowilla Floodplain and Lindsay–Wallpolla Islands icon site (MDBA)

The boundary of the Chowilla Floodplain is defined by the 1956 flood extent and the game reserve property boundary immediately to the west of the Chowilla Homestead. The Chowilla Floodplain is part of the Riverland Wetland Complex Ramsar area and is contained within the South Australian Department for Environment and Natural Resources game reserve (with the exception of the area in New South Wales); please see **Figure 2.2** for boundary details.

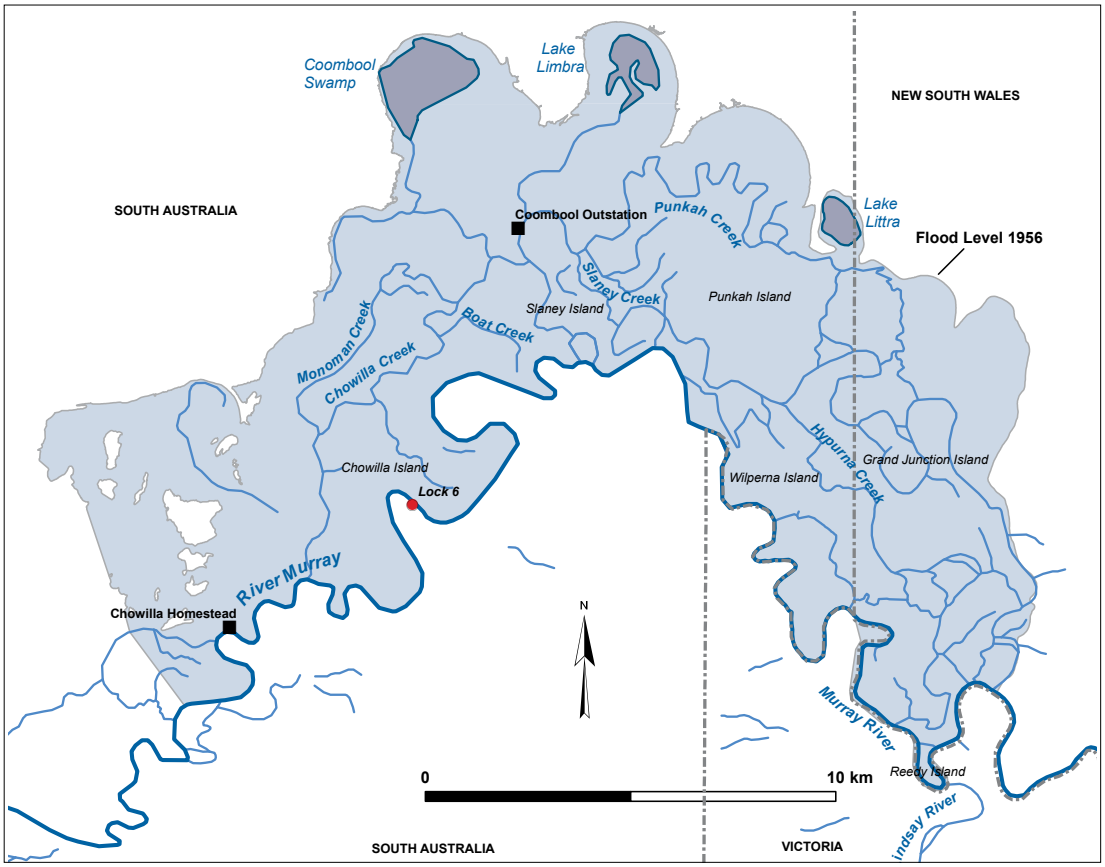

Figure 2.2: The Chowilla Floodplain boundary (MDBA)

Land tenure

A range of land tenures apply within the South Australian and New South Wales portions of the Chowilla Floodplain. The South Australian Government, vested in the Minister for Environment and Conservation, is the landowner for the South Australian portion (excluding 17.3 ha of freehold land), which consists of several land tenures including:

Chowilla Game Reserve

Under the *National Parks and Wildlife Act 1972 (SA)*, 14,620 ha of the Chowilla Floodplain is gazetted as a game reserve (proclaimed in early 1993). The Game Reserve Management Plan guides land management activities over the area and is overseen and implemented by the South Australian Department for Environment and Natural Resources.

Chowilla Station

Crown reserve land on Chowilla Station is vested in the South Australian Minister for Environment and Conservation

Robertson Chowilla Pty Ltd has operated Chowilla Station as a wool-growing operation since 1865; the company is the leaseholder of 12,062 ha of the Chowilla Floodplain. The lease area falls entirely within the game reserve. A 40-year lease was finalised in 1993, with conditions and rental based on equivalent terms to pastoral leases granted under the *Pastoral Natural Resources and Conservation Act 1989* (SA). An agreement was made between the South Australian Department for Environment and Heritage (now Department for Environment and Natural Resources) and Robertson Chowilla Pty Ltd to exclude livestock grazing from 83% of the Chowilla Floodplain, effective September 2005.

Freehold

A freehold parcel of 17.3 ha (section 78), historically known as the Chowilla Orangery, is currently a vineyard run by Lonver Pty Ltd.

Kulcurna

The New South Wales portion of the Chowilla Floodplain, covering about 5,192 ha, is owned by the New South Wales Government (excluding 1 ha of freehold land), and vested in the Water Administration Ministerial Corporation on the behalf of the Murray–Darling Basin Authority. The land is managed by the NSW Office of Water on behalf of the MDBA.

Known as 'Kulcurna', the area is made up of a mixture of tenures consisting of some freehold parcels and Crown and Western Lands Leases. In addition, two travelling stock routes and a forestry reserve overlay parts of the Western Lands Leases. These tenures have various implications to land management, public access and resource access and management. There is also a freehold parcel of 1 ha that contains the original Tareena Post Office near Tareena Billabong; the post office is currently unoccupied, but is being redeveloped as part of a farm stay and ecotourism enterprise.

Description of icon site key ecological assets

The Chowilla Floodplain is one of the last remaining parts of the lower Murray floodplain that retains much of the area's natural character and attributes. Significantly, it contains the largest remaining area of natural river red gum forest in the lower River Murray (MDBC 2003a) and has highly diverse floodplain vegetation.

The region's aquatic habitats include permanent and temporary waterbodies, including over 100 km of anabranch creeks. In high-river flows, these creeks spread into a series of temporary wetlands, lakes and billabongs that create an area of outstanding environmental significance. Owing to the head differential created by Lock 6, between 20 to 90% of River Murray flows are now diverted through the Chowilla anabranch system under low-flow conditions, resulting in a mosaic of lotic habitats that are now rare in the lower Murray system. These areas have been identified as a spawning area for large-bodied native fish (Zampatti *et al*. 2006).

Icon site values

Flora

Chowilla's vegetation communities are distributed across the floodplain and upland rise according to local hydrological conditions that include environmental watering actions, soil type and salinity gradients, while the floristic composition of aquatic and littoral communities strongly correlates with current velocity (Roberts & Ludwig 1991). The major vegetation communities of the floodplain are:

- river red gum forest and woodlands
- black box woodlands
- lignum (*Muehlenbeckia florulenta*) low shrubland (SA Department for Environment and Heritage 2010).

Kenny (2004) delineated over 40 broad vegetation associations for the Chowilla Floodplain based on overstorey dominance and structural similarity. These associations are presented in **Figure 2.3**. Black box woodland is the most widespread vegetation class, occupying approximately 5,117 ha (29%) of the Chowilla Floodplain (CSIRO 2005).

Of 405 plant species (including 92 exotics) recorded across the Chowilla Floodplain, 156 species recorded by O'Malley and Sheldon (1990), whose survey area included the adjacent highland, three species recorded by Roberts and Ludwig (1991), and two species recorded in surveys conducted by the South Australian Department for Environment and Heritage (pre-2000) have not been recorded since 2000.

Since 1989,18 taxa listed as rare, five listed as vulnerable and one listed as endangered in South Australia have been recorded in the Chowilla Floodplain system. Of taxa of conservation significance, one endangered taxon (*Crassula sieberana* ssp. *tetramera*) and nine of the 18 rare taxa have been recorded or observed since 2004; however, none of the vulnerable species has been observed since 2004 (Nicol *et al*, in prep.).

Kulcurna contains extensive areas of two significant plant communities typical of south-western New South Wales that are otherwise poorly represented elsewhere in that state's reserve system. These are the river red gum/black box woodlands and open rosewood (*Alectryon oleifolius*)—belah (*Casuarina pauper*) mallee mosaic (Jaensch 2000).

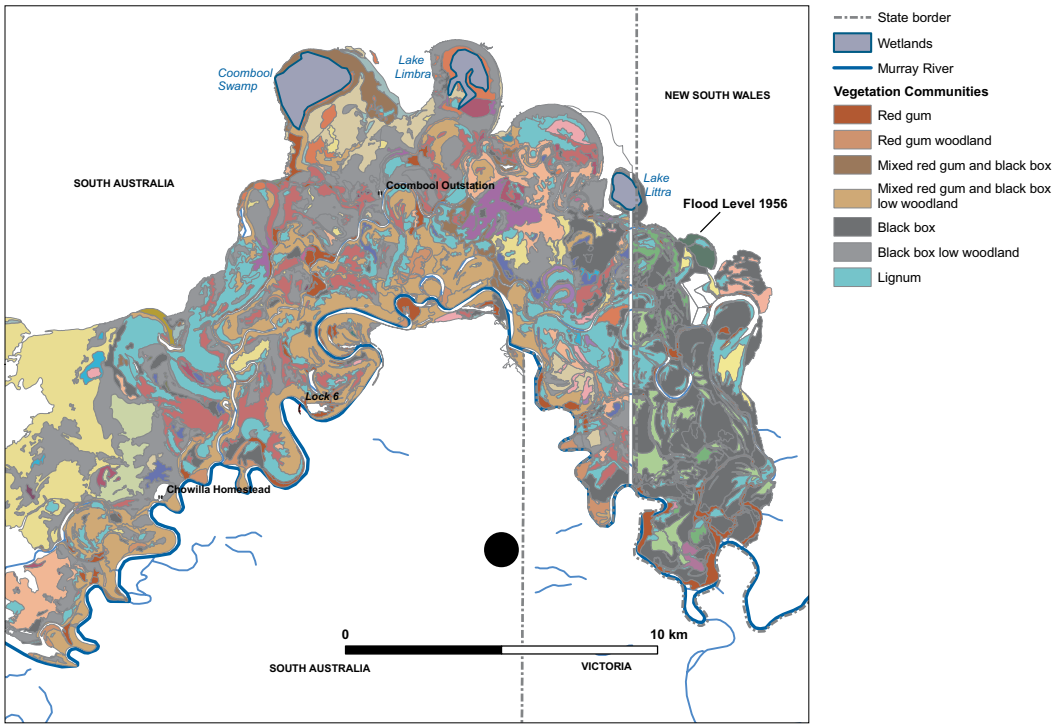

Figure 2.3: Vegetation communities: Chowilla Floodplain

Source: SA Department for Environment and Heritage 2005a; see **Appendix B**, for regional floristic descriptions.

Fauna

The diverse vegetation assemblages and the variability of the riverine environment create a mosaic of differing habitat types that vary in time and space in response to changing river flows. This creates distinct aquatic and terrestrial fauna assemblages that include threatened species listed at both a national and state level. Three species have been listed as vulnerable under *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) — the regent parrot (*Polytelis anthopeplus*), the southern bell frog (*Litoria raniformis*) and the Murray cod (*Maccullochella peelii*). Species listed under the *National Parks and Wildlife Act 1975* (SA), the *Threatened Species Conservation Act 1995* (NSW) and the *Fisheries Management Act 1994* (NSW) include four mammals, five reptiles, one amphibian, five fish and 20 bird species. A full list of threatened species is presented in **Appendix C**.

In a one-off bird survey conducted in 1988, Carpenter (1990) recorded 170 species in the floodplain region, and identified a further 33 species that may potentially be found on the site. A recent biological survey of the South Australian component of Chowilla confirmed this diversity, recording 67 bird species (SA Department for Environment and Heritage 2005a). This diversity and abundance is driven by the range of habitats within the floodplain and adjacent region, including habitats for both terrestrial and aquatic birds.

Among the most important habitat types for birds in Chowilla are river red gum woodlands, black box woodlands, lignum shrubland, temporary shallow wetlands and permanent wetlands, anabranches and the Lock 6 weir pool. These key vegetation communities depend on periodic floodplain inundation, although the nature of this dependence varies among these communities (Rogers & Paton 2008).

Wetlands in the Chowilla Floodplain also provide seasonal habitat for migratory birds listed under the following international agreements: Japan–Australia, China–Australia and the Republic of Korea – Australia Migratory Bird Agreements.

The Chowilla Floodplain is known to contain 17 native mammals, including the feathertail glider (*Acrobates pygmaeus*), Giles' planigale (*Planigale gilesi*) and the fat-tailed dunnart (*Sminthopsis crassicaudata*) as well as eight introduced species (Brandle & Bird 1990). The bat fauna of the Chowilla Floodplain is especially rich — eight species have been recorded (Brandle & Bird 1990) and the area within 50 km of Chowilla is identified as a location containing the greatest diversity of bats found anywhere in South Australia (Brandle & Bird 1990).

Eight species of frog have been recorded in the area, including the southern bell frog, which is listed nationally as vulnerable (SA MDB NRM Board 2010a). In addition, the area is known to contain five

South Australian-listed reptiles, including the carpet python (*Morelia spilota*) and the broad-shelled tortoise (*Macrochelodina expansa*) (Bird & Armstrong 1990).

The Chowilla anabranch and floodplain system provide flowing water habitats for native fish that are now poorly represented in the South Australian section of the River Murray. The construction of Lock 6 has resulted in the once ephemeral streams of the anabranch system becoming permanent, providing a rich mosaic of streams that vary in depth, width, velocity, aquatic vegetation and density of woody debris. This system supports 11 species of native fish, including a breeding population of the federal Environment Protection and Biodiversity Conservation Act-listed Murray cod and five species listed under the Fisheries Management Act (NSW) including silver perch (*Bidyanus bidyanus*), freshwater catfish (*Tandanus tandanus*) and the crimson-spotted rainbowfish (*Melanotaenia splendida fluviatilus*).

Indigenous values

The word Chowilla (or 'Tjowila') means 'place of spirits and ghosts' (Tindale 1974) and this floodplain is of high cultural, spiritual and emotional value for the First Peoples of the River Murray, the Mallee and Barkindji peoples and other Aboriginal groups downstream of the floodplain. They regard the ongoing preservation, protection and management of sites located on the floodplain as a high priority. These sites are also of high heritage value to South Australia and the Murray–Darling Basin as a whole.

The First Peoples of the River Murray and the Mallee and Barkindji peoples have maintained a long association with the River Murray and see it as a living body. Indeed, the river and its surrounds are one of the richest sources of Aboriginal archaeological and heritage sites. Aboriginal occupation of the Chowilla region dates back some 12,000 years to the upper Pleistocene epoch (SA Department for Environment and Natural Resources 1995).

The Maraura inhabited the northern side of the River Murray from Chowilla upstream to the junction of the Darling River and the Ngintait tribe used the southern side of the river between Paringa and Wentworth, although their lands also included the northern side of the river around Salt Creek and between Chowilla and Hunchee islands (Sharley & Huggan 1995).

The river environment provided resources such as water, fish, yabbies (*Cherax* genus) and plant material. The surrounding floodplains were places to harvest possums, kangaroos and other animals for food—providing the basis for a rich cultural economy. The bark from river red gums was used for canoes and the area was associated with campsites, ceremonies and funeral practices (SA State Planning Authority 1978; Sharley & Huggan 1995).

During 1991–92, the Murray–Darling Basin Commission funded an Aboriginal site survey of the upper River Murray region of South Australia (SA Department for Environment and Natural Resources 1995). The survey found that the Chowilla Floodplain contained numerous Aboriginal sites, including artefact-scatters, middens, hearths and scarred trees. The sand bodies (dunes and lunettes) are particularly rich with sites that include cemeteries and individual burials. The survey also found burials, hearths and artefact-scatters at Lake Littra that are thought to be of mid-Holocene age (5,000 years before present [using radiocarbon years]).

In 2005, a baseline Aboriginal cultural heritage study was undertaken on the Chowilla Floodplain (Wood *et al*. 2005). The study brought together a variety of data relating to the Aboriginal cultural heritage of the Chowilla Floodplain. A number of highly significant sites, both in terms of scientific and Aboriginal values, were identified.

Remediation works have occurred in recent years to protect burial sites, including revegetation of protected areas and realignment of access roads.

European values

The first European pastoralists settled at Chowilla in 1846, when squatters occupying Crown land were granted an annual occupation licence (SA Department for Environment and Natural Resources 1995). A pastoral lease was issued in 1851; this changed several times before 1864 as grazing continued to expand.

The success of the riverboat trade during this period provided a strong stimulus for development that lead to increased stocking of the floodplains and terraces. A mixture of horses, cattle and sheep grazed the area until about 1865. From that time, the Robertson family held and operated Chowilla Station as a wool-growing operation; however, in September 2005 livestock grazing was excluded from 83% of the Chowilla Floodplain. Chowilla Homestead was built after the great flood of 1870.

The Chowilla Floodplain also became part of the overland stock route, which at its peak saw up to 300 000 sheep move through the area per year (Department for Environment and Natural Resources 1995). To prevent sheep infected with scabby mouth (contagious pustular dermatitis) from entering South Australia, a stock inspector was appointed; Littra House was built at nearby Lake Littra as his residence.

European settlers inhabited the New South Wales portion of Chowilla from the late 1830s, with a small town built on the edge of Tareena Billabong as part of the Salt Creek community (Gell *et al*. 2005). This town was abandoned in the early 1900s, probably because of the severity of floods and droughts (Gell *et al*. 2005). River regulation in the 1920s created a more consistent water level within the area, enabling properties to remain active and allowing irrigation of pastures on Tareena Billabong's eastern and western margins.

Although in 1963 the River Murray Commission acquired 184 km^2 of the Chowilla Floodplain for a proposed dam to provide a major water storage for South Australia, Robertson Chowilla Pty Ltd continued to operate in this area under a short-term leaseback agreement. The dam was never built because of the risks associated with shallow saline groundwater and the project was formally abandoned in 1992 (SA Department for Environment and Heritage 2003). Following extensive public consultation by the Murray–Darling Basin Commission, it was agreed that lands purchased for the dam should revert to public lands, managed within a conservation framework, but that provision be made for the continuation of sheep-grazing within the area. Before the Regional Reserve was established in 1993, a lease agreement was drawn up to clarify grazing and ownership rights (SA Department for Environment and Natural Resources 1995).

Recreation and tourism

The Chowilla Floodplain is an exceptional location for a range of tourism and recreational activities. It is used primarily by South Australians, although it is also a destination for interstate visitors. Recreational use of the area tends to be short term and highly seasonal, coinciding with school holidays and long weekends, with the Easter break being particularly popular (Sharley & Huggan 1995).

The area is recognised as being the most valuable in South Australia for the canoeing component of outdoor educational programs for secondary schools, tertiary educational classes and youth agencies (SA Department for Environment and Heritage 1998). The Chowilla Floodplain experiences more than 2,500 camping nights per year, and the area is a popular fishing and hunting site for locals (SA Department for Environment and Heritage 1998). A significant number of visits to Chowilla are by pleasure craft such as houseboats using the main stream of the River Murray, along with dinghies and canoes accessing the anabranch creek systems (MDBC 2003b).

Scientific research

Various groups have used the Chowilla Floodplain for research purposes over many years, including CSIRO; the Murray–Darling Basin Authority; state government agencies such as the SA Department for Environment and Natural Resources, SA Department for Water, SA Research and Development Institute, NSW Fisheries; universities such as the University of Adelaide, Flinders University and University of South Australia); and private groups such as the Riverland Biosphere Trust.

Economic values

The Chowilla Floodplain has been used for wool-growing since 1865, and 17% of the floodplain continues to be grazed by stock. In 1881, 70,250 sheep were shorn at Chowilla, the tally achieved in an environment where there were no rabbits, few kangaroos and no goats (Bookmark Guides 2010). Professional fishermen also used the Chowilla anabranch system until 2003, when professional fishing was removed from the South Australian River Murray system.

Tourism in the Riverland contributes over $100 million annually to the local economy (QED 2006). Sites such as the Chowilla Floodplain and the River Murray are major attractions that contribute to the tourism industry.

Cultural economy

The Chowilla Floodplain and river is used by Aboriginals as a place for hunting, fishing, gathering and making tools. The River Murray corridor, including the Chowilla Floodplain, was one of the richest areas in Australia for natural resources and supported some of densest Indigenous populations (Angus 1847; Butlin 1983; Lawrence 1968; Taplin 1879; Tindale 1974).

The river, land and associated wetlands on the Chowilla Floodplain continue to be valued by local Aboriginals in their pursuit of a cultural economy, based on traditional practices and knowledge.

3. Ecological objectives and water requirements

Based on an understanding of the Chowilla icon site's characteristics and ecological requirements, The Living Murray (TLM) interim First Step Decision ecological objectives were developed and approved by Murray–Darling Basin Ministerial Council in 2003.

The vision for the Chowilla Floodplain is:

> To maintain and restore a diverse and healthy floodplain environment that will provide for the long-term ecosystem and community needs and serve as a showcase for lower River Murray floodplain management (MDBC 2006).

The First Step ecological objectives for the the Chowilla Floodplain and the Lindsay, Mulcra and Wallpolla islands were developed for the Chowilla Floodplain and applied to the entire icon site. They are to:

Maintain high biodiversity values of the Chowilla Floodplain, as indicated by:

- high value wetlands maintained
- current area of river red gum maintained
- at least 20% of the original area of black box vegetation maintained.

Since these objectives were approved by Ministerial Council in 2003, jurisdictional agencies have continued to review and refine the First Step interim objectives to develop refined ecological objectives for icon sites. These refined ecological objectives reflect eight years of learning's from the delivery of environmental water, monitoring, modelling and consultation activities and scientific research, and enable a clearer, more effective, evaluation of environmental responses to environmental water delivery.

The Chowilla environmental water management plan includes both the First Step Decision and refined ecological objectives for Chowilla icon site.

The Living Murray condition monitoring program designed for the Chowilla Floodplain and the Lindsay, Mulcra and Wallpolla islands (Murray–Darling Freshwater Research Centre 2009) refined these broad objectives into 17 site-specific objectives using new information, including the results of the Chowilla icon site condition monitoring program, ecological investigations conducted to inform the development of the Chowilla Creek environmental regulator and consultation with the E-flows working group. These refined objectives (presented in **Table 3.1**), and the associated monitoring program will support the First Step interim objectives and allow the efficacy of environmental water delivery to be assessed.

Table 3.1: Refined site-specific ecological objectives: Chowilla Floodplain

Refined site-specific ecological objectives by functional groups	
Vegetation	
(1)	Maintain viable river red gum populations within 70% (2,414 ha) of river red gum woodland.
(2)	Maintain viable black box populations within 45% (2,075 ha) of black box woodland.
(3)	Maintain viable river cooba (*Acacia stenophylla*) populations within 50% of river cooba, and mixed red gum and river cooba woodland areas.
(4)	Maintain viable lignum populations in 40% of areas.
(5)	Improve the abundance and diversity of grass and herblands.
(6)	Improve the abundance and diversity of flood-dependent understorey vegetation.
(7)	Maintain or improve the area and diversity of grazing sensitive plant species.
(8)	Limit the extent of invasive (increaser) species including weeds.
(9)	Improve the abundance and diversity of submerged and emergent aquatic vegetation.
Fish populations	
(10)	Maintain or increase the diversity and extent of distribution of native fish species.
(11)	Maintain successful recruitment of small and large bodied native fish.
Frog populations	
(12)	Maintain sustainable communities of the eight riparian frog species recorded at Chowilla.
(13)	Improve the distribution and abundance of the nationally listed southern bell frog at Chowilla.
Bird populations	
(14)	Create conditions conducive to successful breeding of colonial waterbirds in a minimum of three temporary wetland sites at a frequency of not less than one in three years.
(15)	Maintain or improve the diversity and abundance of key bird species.
(16)	Maintain the current abundance and distribution of regent parrots
(17)	Maintain the current abundance and distribution of the bush stone-curlew (*Burhinus grallarius*)
Please note soil condition and groundwater targets are currently being developed	

Water requirements

Flora

River red gum and black box forests and woodlands existing in a semi-arid climate characterised by low rainfall and high potential evaporation, such as the Chowilla Floodplain, rely on periodic flooding to supply fresh water and to leach salt from the soil profile (Overton & Doody 2008).

The distribution of vegetation across the floodplain is directly determined by parameters such as a plant species tolerance to a range of variables, including to changes in the local hydrology and soil and groundwater salinities. As the range of these tolerances can be extremely broad — an adaption to a variable environment — a single species will occur across a range of hydrological regimes. This means it is not possible to define a single hydrological indicator for the vegetation community targets in **Table 3.1** because the species within these communities cover a wide range of flows and a single indicator to meet the whole target would be misleading.

The duration and timing of several flow bands that contribute towards achieving the vegetation targets have been identified. These hydrological indicators were developed using results from weighted index of salinisation modelling (WINDS) (CSIRO 2005). The flow regimes outlined in **Table 3.2** are the flows required by each vegetation community to prevent salt accumulation in the soil and to provide sufficient inundation frequencies for that community's long-term survival.

Table 3.2: Hydrological indicators — all vegetation target areas: Chowilla Floodplain

Flow band (ML/d)	Majority of target vegetation in flow band	Required % time inundated	Average flow regime required	Timing (preferred)
5,000 to 40,000	River red gum forest, herbland	15% (61 in 100 years for 90 days)	3 months (1 in 1–2 years)	Late winter/spring/summer
40,000 to 50,000	River red gum forest, tea tree (*Leptospermum* genus), herbland, lignum, cooba	13% (53 in 100 years for 90 days)	3 months (1 in 2 years)	Late winter/spring/summer
50,000 to 60,000	River red gum woodland, black box, cooba, tea tree, grassland, lignum, chenopod, herbland	11% (45 in 100 years for 90 days)	3 months (1 in 2–3 years)	Late winter/spring/summer
60,000 to 70,000	River red gum woodland, black box, cooba, grassland, lignum, chenopod, herbland	8% (32 in 100 years for 90 days)	3 months (1 in 3 years)	Late winter/spring/summer
70,000 to 80,000	Black box, lignum, chenopod, samphire (*Tecticornia genus*), herbland	7% (28 in 100 years for 90 days)	3 months (1 in 4 years)	Late winter/spring/summer
80,000 to 90,000	Black box	6% (24 in 100 years for 90 days)	3 months (1 in 4–6 years)	Late winter/spring/summer
90,000 to 140,000	Black box	3% (12 in 100 years for 90 days)	3 months (1 in 8 years)	Late winter/spring/ summer

These flow volumes and frequencies outlined in **Table 3.2** are not attainable under current conditions without complementary works and measures and environmental water flow deliveries. To fully meet the refined environmental objectives of the floodplain, a combination of natural and managed inundations would be required.

Table 3.3 outlines the water requirements to assist in meeting the Chowilla ecological objectives while **Table 4.1** in chapter 4 of this environmental water management plan considers how the Chowilla Creek environmental regulator could be used to artificially inundate larger areas of the Chowilla Floodplain than would be possible with the equivalent natural flow.

While **tables 3.3** and **4.1** present a range of management options to meet the environmental objectives for the Chowilla Floodplain, they do not present an overall operating strategy for the Chowilla Creek environmental regulator and other floodplain structures. This operating plan is currently being developed and will be attached to the environmental water management plan as a schedule when completed.

Fauna

The flooding frequencies and magnitudes identified to meet the vegetation targets listed in **Table 3.2** and the complementary management actions identified in **Table 4.2** would be sufficient to meet the fauna objectives presented in **Table 3.1**.

However, meeting the objectives for some fish species will require ongoing monitoring and investigation.

Climate and rainfall in the Murray–Darling Basin

Historically, the climate of the Murray–Darling Basin has been variable. Climate change science indicates a likely increase in this variability, resulting in more frequent and extreme floods and droughts (MDBA 2010a). Consequently, river storages and the use of environmental water will be managed according to these varying river flows.

Between 1996 and 2010, the Murray–Darling Basin was in a drought characterised by below-average rainfall in autumn and winter and few wet periods. This drought was significantly drier than the Federation Drought (mid-1890s to early 1900s) and the droughts of the World War II era (c. 1937–45).

Beginning in spring 2010, and continuing through the summer of 2010–11, widespread, above average rainfall across the Murray-Darling Basin broke the long standing drought. This rainfall was associated with the development, beginning in 2010, of a moderate to strong La Nina event making 2010 the wettest year on record for the Murray–Darling Basin.

Meteorological information recorded at nearby Renmark, indicates that the climate is semi-arid with long hot summers. The mean annual maximum temperature is 24.3°C, and the hottest month is January, which has a mean daily maximum temperature of 32.5°C. The coolest month is July, with a mean daily minimum temperature of 5.9°C. Both diurnal and seasonal temperature variation can be significant. The mean annual rainfall is 260 mm, with the wettest months tending towards late winter

and spring (August, September and October). However, this rainfall is undependable and shows considerable variation from year to year — extended dry spells are common (Bureau of Meteorology 2004). High evaporation rates occur throughout the year because of low relative humidity, high temperatures and frequently strong winds. Evaporation exceeds rainfall in every month of the year (SA State Planning Authority 1978), which results in a particularly short growing season of only 2 to 3 months in the Chowilla area (Jarwal *et al*. 1996).

Table 3.3: Water requirements for the icon site ecological objectives

			Required flow regime						
First Step Decision objective	Refined site-specific ecological objectives	Vegetation community	Area of floodplain inundated (ha)	Flow rate QSA (ML/d)	Average duration	Timing	Average frequency (years in 10)	Maximum time between events	Works or other mechanisms to assist meeting objectives *
High value wetlands maintained	(1) River red gum (9) Aquatic vegetation (10) Fish diversity (11) Fish recruitment (12) Frogs (13) Southern bell frogs	Permanent and temporary wetlands. Permanent creeks.	Total of 472 ha 125 ha of permanent wetlands and 347 ha permanent flowing creeks	1,000 to 5,000	3 months	Late winter/ spring/ summer	Base flows	0 years	Manipulation of Pipeclay and Slaneys weirs to reintroduce seasonal flow variability to permanently flowing creeks Use of wetland flow control structures to reintroduce wetting and drying cycles to Lock 6 pool level wetlands
Current area of river red gum maintained	(1) River red gum (3) River cooba (4) Lignum (5) Grass and herbland	River red gum forest, herbland	0 to 1,000	5,000 to 40,000	3 months	Late winter/ spring/ summer	5 to 10 in 10 years	3 years	Manipulation of Pipeclay and Slaneys weirs to reintroduce seasonal flow variability to permanently flowing creeks
High value wetlands maintained	(10) Fish diversity (11) Fish recruitment (12) Frogs (13) Southern bell frogs	Permanent and temporary wetlands. Permanent creeks.							Use of wetland flow control structures to reintroduce wetting and drying cycles to Lock 6 pool level wetlands
Current area of river red gum maintained	(1) River red gum (3) River cooba (4) Lignum (5) Grass and herbland (10) Fish diversity (11) Fish recruitment	River red gum forest, herbland, lignum and river cooba	1,500 to 1,800	40,000 to 50,000	3 months	Late winter/ spring/ summer	5 in 10	3 years	
High value wetlands maintained	As above plus (6) Flood-dependent understorey vegetation (12) Frogs (13) Southern bell frogs (14) Waterbirds								

			Required flow regime						
First Step Decision objective	Refined site-specific ecological objectives	Vegetation community	Area of floodplain inundated (ha)	Flow rate QSA (ML/d)	Average duration	Timing	Average frequency (years in 10)	Maximum time between events	Works or other mechanisms to assist meeting objectives *
Current area of river red gum maintained At least 20% of the original area of black box vegetation maintained	(1) River red gum (2) Black box (3) River cooba (4) Lignum (5) Grass and herbland (6) Flood-dependent understorey vegetation (15) Key bird species	River red gum woodland, black box , river cooba, tea tree grassland, lignum chenopod and herbland	1,800 to 4,400	50,000 to 60,000	3 months	Late winter/ spring/ summer	3 to 5 in 10	3 years	Upon flood recession close flow control structures at Lakes Littra, Lake Limbra, Werta Wert and Woolshed Creek to extend inundation durations
High value wetlands maintained	As above plus (12) Frogs (13) Southern bell frogs (14) Waterbirds	Temporary floodplain wetland communities							
Current area of river red gum maintained At least 20% of the original area of black box vegetation maintained	(1) River red gum (2) Black box (3) River cooba (4) Lignum (5) Grass and herbland (6) Flood-dependent understorey vegetation (15) Key bird species	River red gum woodland, black box cooba, grassland lignum, chenopod and herbland	4,400 to 5,700	60,000 to 70,000	3 months	Late winter/ spring/ summer	3 in 10	3 years	Upon flood recession close flow control structures at Lake Littra, Lake Limbra, Werta Wert and Woolshed Creek to extend inundation durations
High value wetlands maintained	As above plus (12) Frogs (13) Southern bell frogs (14) Waterbirds	Temporary floodplain wetland communities							
At least 20% of the original area of black box vegetation maintained	(2) Black box (5) Grass and herbland (6) Flood-dependent understorey vegetation (15) Key bird species	Black box, lignum, chenopod, samphire and herbland	5,700 to 9,400	70,000 to 80,000	3 months	Late winter/ spring/ summer	2 to 3 in 10	4 years	
High value wetlands maintained	As above plus (1) River red gum (3) River cooba (4) Lignum (12) Frogs (13) Southern bell frogs 14) Waterbirds	Temporary floodplain wetland communities							

				Required flow regime					
First Step Decision objective	Refined site-specific ecological objectives	Vegetation community	Area of floodplain inundated (ha)	Flow rate QSA (ML/d)	Average duration	Timing	Average frequency (years in 10)	Maximum time between events	Works or other mechanisms to assist meeting objectives *
At least 20% of the original area of black box vegetation maintained	(2) Black box (5) Grass and herbland (6) Flood-dependent understorey vegetation (15) Key bird species	Black box	>9,400	80,000 to 90,000	3 months	Late winter/ spring/ summer	1 to 2 in 10	6 years	
At least 20% of the original area of black box vegetation maintained	(2) Black box (5) Grass and herbland (6) Flood-dependent understorey vegetation (15) Key bird species	Black box	>13,500	90,000 to 140,000	3 months	Late winter/ spring/ summer	1 in 10	10 years	

* This table presents the flow regime identified in Table 3.2 and indicates the minor works or mechanisms that would be applied to naturally occurring high flows to assist in meeting the icon site ecological targets.

Baseline condition

When established, baseline condition for the Chowilla Floodplain will be attached to the environmental water management plan as a schedule. A summary of the current condition of the Chowilla Floodplain is presented below and a more detailed description is presented in **Appendix A**.

Current condition

The environmental health of the Chowilla Floodplain is closely related to River Murray flow regimes, groundwater level and salinity and, to a lesser extent, localised rainfall, although most ecological communities on the floodplain cannot be sustained by rainfall alone and are dependent to varying extents on overbank flows.

Numerous ecological studies (e.g. O'Malley & Sheldon, 1990; Margules & Partners *et al*. 1990; Overton & Jolly 2003; MDBC 2003a; SA Department of Water, Land and Biodiversity Conservation 2005, MDBC, 2008, Cunningham *et al*. 2009, Gehrig *et al*. 2010, Nichols *et al*. [in prep])and the continuing TLM condition monitoring program (e.g. SA MDB NRM Board 2009a; SA MDB NRM Board 2010a) have demonstrated a dramatic and continued decline in the health of the Chowilla Floodplain as a consequence of changes to the natural flow regime, increasing levels of water extraction, grazing, a protracted period of drought and the complete absence of overbank flows between 2000–10.

The only exceptions to this decline are the flushed zones where the decline in over-storey vegetation and lignum appears to be slower than the remainder of the floodplain and at environmental watering sites, where a recovery in condition has been observed at sites watered on multiple occasions. Since 2004, 28 sites on the Chowilla Floodplain have received environmental water; with the exception of higher floodplain sites watered for the first time in 2010, all sites have been watered on two to four occasions. In the complete absence of natural inundation, the best environmental outcomes have been observed at sites watered on four occasions.

Appendix A summarises the current condition and trajectory of the floodplain as defined by a combination of environmental studies and surveys, the current TLM environmental monitoring program and modelling undertaken to determine conditions for tree growth based on predicted future flow regimes and soil salinity (WINDS modelling).

Antecedent hydrological conditions

The natural flow regime of the River Murray has been significantly modified via flow regulation through the operation of a series of weirs and upstream storages. These changes have altered the hydrology of floodplain environments so that they are now either permanently inundated, permanently dry or flood less frequently with altered seasonality. Thoms and others (2000) broadly summarised the characteristics of the current flow regime compared with natural as a reduction in flow volume, the presence of longer periods of sustained low flows and an overall reduction in flood frequency. The effect of flow regulation and diversions on the Chowilla Floodplain has been to reduce flood frequency for all but the largest floods as shown in **Table 3.4**.

Table 3.4: Flooding extent, frequency, and duration under natural and current conditions: Chowilla Floodplain

River Murray flow to SA (ML/d)	Area inundated (ha)[a]	Percentage of area of Chowilla Floodplain inundated	Return period[b] (Number of times peak flows occur in 100 years)		Duration (Number of months flow is exceeded)	
			Natural	Current	Natural	Current
3,000	–	–	100	100	11.8	11.9
10,000	–	–	100	94	10.1	4.6
20,000	–	–	99	63	7.8	4.6
40,000	1,400	8.0	91	40	4.9	3.3
45,000	1,700	9.6	83	34	4.6	3.2
55,000	3,100	17.5	–	–	–	–
65,000	4,800	37.1	–	–	–	–
75,000	6,700	37.8	45	–	–	–
80,000	8,200	46.3	45	12	3.2	2.6
90,000	11,100	62.7	37	11	3.1	2.1
110,000	14,200	80.2	27	5	2.4	3.2
140,000	16,800	94.9	14	4	2.1	2.5
200,000	17,700	100	3	1	2.0	2.0
300,000	17,700	100	1	0	2.0	–

Notes
a Column one shows actual flows where floodplain inundation was measured where inundation data are interpolated (Sharley & Huggan 1995).
b Figures refer to highest daily flow in the month, not average daily flows for the month.

4. Water delivery

Prioritisation of water requirements

The Living Murray (TLM) Annual Environmental Watering Plan was developed by the Environmental Watering Group. The plan includes a flexible decision framework to guide prioritisation of environmental watering actions, as well as icon site environmental watering proposals, water availability forecasts and management objectives for water resource scenarios (see **Table 4.1**).

Throughout the year the Environmental Watering Group recommends environmental watering actions to the Murray–Darling Basin Authority (MDBA) for approval. These recommendations are based on the Annual Environmental Watering Plan and the volume of water available in The Living Murray environmental water portfolio.

Table 4.1: Objectives under different water availability scenarios

	Extreme dry	Dry	Median	Wet
Ecological watering objectives	Avoid irretrievable loss of key environmental assets.	Ensure priority river reaches and wetlands have maintained their basic functions.	Ecological health of priority river reaches and wetlands have been protected or improved.	Improve the health and resilience of aquatic ecosystems.
Management objectives	Avoid critical loss of species, communities and ecosystems. Maintain key refuges. Avoid irretrievable damage or catastrophic events.	Maintain river functioning with reduced reproductive capacity. Maintain key functions of high priority wetlands. Manage within dry-spell tolerances. Support connectivity between sites.	Enable growth, reproduction and small-scale recruitment for a diverse range of flora and fauna. Promote low-lying floodplain-river connectivity Support medium flow river and floodplain functional processes	Enable growth, reproduction and large-scale recruitment for a diverse range of flora and fauna Promote higher floodplain-river connectivity Support high flow river and floodplain functional processes
Priority locations for the Chowilla floodplain	Base flows throughout the Chowilla anabranch system to maintain native fish populations	Use of Pipeclay and Slaneys weirs to reintroduce seasonal flow variability. Lock 6 weir pool manipulations to reintroduce seasonal flow variability. Maintain pool level wetlands — e.g. Pilby Lagoon, Pilby Creek, Pipeclay Billabong, Slaney Billabong, Bunyip Waterhole. Pumping water in to high value wetlands e.g. Werta Wert, Lake Littra, Coppermine Waterhole, Woolshed Creek and Monoman Island Horseshoe.	Operation of Chowilla environmental regulator to inundate priority floodplain wetlands and low lying floodplain — e.g. Werta Wert, Lake Littra, Coppermine Waterhole, Woolshed Creek, Monoman Island Horseshoe and Gum Flat.	Natural flood events to inundate the broader floodplain. Operation of the Chowilla environmental regulator to enhance natural high flows and flood events to inundate higher elevations of the floodplain, e.g. Black box woodlands.

The Living Murray works and water modelling

Modelling completed in 2008 found that the environmental water requirements of the floodplain icon sites (with the exception of Barmah-Millewa and the Lower Lakes, Coorong and Murray Mouth and River Murray Channel icon sites) could largely be met by a combination of the proposed TLM works, the 500 GL of recovered TLM water and 70 GL long-term Cap equivalent (LTCE) of River Murray Increased Flows.

This modelling was based on a number of assumptions including the use of unregulated flow events for environmental watering actions. It was also agreed as a modelling principle that return flows could be used to water at multiple environmental sites. There are a number of constraints to the implementation of this principle which TLM are currently working to resolve.

Further modelling is also planned to allow greater optimisation of works and measures to achieve icon site ecological objectives as we gain a greater understanding of operating scenarios.

Operating regimes for environmental watering actions

This section of the environmental water management plan provides a broad description of the proposed operating regimes to maximise ecological outcomes from the use of The Living Murray Water portfolio and works. To meet the proposed operating regimes a combination of unregulated and regulated environmental water may be used. While this Plan focuses on the use of environmental water from the The Living Murray's Water Portfolio, there may also be other sources of environmental water available to meet the proposed regimes.

Options for environmental watering

Brookes and others (2006) noted that the ideal long-term solution to the declining state of the Chowilla Floodplain would be to restore significant flows to the river. However, they suggested that this was unlikely to occur even with the 500 GL per annum target of The Living Murray program proposed for 2009. Under present operating conditions, seasonal entitlement flows to South Australia determined by irrigation requirements are 3,000 to 7,000 ML/d. To have sustained significant overbank flows at Chowilla, a flow of 65,000 ML/d is required; to sustain this for 60 days would require an additional 3,900 GL of water of flow to South Australia. Brookes and others (2006) concluded that restoring and maintaining the ecological values of the Chowilla Floodplain would require finding a pragmatic solution that uses smaller flows to best effect.

In 2006 URS undertook an options assessment (Overton *et al*. 2005), in which a range of management options for delivering environmental water to the Chowilla icon site were considered. The options assessment was made primarily using hydrodynamic and groundwater modelling as well weighted index of salinisation modelling (WINDS) vegetation health modelling to determine management techniques that might result in improved environmental outcomes for river red gum and black box populations over approximately 30 years. Some of these options were further considered by Brookes and others (2006), including the 'do nothing approach', continued deployment of mobile pumps to pump water into discrete areas of the floodplain, irrigation infrastructure and a flow regulator on Chowilla Creek. The top-ranking options from this assessment were:

- First, construction of an environmental regulator at the downstream end of Chowilla Creek in combination with the raising of Lock 6 upper pool level to 19.87 m (Australian height datum) during regulator operation.
- Second, this option in combination with a 38-well bore-field salt interception scheme.

These two options came closest to satisfying the interim ecological objectives for the Chowilla Floodplain.

Brookes and others (2006) concluded that the construction of an environmental regulator would affect a larger, more continuous area than could be serviced by mobile pumps. They noted that in addition to increasing the area that could be inundated, an environmental regulator would have the additional benefits of:

- enhancing surface-water connectivity between wetlands and the river channel
- increasing the productivity of the wetlands and woodlands
- freshening the soil profile
- contributing to the re-establishment of a healthy plant community
- combating salt accumulation in the plant root zone
- increasing zooplankton abundance
- providing additional habitat for small native fish.

The report noted that the ecological benefits relative to pumping would be reduced if there were not a substantial continual flow over the regulator during operation.

The Chowilla environmental regulator

Most of the environmental water delivered to the Chowilla Floodplain will be through the operation of the Chowilla Creek environmental regulator. This will reduce the severe ecological decline that has resulted from the reduction in overbank flows, and enable up to 50% of the floodplain to be inundated under a range of flow conditions. An operating plan is being developed for the environmental regulator.

The MDBA approved the construction of the Chowilla Creek environmental regulator and complementary works. Construction began in January 2010 and is anticipated to take two years, with operation likely to begin in 2012. The location of these structures is shown in **Figure 4.1**.

These works will enable the restoration of a flooding sequence on the Chowilla Floodplain that more closely resembles the natural conditions under which the floodplain's biota evolved. The environmental regulator will be operated specifically for environmental outcomes and will only be operational for short periods (typically for three to four months, on average one year in three); however, it may be more frequent in the initial 'recovery' period.

The proposed regulator will enable water level variation within the Chowilla Floodplain to approximately 3.6 m. It will operate under low flows ranging from entitlement conditions (3,000 to 7,000 ML/d) up to 50,000 ML/d, although flows of at least 10,000 ML/d would be preferred for operation at the maximum possible extent. The design includes fishways to enable fish passage for large-, medium- and small-bodied native fish while the main control regulator is in operation.

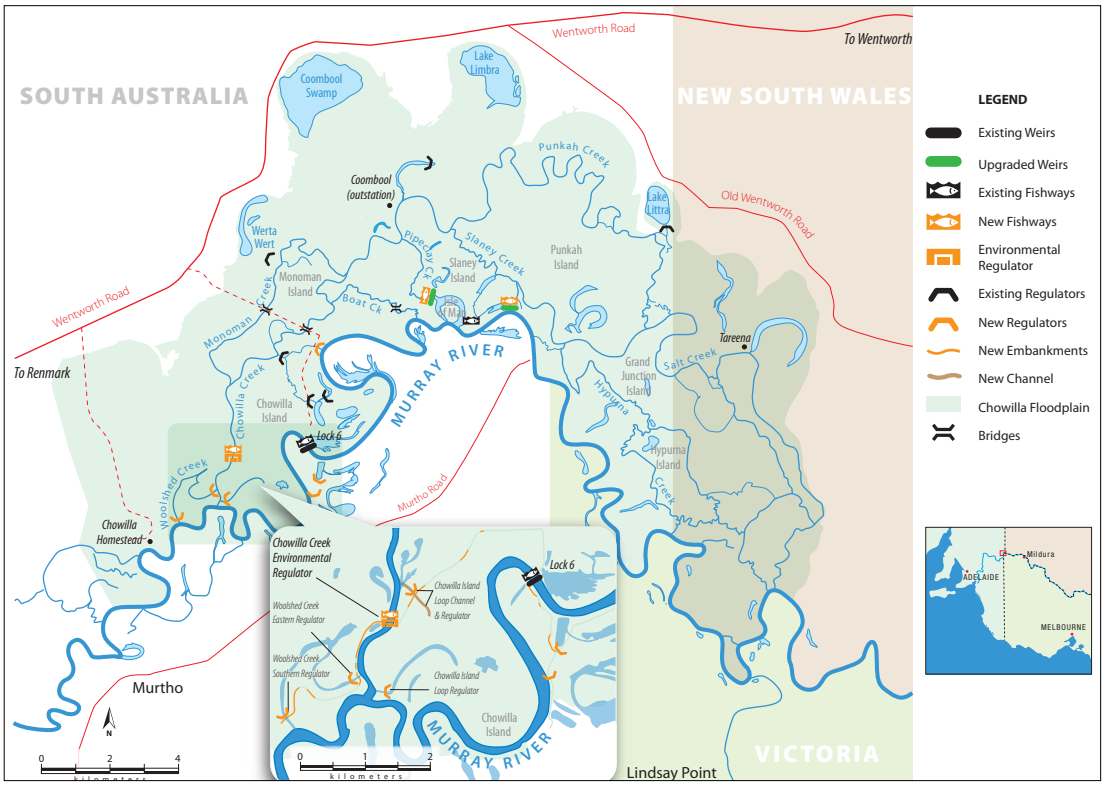

Figure 4.1: Schematic diagram of the proposed Chowilla Floodplain water management structures (MDBA 2010b)

Operation of the environmental regulator at full height of 19.87 m will enable the flooding of between 5,630 ha and 9,000 ha (or 35% and 50%) of the floodplain (as shown in figures 4.2 and 4.3), depending on the current river flow to South Australia, and will influence an even larger area through lateral groundwater freshening. This will enable the maintenance and improvement of 78% of the river red gum community and 31% of the black box community. It will also inundate large areas of other floodplain habitats, including 91% of wetlands and water courses, 75% of river cooba woodlands and 58% of floodplain grasslands (Overton and Doody 2008).

As well as the vegetation benefits, the regulator will provide environmental benefits within and beyond the inundated area, including:

- increasing connectivity between riverine and floodplain habitats
- freshening groundwater systems
- improving soil condition
- rejuvenating existing wetland habitats
- establishing new floodplain and wetland plant communities
- enhancing regional biodiversity
- increasing zooplankton abundance
- increasing habitat and breeding opportunities for waterbirds and frogs
- providing additional habitat for small native fish (Brookes *et al*. 2006; Nicol in prep.; SA MDB NRM Board 2009a).

Pipeclay and Slaneys weirs

Pipeclay and Slaney creeks are two of the major flow paths into the Chowilla anabranch system. During low-to-medium flows (5,000 to 25,000 ML/d), up to 75% of the flow to Chowilla enters through Pipeclay and Slaneys creeks. Flow in both creeks is controlled by concrete weirs with removable stop logs. Fish are known to accumulate below these structures (Zampatti & Leigh 2005), and there is currently no fish passage through them. MDBA has approved work to refurbish these structures, including the installation of fishways, which will allow fish passage between the main channel of the Murray and the Chowilla system. The refurbished weirs will allow flexible operation of flows into Pipeclay and Slaney creeks.

An operating strategy for Pipeclay and Slaney weirs is nearly completed. Management of the weirs using the new operating strategy will increase in-channel flow variation, effectively reinstating certain natural flow characteristics such as spring pulse flows and autumn low flows. It will also establish an approach to make use of high in-channel flows and protect high-value habitats during extended low-flow periods. Other factors, such as an increase in the magnitude of flows and variations in water levels, will benefit vegetation, fish and other biota. The Pipeclay and Slaney weirs will be used both during and between regulator use; they are critical to improving conditions for large-bodied fish species such as Murray cod and silver perch.

Operation of locks 6 and 7

Variation in the height of Lock 6 will be an important component of the overall operating strategy for Chowilla Floodplain structures. In combination with the operation of Pipeclay and Slaneys weirs, raising Lock 6 has the capacity to increase the volume of water passing through the Chowilla anabranch system and/or to inundate floodplain areas. These are both important considerations when developing operating regimes for the Chowilla Floodplain structures.

Raising Lock 6 during regulator operations is also an important component of the risk mitigation strategy. Mallen-Cooper and others (2008) identified the benefits for large-bodied native fish of maintaining fast-flowing habitat within the Chowilla system during regulator operations. Hydraulic modelling presented in Mallen-Cooper and others (in prep.) has demonstrated that by raising Lock 6 above the height of the regulator during a managed inundation, flow velocity through core fish habitats can be maintained.

Manipulating the Lock 6 weir pool also provides an opportunity to gain environmental benefits from the manipulation of existing structures. Weirs in the lower River Murray have traditionally been managed to maximise the stability of the agreed weir-pool height. Through a more flexible approach to the maintenance of weir pool levels, the Lock 6 weir pool could be managed to:

- raise water levels in low flows to inundate exposed banks and edges of marginal wetlands
- fluctuate the water levels in weir pools to mimic natural short-term water level changes
- raise the effective height of small-to-medium flows in the Murray to activate flow in temporary anabranches, inundating low-lying temporary wetlands and watering marginal river red gum woodlands and riparian vegetation
- lower water levels to dry flooded wetlands; expose riverbanks; trigger organisms to lay desiccation-resistant stages, eggs, or seeds; and stimulate riparian and wetland plant colonisation.

Weir manipulation trials undertaken in 2000, 2005 and 2006 resulted in low-lying areas along

the river channel being inundated, water flowing into anabranches and the flooding of a number of managed wetlands (Cooling *et al*. 2010). Weir manipulation is likely to be routinely undertaken during the years in which the Chowilla Creek environmental regulator is not operated.

Raising the Lock 6 weir pool potentially could reduce the magnitude and length of flowing habitat in Mullaroo Creek and could lead to water quality issues because of increased residence times of water within the Lindsay Island system. The relationship between raising locks 6 and 7 was investigated by Water Technology (2007) using a one-dimensional model to simulate various combinations of locks 6 and 7 weir pool levels. The results of this modelling show that the simultaneous raising of locks 6 and 7 can result in equivalent or higher flow velocities in the Mullaroo and Lindsay system than would occur if no weir-raising were conducted. This outcome suggests that risks to high-value fish habitats and water quality issues could be minimised through the joint operation of locks 6 and 7.

Pumping environmental water to high-value floodplain wetlands

Operation of the Chowilla environmental regulator to artificially inundate the floodplain is unlikely to occur with River Murray flows to South Australia of less than 10,000 ML/d (SA MDB NRM Board 2009). To meet Chowilla Floodplain ecological objectives during low-flow periods, other watering actions (such as pumping) will be required. Results from the Chowilla environmental watering program, which commenced in 2004, demonstrate the benefits of using pumps to inundate areas that would not have received water under low-flow conditions. Water consumption and pumping frequencies for this management action are presented in **Table 4.2**.

Developing an operating strategy for the Chowilla environmental regulator and other floodplain structures

The operations plan for the Chowilla environmental regulator will present a multi-year operation strategy that will describe how the regulator can be used in conjunction with existing structures on the floodplain —including small (e.g. wetland inlets) and larger (e.g. Pipeclay and Slaney weirs and Lock 6 structures)—to produce a dynamic floodplain in which biota vary in abundance and composition in time and space.

The aim of the operations plan is not to produce a single 'static' operation that is endlessly repeated; rather, it is to identify potential operations that build on available flows that reflect variations in the natural system and to focus on reintroducing historical process such as floodplain inundation and within-channel high flows.

This suggests an operating regime in which the regulator height and the extent of floodplain inundation vary with available flow, and one in which other structures are used between regulator operations to reproduce seasonal variation to within-channel flows. Choosing not to use the regulator for selected high-flow events would also be part of the long-term operating strategy, because this is an important component of achieving a variable operating regime with the capacity to benefit all ecological targets.

An initial operational plan will be completed in 2011 and will be attached to the Environmental Water Management Plan as a schedule.

Potential operations of the Chowilla Creek environmental regulator and their links to Chowilla's ecological objectives are presented in **Table 4.2**.

Figure 4.2: Inundation at 10 GL/d without the Chowilla regulator

Figure 4.3: Inundation with the regulator in operation at 10 GL/d and raised to 19.87 m AHD

Table 4.2: Operating regimes contribution to the ecological objectives

First Step Decision objective	Vegetation community (Hectares)	Works or other mechanisms to assist meeting objectives	Frequency (Years in 10)	Duration (Days)	Estimated volume of water required (GL)	Estimated volume of water used (GL)
Preferred operating scenario						
High value wetlands maintained Current area of river red gum maintained	Permanent creeks (347 ha)	Manipulation of Pipeclay and Slaneys weirs to reintroduce seasonal flow variability to permanently flowing creeks.	Base flows	Seasonal variation	To be determined	To be determined
	Permanent and temporary wetlands (125 ha)	Use of wetland flow control structures to reintroduce wetting and drying cycles to Lock 6 pool level wetlands.				
		Pumping high-value wetlands.	5 years in 10 under continued extreme dry and dry conditions	NA	16	16
Current area of river red gum maintained	River red gum forest, herbland (0 to 1,000 ha)	Use of the Chowilla Creek environmental regulator to produce a within-channel water level rise. This operation would require a flow of between 5,000 to 10,000 ML/d (flow to South Australia).	5 years in 10	90 to 120	450 to 1,200	TBD
	River red gum forest, tea tree (*Leptospermum* genus), herbland, lignum — river cooba shrubland (2,850 to 5,580 ha)	Operation of the Chowilla Creek environmental regulator at 10,000 ML/d (flow to South Australia).	1 to 2 years in 10	120	1,200	60

First Step Decision objective	Vegetation community (Hectares)	Works or other mechanisms to assist meeting objectives	Frequency (Years in 10)	Duration (Days)	Estimated volume of water required (GL)	Estimated volume of water used (GL)
Current area of river red gum maintained At least 20% of the original area of black box vegetation maintained	River red gum woodland, black box, cooba, grassland, lignum, chenopod shrubland, herbland (2,850 to 5,700 ha)	Operation of the Chowilla Creek environmental regulator at 20,000 ML/d (flow to South Australia).	1 in 10 years	120	2,400	75
	Black box, lignum, chenopod shrubland, samphire, herbland (8,100 ha)	Operation of the Chowilla Creek environmental regulator at 45,000 to 50,000 ML/d (flow to South Australia).	1 in 10 years	120	5,400 to 6,000	75 to 100
Minimum operating scenario						
High-value wetlands maintained Current area of river red gum maintained	Permanent creeks (347 ha)	Manipulation of Pipeclay and Slaneys weirs to reintroduce seasonal flow variability to permanently flowing creeks.	Base flows	Seasonal variation	TBD	TBD
	Permanent and temporary wetlands (125 ha)	Use of wetland flow control structures to reintroduce wetting and drying cycles to Lock 6 weir pool-level wetlands.				
		Pumping high value wetlands.	5 years in 10 under continued extreme dry and dry conditions	NA	16	16
High value wetlands maintained Current area of river red gum maintained	River red gum forest, tea tree, herbland, lignum–river cooba shrubland (1,500 to 1,800 ha)	Operation of the Chowilla Creek environmental regulator at 10,000 ML/d for 120 days.	3 years in 10	120	1,200	60

Notes
Frequency of operation is an expected average actual operation frequency would depend on prevailing flow conditions and the current condition of the floodplain. TBD indicates where volume of water required and volume of water used is yet to be determined.

Water accounting and measurement

Water accounting methodology will be developed and agreed in advance by The Living Murray Committee and the Basin Officials Committee. Consistency of water accounting methodology will be sought wherever possible. Where relevant, water accounting will be consistent with the Water Accounting Conceptual Framework and Australian Water Accounting Standards.

The best available, most appropriate and cost-effective measurement technique will be used to determine environmental water use. The appropriateness of the measurement technique is likely to differ depending on icon site and event. For example, under dry conditions, environmental water pumped into Hattah Lakes is likely to be measured using a meter while return flows are measured via a gauging station; under wet conditions, environmental water returning from Barmah–Millewa Forest will need to be modelled.

Hydraulic modelling undertaken by Water Technology (2009) estimated losses for the hypothetical full-height operational regime (at flows of 10,000 ML/d for 120 days) as 46 GL (3.7% of total inflows). These losses should accurately reflect the water losses associated with the operation of the Chowilla Creek regulator because they also take into account the identical inflows under a "'no-regulator' scenario. **Table 4.3** details the scenarios modelled by Watertech to calculate water losses under the 10,000 ML/d for a 120-day operating event. Additional modelling of water use for a range of potential operations (including a within-channel rise) will be undertaken in conjunction with development of an operating strategy for Chowilla Floodplain structures.

Evaluation and management of potential risks

A series of detailed investigations and risk assessments were undertaken between 2006 and 2010 to determine potential risks involved in regulator operation. These risks included abiotic factors such as floodplain geomorphology, surface-water quality and groundwater, surface-water and soil salinity interactions. Flora and fauna (e.g. predicted responses of birds, amphibians, fishes, pest plants and vegetation, including trees and understorey vegetation) responses to regulator operation were also considered

A summary table of the identified risks, mitigation measures and required monitoring is presented in Schedule 1 of this report. A specific risk management plan will be included in the operations plan for Chowilla environmental regulator; this will be attached to the environmental water management plan as a schedule when completed.

An analysis of surface-water quality considered that the greatest risks to water quality during operation of the Chowilla environmental regulator were the development of cyanobacterial blooms and deoxygenation of surface-water caused by the breakdown of organic material. It was observed that these risks are tightly coupled with the ability to maintain flow (both volume and velocity) within both the inundated floodplain and main river channel. Brookes and others (2007) suggest that if the proposed regulator is operated at River Murray flows of 10,000 ML/d, the risk of cyanobacterial blooms will be greatly reduced. Follow-up work based on modelling informed by in situ measurements of water quality at two environmental watering sites on the

Table 4.3 Net loss when using Chowilla Regulator for 120 consecutive days (Water Technology 2009).

Flow to South Australia (GL/d)	Net loss without regulator (GL)	Net loss with regulator (GL)	Net loss difference (GL)
10	13	59	46
50	36	76	40

Chowilla Floodplain demonstrated that, with modest water exchange, oxygen levels can be maintained within acceptable standards. It is suggested that maintaining water movement during the initial filling stages and/or pulsing the stage height of the regulator to draw water out of the system and subsequent re-inundation of the system, could provide the capacity to manage these events.

In their assessment of risks to floodplain geomorphology, Gippel and others (2008) concluded that the identified risks could be managed. The assessment of the potential for bank-slumping after a manufactured inundation provided a safe upper limit for draw-down of 0.10 ML/day, but suggested a slower rate of 0.05 ML/day, which is closer to the median natural rate of flood recession.

This report also found that the risks (channel bank erosion and streambed scour) associated with passing flows through Pipeclay and Slaney creeks for environmental benefit could also be managed. In their report, Gippel and others (2008) suggested that flows up to 1,000 ML/d can be passed down Pipeclay and Slaney creeks upstream of Salt Creek when tail water is low without major risk of bank erosion but at the same time mobilising the majority of the bed sediment. Higher flows (possibly up to 2,000 ML/d with a higher tail water) can be passed down Pipeclay and Slaney creeks downstream of Salt Creek without exposing the banks to serious erosion risk.

The risk of soil salinisation because of groundwater movement in the absence of inundation at the peripheries of a manufactured inundation was also considered by Overton and Jolly (2004) and Overton and Doody (2008). Overton and Doody (2008) suggested that by varying the extent of inundation in successive floods, this risk could be avoided. Such variation would also result in superior environmental outcomes because it is more consistent with this river system's natural variability.

The results from ecological investigations into floodplain biota and fishes undertaken by Zampatti and others (2006) indicated that there is likely to be a net benefit to floodplain biota when operating the Chowilla environmental regulator. WINDS modelling (CSIRO 2005) indicted that with regulator operation, 4,018 ha of floodplain trees would remain healthy in 2037 as opposed to 2,282 ha without regulator operation. The risk assessments for birds (Rogers & Patton 2008) and amphibians (Ecological Partners 2009) indicted that in general these taxa would benefit from regulator operation.

The risk assessment for fish (Mallen-Cooper *et al*. 2008) highlighted several potential negative impacts on fish; in particular, the reduction in flow velocities during regulator operation would result in a decline of habitat quality for large-bodied fishes. Most small-bodied fishes would benefit from increased breeding opportunities, as would exotic fish (including carp), resulting in potential increases to river populations. However, Mallen-Cooper and others (2008) noted that many potential risks identified for native large-bodied fishes could be lessened by operating the regulator during higher River Murray flows to maintain velocities in core habitat areas.

A summary of predicted responses for floodplain biota and fishes to regulator operation is presented in **Table 4.4**; the assessments in this table were based on operating the Chowilla environmental regulator on average one year in three to increase flood magnitude, duration and frequency. The level to which the regulator is operated for any single event would depend on inflows to South Australia at the time of operation. **Table 4.5** identifies the predicted results of the do-nothing approach where no operation of the Chowilla regulator or other environmental watering occurs.

Table 4.4: Summary: predicted responses of floodplain biota and fishes to operation of the Chowilla environmental regulator

Biota	Strong decline	Some decline	No change	Some improvement	Strong improvement
Amphibians					
General	–	–	–	–	Yes
Threatened species					
Southern bell frog [a]	–	–	–	–	Yes
Long-thumbed frog (*Limnodynastes fletcheri*)[b]	–	–	–	–	Yes
Birds					
Waterbirds	–	–	–	–	Yes
Terrestrial birds	–	–	–	–	Yes
Threatened species					
17 species, including waterbirds and terrestrial birds[c, d, e]	–	–	–	Yes	Yes
Bush-stone curlew (*Burhinus grallarius*)[d]	–	–	–	Yes	–
Major Mitchell's cockatoo (*Cacatua leadbeateri*)[d]	–	–	No change (either decline or improvement)	–	–
Regent parrot (*Polytelis anthopeplus*)[a]	–	–	No change (either decline or improvement)	–	–
Fish					
Small-bodied and common species	–	–	No change (either decline or improvement)	Yes	Yes
Golden perch (in SA, callop) (*Macquaria ambigua*)	Yes	–	–	–	–
Threatened species					
Murray cod [a]	Yes	–	–	–	–
Silver perch[b]	Yes	–	–	–	–
Freshwater catfish[d]	–	Yes	–	–	–
Exotic fish	–	–	–	–	Yes
Vegetation					
River red gums	–	–	–	–	Yes
Black box	–	–	–	–	Yes
River cooba	–	–	–	–	Yes
Lignum	–	–	–	–	Yes
Flood respondent	–	–	–	–	Yes
Threatened species					
14 amphibious or flood-dependent understory species[c, d, e]	–	–	–	–	Yes

Notes
a Listed as **vulnerable** under the federal *Environment Protection and Biodiversity Conservation Act 1999*.
b Listed as **vulnerable** under the New South Wales *Threatened Species Conservation Act 1995*.
c Listed as **rare** under the South Australian *National Parks and Wildlife Act 1972*.
d Listed as **vulnerable** under the National Parks and Wildlife Act (SA).
e Listed as **endangered** under the National Parks and Wildlife Act (SA).

Table 4.5: Summary: the predicted responses of floodplain biota and fishes to the do-nothing scenario

Biota	Strong decline	Some decline	No change	Some improvement	Strong improvement
Amphibians					
General	Yes	–	–	–	–
Threatened species					
Southern bell frog[a]	Yes	–	–	–	–
Long-thumbed frog[b]	Yes	–	–	–	–
Birds					
Waterbirds	Yes	–	–	–	–
Terrestrial birds	Yes	–	–	–	–
Threatened species					
17 species, including waterbirds and terrestrial birds[c, d, e]	Yes	Yes	–	–	–
Bush-stone curlew[d]	–	–	No change (either decline or improvement)	–	–
Major Mitchell's cockatoo[d]	–	–	No change (either decline or improvement)	–	–
Regent parrot[a]	–	–	No change (either decline or improvement)	–	–
Fish					
Small-bodied and common species	–	–	No change (either decline or improvement)	–	–
Golden perch (in SA, callop)	–	–	No change (either decline or improvement)	–	–
Threatened species					
Murray cod[a]	–	–	No change (either decline or improvement)	–	–
Silver perch[b]	–	–	No change (either decline or improvement)	–	–
Freshwater catfish[d]	–	–	No change (either decline or improvement)	–	–
Exotic fish	–	–	No change (either decline or improvement)	–	–
Vegetation					
River red gums	Yes	–	–	–	–
Black box	Yes	–	–	–	–
River cooba	Yes	–	–	–	–
Lignum	Yes	–	–	–	–
Flood respondent	Yes	–	–	–	–
Threatened species					
14 amphibious or flood-dependent understorey species[c, d, e]	Yes	–	–	–	–

Notes
a Listed as **vulnerable** under the federal *Environment Protection and Biodiversity Conservation Act 1999*.
b Listed as **vulnerable** under the New South Wales *Threatened Species Conservation Act 1995*.
c Listed as **rare** under the South Australian *National Parks and Wildlife Act 1972*.
d Listed as **vulnerable** under the National Parks and Wildlife Act (SA).
e Listed as **endangered** under the National Parks and Wildlife Act (SA).

5. Environmental monitoring

Different monitoring methods are used to assess progress toward the icon site ecological objectives. These include River Murray system-scale, icon site condition and intervention monitoring. The Living Murray Outcomes (TLM) Evaluation Framework (MDBC 2007) outlines the rationale for these monitoring methods, which are summarised below.

River Murray system-scale monitoring

Conducted annually, River Murray system-scale monitoring and evaluation focuses on the system's ecological health, measuring improvements relating to fish, waterbirds and vegetation.

Icon site condition monitoring

Condition monitoring assesses each icon site's condition in relation to its ecological objectives. Condition monitoring is typically conducted on a medium-frequency basis (months to years), depending on the rate of change. Condition monitoring includes standard methodologies for monitoring fish, birds and vegetation, as well as icon site-specific methods for monitoring other ecological objectives (see **Schedule 1**). These monitoring activities have been classified into three categories—A, B and O:

- 'A' category monitoring activities are undertaken at all icon sites using agreed standardised methodologies:
  - fish condition monitoring using the MDBA Sustainable Rivers Audit methodology
  - waterbird condition monitoring using a standard on-ground method to link with the annual aerial waterbird survey
  - tree condition monitoring for river red gum and black box using on-ground assessments linked to remote-sensing data.
- 'B' category contains icon site-specific monitoring using locally appropriate methods. This monitoring responds to unique icon site characteristics and is less easily standardised.
- 'O' category uses icon site monitoring related to objectives and is less easily linked to TLM ecological objectives.

The components of the current Chowilla Floodplain monitoring program and their relationship to these categories are presented in **Table 5.1**.

Table 5.1: Components of the Chowilla Floodplain condition monitoring program and their relationship with the A, B and O categories of monitoring

Monitoring component	A	B	O
Tree condition assessment			
The Living Murray stand condition model	✓	–	–
Surveys to inform TLM assessment for river red gums and black box	✓	–	–
Tree population structure/recruitment and relative abundance	–	✓	–
Understorey plant assemblages			
Wetland and floodplain plant assemblages	–	✓	–
Lignum	–	✓	–
Fish			
Sustainable Rivers Audit-aligned protocol	✓	–	–
Age structure of golden perch	–	✓	–
Birds			
Waterbirds — aerial survey	✓	–	–
Waterbirds — ground survey	✓	–	–
Bush birds	–	✓	–
Threatened bird species (regent parrot and bush stone-curlew [*Burhinus grallarius*])	–	–	✓
Amphibians			
Frog surveys	–	–	✓
Groundwater			
To be determined	–	–	–

Intervention monitoring

The complexity of ecological system processes makes the results of any management intervention difficult to predict. Therefore, intervention monitoring is a key component of The Living Murray environmental monitoring program. The aim of intervention monitoring is to improve understanding of the causal links between TLM environmental watering and other management actions, and ecological responses at icon sites. This knowledge enables TLM to continually adapt and improve management of icon sites and watering into the future to optimise ecological outcomes

As TLM works are completed, measuring the volume of water used at icon sites (including timing, volume and quality of any return flows) is essential to account for and report on how TLM environmental water is used and managed. This area of monitoring was previously included in the compliance monitoring category of the Outcomes and Evaluation Framework, but is now encompassed within intervention monitoring. This change is to ensure clear linkages between the various information requirements for managing successful watering events and informing the operation of works at icon sites. This includes systems for water measurement and accounting and monitoring risks (previously defined in compliance monitoring), and assessing ecological outcomes resulting from specific watering events or other management actions.

Implementation of the monitoring program

Core components of the monitoring program have already been implemented both to determine the overall site condition and trajectory and to assess the effects of intervention measures. This monitoring has included the establishment of 25 annual tree monitoring sites in 2008 to inform The Living Murray stand condition model; these monitoring sites are in addition to 108 permanent tree condition transects established between 2004 and 2008 that are used as needed to monitor the response to the ongoing environmental watering program.

Between 2006 and 2009, 80 understorey vegetation transects were established in the major wetlands, along the anabranch creeks and on parts of the floodplain inundated only by high flows (Gehrig *et al*. 2010). These sites have been used on an annual basis to determine annual site condition and trajectory, and have been surveyed as needed to determine the response of understorey vegetation to environmental watering (e.g. Nicol *et al*. 2010).

Annual fish condition monitoring is conducted at 22 sites throughout the Chowilla anabranch system; these sites were selected as representative of all aquatic mesohabitats present in the Chowilla region (i.e. slow-flowing water, fast-flowing water, backwater and River Murray main channel). One-off specific intervention monitoring programs have also been conducted — for example, investigations of the movement of large-bodied native fish in relation to flow alteration.

In addition to the annual aerial waterbird surveys, monthly waterbird surveys of selected environmental watering sites are conducted while these sites are inundated. Bush bird surveys will be added to the overall monitoring package in 2011. These surveys will provide another measure of overall floodplain health and will have particular relevance in assessing the impacts of regulator operation on the condition and functionality of river red gum and black box communities. O class monitoring (e.g. threatened bird species and amphibians) is currently being conducted by the South Australian Department of Environment and Natural Resources.

Knowledge generated from groundwater and surface-water monitoring programs is used to assess the effects of on-ground actions such as the environmental watering program, and to inform the design and assessment of large-scale intervention projects such as the Chowilla environmental regulator. For example, data generated from investigations into flow patterns throughout the anabranch system have been used in the development of the Chowilla hydrodynamic model that currently underpins the bulk of planning and management actions at this site. Maintaining both the groundwater and surface-water monitoring network will be an essential component in the long-term operation of floodplain structures to achieve large-scale environmental benefits and avoid any potential risks.

6. Community consultation and communication

The South Australian Department for Water in conjunction with the South Australian Murray–Darling Basin Natural Resource Management Board is responsible for community consultation and communication activities for the icon site.

The Chowilla Floodplain Community Reference Committee was formed during 2005; since that time, it has met approximately four times per year to provide informed input to the planning and management of the Chowilla project and activities.

The Community Reference Committee includes representation from key stakeholder groups, including site lessees, neighbouring landholders, the Aboriginal community, irrigation and tourism industries, conservation and recreation interests and local government. The committee also comprises representatives from the Lower Murray Darling and the Mallee catchment management authorities, and New South Wales and South Australian government agencies.

During 2009 a project was undertaken to assess community understanding of the project and develop an associated community engagement strategy for the Chowilla Floodplain icon site with a particular focus on the construction of the environmental regulator on Chowilla Creek.

A stakeholder assessment was undertaken, and the community engagement strategy was developed in close consultation with the Community Reference Committee, which provided input through workshops, detailed interviews and document review.

This work underpins an ongoing communications and engagement strategy for the icon site that is reviewed and updated annually (see **Schedule 2**).

The Community Reference Committee receives detailed briefings on every aspect of icon site management, including planning, environmental watering, implementing the Chowilla environmental regulator and developing operating strategies for associated infrastructure. Committee members' feedback and advice is sought on all key components of TLM, particularly consultation and engagement activities.

These activities are focused on information and documents provided on the website of the South Australian Murray–Darling Basin Natural Resources Management Board, on presentations and displays at key events, and, most importantly, on the hosting of tours of the icon site during which current and future projects to restore the site are explained.

The Community Reference Committee has also been briefed on how the icon site's Environmental Water Management Plan is being developed and updated (including its purpose and content). A workshop session was held at which details of the draft document were presented to Community Reference Committee, with a particular focus on:

- ecological objectives and the associated water requirements and water delivery
- community consultation and communication and Aboriginal engagement
- monitoring and adaptive management and reporting.

Community Reference Committee members provided particular comment and advice in regard to aspects of risk management and community consultation with advice provided regarding community concerns and opportunities for engagement and information sharing.

Community Reference Committee members have been provided with draft icon site environmental water management plan documents with the opportunity to make more detailed comment and members are encouraged and supported to share information to and from their own community networks. Based upon advice from the Community Reference Committee the draft plan and the opportunity to comment have also been provided to key NRM stakeholder groups, Riverland Ramsar Plan Steering Committee and local government. The Community Reference Committee have also provided advice regarding key stakeholder groups that should receive copies of the plan once it is published.

The Chowilla Floodplain icon site project team continue to undertake a wide range of communication and community engagement activities including:

- Icon site tours for community members and a range of other interest groups and stakeholders to highlight the ongoing planning and implementation of the Environmental Water Management Plan. These tours include inspection of environmental watering sites, and sites where works and measures are occurring with detailed overview of current and future plans for the site provided.
- Input to local print and television media.
- Provision of program updates for community and industry groups via presentations at meetings or input to newsletters.

The content and features of the icon site Environmental Water Management Plan will be communicated to the wider community via these networks.

The complete Community Engagement Strategy is presented in Schedule 2.

7. Aboriginal engagement

Aboriginal people have many social, cultural, customary and economic interests in the water resources of the River Murray.

The Living Murray aims to maximise ecological outcomes through the delivery of environmental water and therefore cannot provide for the commercial economic interests of any of its stakeholders. However, TLM is committed to taking into account Aboriginal values and objectives in its environmental water planning and management. As Aboriginal communities identify objectives and strategies for achieving these Indigenous objectives they will be incorporated into EWMPs in the future. Indigenous consultation will be reported on in the Annual TLM Environmental Watering Report and Annual TLM Implementation Report.

A memorandum of understanding between Murray Lower Darling River Indigenous Nations and the Murray–Darling Basin Commission was signed in March 2006. The memorandum of understanding provides for engagement with Traditional Owners at a strategic level along the length of the River Murray and across state boundaries, while being inclusive of formal jurisdictional arrangements.

Aboriginal consultation continues to be sought on the Chowilla Floodplain to:

- identify and protect Aboriginal cultural heritage sites
- identify opportunities for Aboriginal partnerships in planning and management of the icon site under The Living Murray
- ensure that Aboriginals have meaningful roles in planning and managing the icon site
- ensure that Aboriginal knowledge, values, perceptions and aspirations are incorporated into the Chowilla Floodplain Environmental Water Management Plan in a meaningful and comprehensive way that informs management decisions
- facilitate input from and involvement of the Aboriginal community in planning processes and in the implementation of projects
- provide technical support and resources to build capacity for Aboriginals to contribute to the icon site's future management
- ensure that Aboriginal involvement in planning and management is undertaken in a culturally appropriate manner
- promote the protection and preservation of cultural sites and knowledge
- coordinate the development of cultural maps for Chowilla
- foster links and partnerships between the Aboriginal community, the South Australian asset manager, the South Australian Department for Water, the NSW Office of Water, the South Australian Department for Environment and Natural Resources, the Murray–Darling Basin Authority Indigenous Partnership Project and the Murray Lower Darling Rivers Indigenous Nations.

Engagement with Traditional Owners and the wider Aboriginal community is undertaken through the support and facilitation provided by The Living Murray Indigenous Facilitator, who is employed through a partnership arrangement between the South Australian Department for Water and the Mallee Catchment Management Authority that links Aboriginal facilitation for the Lindsay–Wallpolla Islands and the Chowilla Floodplain.

The Environmental Water Management Plan will be implemented with input and advice from the First Peoples of the River Murray and the Mallee Region and the Barkindji Mauraura Elder Council. Wider community input will be provided through the work of the Holistic Empowerment Aboriginal Riverland Integrated Network Gathering (HEARING) committee, which comprises representatives from local Aboriginal service providers and community elders who meet monthly to discuss a range of local Aboriginal issues. Key activities are:

- attendance at meetings and provision of presentations for information-sharing that enables community input and advice to be provided
- distribution of a regular newsletter targeting the Aboriginal communities, which will be developed by the Indigenous Facilitator
- conduct of regular tours to the icon site to enable community members to keep up to date with icon site management activities.

Specific actions to provide information to the Aboriginal communities about development of the icon site environmental water plan and its ongoing implementation include:

- presentation and discussion at a Holistic Empowerment Aboriginal Riverland Integrated Network Gathering committee
- convening of an Aboriginal stakeholders information day at Chowilla Floodplain that includes inspection of works and projects and briefings by icon site staff, and provides an opportunity for input and comment.

Cultural heritage management

The South Australian Department for Environment and Natural Resources is responsible for maintaining and protecting both Aboriginal and European cultural heritage sites in the Chowilla Game Reserve. Overarching responsibility for the protection and preservation of Aboriginal heritage and culture rests with the Aboriginal Affairs and Reconciliation Division of the South Australian Department for Premier and Cabinet. In New South Wales, protection of Aboriginal cultural heritage occurs through the *National Parks and Wildlife Act 1974*, which is administered through the New South Wales Department of Environment and Climate Change.

Consultation with the First People of the River Murray and Mallee Region and the Barkindji Maurara Elder Council during development of plans for the Chowilla Creek environmental regulator raised concerns regarding potential impacts on Aboriginal burial sites. To address these concerns, a project to overlay outcomes of predictive modelling of Aboriginal heritage site distribution was undertaken by Wood and others (2005). This modelling was to determine the extent of flood inundation that would occur during the regulator's operation to identify overlap with areas that have a high potential of significant cultural heritage sites.

An Aboriginal cultural heritage survey later targeted areas identified during this modelling exercise (Harris 2007), to investigate the potential impact of regulator operations on cultural heritage values. Recommendations made as a result of this work have since been implemented, with work undertaken to ensure that the identified burial sites were protected.

8. Adaptive management and reporting

An adaptive approach is critical in managing water-dependent ecosystems because it enables land managers and policy-makers to update strategies based on the outcomes of research and watering actions. This is known as 'learning by doing' and involves designing, implementing, monitoring, reporting and evaluating our work.

Environmental water management plans are constantly refined by adaptive management, which incorporates outcomes from environmental delivery, ecological monitoring, works, modelling and community consultation.

The Living Murray (TLM) Annual Environmental Watering Plan is developed at the beginning of each watering season and complements the environmental water management plan. As the season progresses, the annual water planning process responds to water availability, opportunities and environmental priorities. A flexible decision-making framework is included in the annual plan so the Environmental Watering Group can assess water priorities throughout the year according to water resource condition.

To highlight and analyse previous activities and outcomes, the Murray–Darling Basin Authority (MDBA) works with icon site managers to produce an annual TLM implementation report (as required under clause 199 of The Living Murray Business Plan), which is used by the Independent Audit Group. An annual external audit is conducted to ensure TLM is implemented at an appropriate level of transparency and accountability, and to promote public confidence in the program's efforts and outcomes. The implementation report and external audit are presented to the Murray–Darling Basin Ministerial Council.

To capture key learning and changing icon site management practices, schedules appended to the environmental watering management plan are updated as required.

As part of the adaptive management system, the Chowilla Monitoring Framework will be reviewed regularly and updated in response to information arising from monitoring, further investigations, modelling and consultation. Issues that will need to be considered and essential steps to be applied in the review process are presented in the Chowilla Monitoring Framework.

These systematic reviews will ensure that the:

- monitoring framework is robust
- results from the monitoring program provide information required for reporting against the ecological objectives and targets
- management actions are based on the latest information and ecological understanding of the system and how it responds to various interventions and natural events
- management actions implemented are successful in terms of meeting the ecological objectives
- deleterious impacts or incidental environmental benefits from management actions are reported upon and accounted for in future management actions
- trigger points are established so that particular outcomes from monitoring trigger corrective action or further investigation
- changes to the monitoring program proposed via a structured process.

Appendix A: Baseline Condition

Floodplain trees

The decline of floodplain trees, particularly river red gums, in the lower River Murray is widespread and ongoing. In the absence of a return to a more natural flooding regime or large-scale intervention the widespread death of floodplain trees and resulting ecosystem collapse will be an inevitable outcome.

A 2003 investigation of the decline of river red gums below Euston found that approximately 80% of the survey sites contained stressed tree, with between 20 to 30% severely stressed. In the area between Wentworth and Renmark, which includes the Chowilla Floodplain, more than half of all trees were stressed or dead (MDBC 2003).

Further studies have indicated the rapidity at which this decline is occurring among both river red gum and black box forests and woodlands. A study of river red gum and black box health along the River Murray found that at 100 sites surveyed in 2002 and 2004, the number of stressed trees had increased from 51.5% in 2002 to 75.5% in 2004 (SA Department of Water, Land and Biodiversity Conservation 2005).

On the Chowilla Floodplain, widespread declines in tree health in the areas outside the flushed zone were noted by Overton and Jolly (2003), who found that in this area that between 45 to 55% of trees by area were dead or in poor health. Further studies and weighted index of salinisation (WINDS) modelling (e.g. CSIRO 2005; Overton & Doody 2008) have indicated that without large-scale interventions, the decline in tree health would continue across the floodplain.

More recent studies have confirmed these trends. The initial report for The Living Murray (TLM) Stand Condition Project (Cunningham *et al*. 2009) reported that while the extent of stands of river red gum and black box in good condition remained stable at around 15% between 2003 and 2009, the condition of stressed stands continued to decline over the same period. This report found that in general the condition of black box stands was worse than that of river red gum stands. No doubt this reflects the location of the black box stands, which are higher on the floodplain away from the flushed zone, and the fact that because of logistical constraints they are not as well represented at environmental watering sites.

In contrast, tree condition monitoring conducted at environmental watering sites by the South Australian Murray–Darling Basin Natural Resources Management Board (MDBC 2008; SA MDB NRM Board 2010) has revealed that tree condition has continued to improve at watering sites, particularly those that have received between three and four rounds of environmental water. However, it should be noted that the total area covered by the combined environmental watering sites is approximately 5% of the Chowilla Floodplain.

River red gum recruitment has been assessed annually at existing river red gum watering sites since 2009. These surveys have shown that while recruitment of river red gums is occurring as a result of environmental watering, overall it is patchy in nature and would not be sufficient to meet the objective, outlined in MDFRC (2008), of 'maintaining viable river red gum populations within 70% of river red gum woodlands'. The reasons behind these low levels of observed recruitment is an area that requires ongoing monitoring and further investigation.

Understorey vegetation

A review of understorey investigation conducted at Chowilla (1988–2009) (Nichol *et al*., in prep.) reported that a total of 405 plant taxa have been recorded at Chowilla. Of these, 92 were exotic species, while 24 species were of conservation significance, including 18 taxa listed as rare, five listed as vulnerable and one listed as endangered in South Australia. From the taxa of conservation significance, the one endangered taxon (*Crassula sieerana* spp. *tetramera*) and nine of the 18 rare taxa have been observed since 2004, but none of the vulnerable species have been observed since 2004.

Annual condition monitoring of floodplain understorey vegetation has been conducted at Chowilla since 2005 by the South Australian Research and Development Institute (Aquatic Sciences). The results of this work indicate that the lack of overbank flooding and shallow saline groundwater have led to a significant decline in the condition and diversity of the floodplain understorey vegetation at Chowilla (Marsland *et al*. 2009).

In the first 12 months after inundation the floodplain is dominated by amphibious and flood-dependent species. As the floodplain dries, this assemblage is replaced by drought-tolerant terrestrial species. If the floodplain is inundated at this stage there will be an easy transition back to the flood-dependent and amphibious species. If the area is not inundated and is saline, shallow groundwater occurs (typical of the Chowilla Floodplain), the terrestrial species will be replaced by salt-tolerant species such as samphire monocultures or bare earth.

In 2009, 10 unwatered sites across the floodplain were dominated by salt-tolerant species; these will continue to decline in the absence of inundation either through natural events or manufactured flooding. At environmental watering sites, the condition of understorey vegetation continued to improve because of the reinstatement of repeated periodic inundation (Gehrig *et al*. 2010).

Lignum provides important habitat for a range of fauna, including water birds and amphibians (e.g. the *Environment Protection and Biodiversity Conservation Act 1999*-listed southern bell frog) when inundated, and terrestrial birds, small mammals and reptiles when dry. It is perhaps one of the most important habitat elements for fauna on the floodplain.

As with floodplain trees and understorey vegetation, the health of lignum is directly related to the prevailing hydrological regime. Lignum monitoring conducted by the South Australian Murray–Darling Basin Natural Resources Management Board (2010) suggests that the health of lignum at environmental watering sites was generally good but could be improved in some instances by additional watering. However, at sites that have only been watered once or not at all because of their location on the floodplain, the condition of lignum continues to decline.

Fish

The construction of Lock 6 has resulted in the once ephemeral streams of the anabranch system becoming permanent. This provides a rich mosaic of streams that vary in depth, width, aquatic vegetation and density of woody debris. Perhaps most important is the diversity of flowing water systems, including fast flowing creeks that have become rare in the South Australian section of the River Murray. Consequently, the Chowilla anabranch system supports a diverse healthy native fish fauna including one of the most significant populations of Murray cod in the lower River Murray. Three exotic species including common carp are also found within the Chowilla system.

In addition to one-off surveys (e.g. Lloyd 1990), an extensive series of investigations and ongoing annual condition monitoring have been conducted at Chowilla since 2005 by the South Australian Research and Development Institute (Aquatic Sciences). These surveys have identified 13 species of fish, including 10 natives and three exotic species (Zampatti *et al*. 2006; Leigh *et al*. 2010). Three state- and/or national-listed species have been recorded over the course of these investigations and include Murray cod, silver perch and freshwater catfish. The faster flowing anabranch creeks were generally the most diverse macro-habitats and are favoured habitats of Murray cod and golden perch while species such as carp gudgeons (*Hypseleotris* spp.) and goldfish (*Carassius auratus auratus*) were most common in slower flowing streams and backwaters.

The fish condition monitoring surveys conducted by the South Australian Research and Development Institute (Aquatic Sciences) since 2005 indicate that between 2005 and 2010 the diversity and distribution of species was similar. Length frequency distribution indicated that successful recruitment occurred in each year for the small-to-medium bodied fish such as bony herring (*Nematalosa erebi*), unspecked hardyhead (*Craterocephalus stercusmuscarum fulvus*), Murray rainbow fish (*Melanotaenia fluviatilis*) and Australian smelt (*Retropinna semoni*). Recruitment of large-bodied native fish also occurred but was more episodic — for example, recruitment of Murray cod and golden perch was evident in at least one of the six years sampled. Annual recruitment was also evident for the two most common exotic species, common carp and goldfish (Leigh *et al*. 2010).

Waterbirds

Waterbird surveys have been conducted at Chowilla's environmental watering sites by the South Australian Department for Environment and Natural Resources since the commencement of the watering program in 2004.

These surveys have indicated that the high species diversity of waterbirds historical observed at Chowilla (e.g. Carpenter 1990) remains intact at these watering sites, with 52 species of waterbirds recorded over the course of the environmental watering program. Breeding has been recorded in 12 of these species, including common species such as grey teal (*Anas gracilis*) and black swan (*Cygnus atratus*), and state-listed species such as the blue-billed duck (*Oxyura australis*) (SA Department for Environment and Natural Resources, unpublished data).

Although the number of birds recorded at individual watering sites between years has been highly variable, no discernable pattern of increasing or decreasing populations is evident. This is typical of waterbird surveys ,which require long time-frames to detect change because of the highly variable nature of species behaviour and the ecosystems that they inhabit (Scott 1997). However, long-term waterbird surveys such as the annual Aerial Survey of Wetland Birds in Eastern Australia, which began in 1983, suggest that the long-term trend in both waterbird abundance and wetland area is downwards (Kingsford *et al*. 2000; Porter & Kingsford 2009).

Amphibians

The South Australian Department of Environment and Natural Resources has conducted monitoring of both frogs and tadpoles across the Chowilla Floodplain since 2004. Although frogs can occupy both still water and flowing water habitats and some species move between the two, frog monitoring at Chowilla has focused on environmental watering sites.

This program has revealed that the seven species of frogs historically recorded on the floodplain (e.g. Bird & Armstrong 1990) are still extant in the floodplain wetlands; it has identified one additional species (SA MDB NRM Board 2010). This program has also indicated that frogs have responded particularly well to the environmental watering program (e.g. Schultz 2007; SA MDB NRM Board 2010) and in general both the number of tadpoles caught in standardised net surveys and the number of calling adults has increased since environmental watering commenced.

This increase has been particularly evident in the Environment Protection and Biodiversity Conservation Act-listed southern bell frog, which is able to rapidly move from refugia in permanent water to breed in areas of temporary inundation at environmental watering sites.

Appendix B: Vegetation groups mapped on Chowilla

Table B.1: Vegetation groups mapped on Chowilla (Kenny 2004)

Regional floristic description	Vegetation composition
Forest	
Eucalyptus camaldulensis var. *camaldulensis* open forest	*Eucalyptus camaldulensis* var. *Camaldulensis* — open forest over *Muehlenbeckia florulenta* +/– *Cyperus gymnocaulos*
	Eucalyptus camaldulensis var. *camaldulensis* open forest over +/– *Acacia stenophylla* +/– *Cyperus gymnocaulos* +/– *Paspalidium jubiflorum*
	Eucalyptus camaldulensis var. *camaldulensis* — open forest over *Phragmites australis* and *Muehlenbeckia florulenta*
Eucalyptus camaldulensis var. *camaldulensis, E. largiflorens* open forest	*Eucalyptus camaldulensis* var. *camaldulensis*, *E. largiflorens* — open forest over *Acacia stenophylla*
	Eucalyptus camaldulensis var. *camaldulensis, E. largiflorens* — open forest over *Senecio cunninghamii* var. *cunninghamii* +/– *Phragmites australis*
	Eucalyptus camaldulensis var. *camaldulensis* +/– *E. largiflorens* — open forest over *Chenopodium nitrariaceum* +/– *Acacia stenophylla* +/– *Muehlenbeckia florulenta*
Eucalyptus largiflorens, E. camaldulensis var. *camaldulensis* open forest	*Eucalyptus largiflorens, E. camaldulensis* var. *camaldulensis* open forest over *Callistemon brachyandrus* and *Enchylaena tomentosa* var. *tomentosa*
E. largiflorens low open forest	*Eucalyptus largiflorens* open forest over *Muehlenbeckia florulenta* +/– *Enchylaena tomentosa* var. *tomentosa*
	Eucalyptus largiflorens low open forest over *Chenopodium nitrariaceum* +/– *Muehlenbeckia florulenta* +/– *Eremophila divaricata*
	Eucalyptus largiflorens low open forest over *Enchylaena tomentosa* var. *tomentosa* +/– *Paspalidium jubiflorum*
Eucalyptus largiflorens, Acacia stenophylla low open forest	*Eucalyptus largiflorens, Acacia stenophylla* low open forest over *Muehlenbeckia florulenta, Enchylaena tomentosa* var. *tomentosa*
Melaleuca lanceolata ssp. *lanceolata* +/– *E. largiflorens* low open forest	*Melaleuca lanceolata* ssp. *lanceolata* +/– *E. largiflorens* low open forest over +/– *Enchylaena tomentosa* var. *tomentosa*
Melaleuca halmaturorum ssp. *halmaturorum* very low open forest	*Melaleuca halmaturorum* ssp. *halmaturorum* very low open forest over +/– *Juncus kraussii* +/– *Samolus repens* +/– *Suaeda australis* +/– *Sarcocornia quinqueflora*
Woodland	
Eucalyptus camaldulensis var. *camaldulensis* woodland	*Eucalyptus camaldulensis* var. *camaldulensis* woodland over *Muehlenbeckia florulenta* +/– *Paspalidium jubiflorum* +/– *Cyperus gymnocaulos* +/– *Acacia stenophylla*
	Eucalyptus camaldulensis var. *camaldulensis* woodland over *Phragmites australis* +/– *Muehlenbeckia florulenta*
	Eucalyptus camaldulensis var. *camaldulensis* woodland over +/– *Cyperus gymnocaulos* +/– *Senecio cunninghamii* var. *cunninghamii*
Eucalyptus camaldulensis var. *camaldulensis*, *Acacia stenophylla* woodland	*Eucalyptus camaldulensis* var. *camaldulensis*, *Acacia stenophylla* woodland over *Muehlenbeckia florulenta*, *Paspalidium jubiflorum*
Eucalyptus camaldulensis var. *camaldulensis*, *E. largiflorens* woodland	*Eucalyptus camaldulensis* var. *camaldulensis*, *E. largiflorens* woodland over *Muehlenbeckia florulenta* +/– *Acacia stenophylla*
	Eucalyptus camaldulensis var. *camaldulensis*, *E. largiflorens* woodland over +/– *Enchylaena tomentosa* var. *tomentosa* +/– *Muehlenbeckia florulenta* +/– *Cyperus gymnocaulos*
Eucalyptus largiflorens +/– *Eucalyptus camaldulensis* var. *camaldulensis* woodland	*E. largiflorens* +/– *Eucalyptus camaldulensis* var. *camaldulensis* woodland over *Halosarcia pergranulata* ssp. *pergranulata* +/– *Halosarcia indica* ssp. *leiostachya* +/– *Disphyma crassifolium* ssp. *clavellatum*

Regional floristic description	Vegetation composition
Eucalyptus largiflorens low open woodland	*Eucalyptus largiflorens* open woodland over *Muehlenbeckia florulenta*
	Eucalyptus largiflorens low woodland over +/– *Atriplex rhagodioides* +/– *Enchylaena tomentosa* var. *tomentosa* +/– *Disphyma crassifolium* ssp. *clavellatum*
	Eucalyptus largiflorens low woodland over *Maireana pyramidata*
Acacia stenophylla low woodland	*Acacia stenophylla* low woodland over *Muehlenbeckia florulenta*, *Enchylaena tomentosa* var. *tomentosa*
	Acacia stenophylla low woodland over *Enchylaena tomentosa* var. *tomentosa*
	Acacia stenophylla low woodland over *Chenopodium nitrariaceum*
Eucalyptus porosa, *Acacia stenophylla* low open woodland	*Eucalyptus porosa*, *Acacia stenophylla* low open woodland over *Muehlenbeckia florulenta*
Shrubland	
Muehlenbeckia florulenta tall shrubland	*Muehlenbeckia florulenta* tall shrubland over +/– *Enchylaena tomentosa* var. *tomentosa* +/– *Halosarcia pergranulata* ssp. *pergranulata* +/– *Suaeda australis*
	Muehlenbeckia florulenta shrubland over +/– *Sporobolus mitchellii* +/– *Sporobolus virginicus*
Dodonaea viscosa ssp. *angustissima* open shrubland	*Dodonaea viscosa* ssp. *angustissima* open shrubland over **Bromus rubens*, **Schismus barbatus* +/– *Enchylaena tomentosa* var. *tomentosa*
Chenopod shrubland	
Atriplex rhagodioides shrubland	*Atriplex rhagodioides* Shrubland over *Enchylaena tomentosa* var. *tomentosa* +/– *Halosarcia pergranulata* ssp. *pergranulata* +/– *Disphyma crassifolium* ssp. *clavellatum*
Chenopodium nitrariaceum shrubland	*Chenopodium nitrariaceum* shrubland
Suaeda australis +/– *Sarcocornia quinqueflora* low closed shrubland	*Suaeda australis* +/– *Sarcocornia quinqueflora* low closed shrubland over +/– *Samolus repens*
Atriplex lindleyi ssp. *lindleyi* +/– *Sclerolaena muricata* var. *muricata* low shrubland	*Atriplex lindleyi* ssp. *lindleyi* +/– *Sclerolaena muricata* var. *muricata* low shrubland over +/– *Atriplex semibaccata*
Halosarcia spp. and / or *Sclerostegia* spp. low shrubland	*Halosarcia halocnemoides* ssp. *halocnemoides*, *Sclerostegia arbuscula* low shrubland over *Disphyma crassifolium* ssp. *clavellatum*, *Maireana oppositifolia*
	Halosarcia indica ssp. *leiostachya* low shrubland over +/– *Suaeda australis* +/– *Disphyma crassifolium* ssp. *clavellatum*
	Halosarcia pergranulata ssp. *pergranulata* +/– *Halosarcia indica* ssp. *leiostachya* low shrubland over +/– *Disphyma crassifolium* ssp. *clavellatum*
	Halosarcia pergranulata ssp. *pergranulata* low shrubland over +/– **Critesion marinum* +/– *Disphyma crassifolium* ssp. *clavellatum* +/– *Suaeda australis*
	Sclerostegia arbuscula low shrubland over +/– *Sarcocornia quinqueflora* +/– **Critesion marinum* +/– *Suaeda australis*
Sarcocornia quinqueflor a low shrubland	*Sarcocornia quinqueflora* low shrubland over +/– *Samolus repens* +/– *Suaeda australis*
Atriplex vesicaria +/– *Maireana sedifolia* low open shrubland	*Atriplex vesicaria* +/– *Maireana sedifolia* low open shrubland
Maireana brevifolia low open shrubland	*Maireana brevifolia* low open shrubland over *Enchylaena tomentosa* var. *tomentosa*
Maireana oppositifolia low open shrubland	*Maireana oppositifolia* low open shrubland over *Stipa stipoides*
Maireana pyramidata low open shrubland	*Maireana pyramidata* low open shrubland over +/– *Atriplex lindleyi* ssp. *lindleyi* +/– **Schismus barbatus*
Pachycornia triandra low open shrubland	*Pachycornia triandra* low open shrubland over +/– *Disphyma crassifolium* ssp. *clavellatum*
Sclerolaena tricuspis, *Sclerolaena brachyptera* low open shrubland	*Sclerolaena tricuspis*, *Sclerolaena brachyptera* low open shrubland over +/– *Brachycome lineariloba* +/– *Plantago cunninghamii*
Grassland	

Regional floristic description	Vegetation composition
Phragmites australis +/– *Typha domingensis* +/– *Schoenoplectus validus* closed (tussock) grassland	*Phragmites australis* closed (tussock) grassland over +/– *Muehlenbeckia florulenta* +/– *Bolboschoenus caldwellii*
	Phragmites australis +/– *Typha domingensis* +/– *Schoenoplectus validus* closed (tussock) grassland over +/– **Paspalum vaginatum* +/– **Paspalum distichum*
Agrostis avenacea var. *avenacea* (tussock) grassland	*Agrostis avenacea* var. *avenacea* (tussock) grassland over *Eleocharis acuta* +/– *Polypogon monspeliensis*
Sporobolus virginicus or *Sporobolus mitchellii* (tussock) grassland	*Sporobolus virginicus* or *Sporobolus mitchellii* (tussock) grassland over +/– *Sclerolaena tricuspis*
Stipa stipoides (tussock) grassland	*Stipa stipoides* (tussock) grassland over *Lawrencia squamata* and *Distichlis distichophylla*
Eragrostis australasica, *Muehlenbeckia florulenta* open (tussock) grassland	*Eragrostis australasica*, *Muehlenbeckia florulenta* open (tussock) grassland over *Trichanthodium skirrophorum*, *Senecio glossanthus*
Sedgeland	
Baumea juncea closed sedgeland	*Baumea juncea* closed sedgeland over *Samolus repens* and *Distichlis distichophylla*
Gahnia filum +/– *Gahnia trifida* +/– *Juncus kraussii* sedgeland	*Gahnia filum* +/– *Gahnia trifida* +/– *Juncus kraussii* sedgeland over *Suaeda australis* +/– *Samolus repens*
Juncus kraussii sedgeland	*Juncus kraussii* sedgeland over +/– *Suaeda australis* +/– *Samolus repens*
Typha domingensis or *Typha orientalis* sedgeland	*Typha domingensis* Sedgeland over +/– **Paspalum vaginatum* +/– **Paspalum distichum*
	Typha orientalis sedgeland over +/– *Schoenoplectus validus*
Herbland	
Angianthus tomentosus herbland	*Angianthus tomentosus* herbland over *Atriplex lindleyi* ssp. *lindleyi*
Disphyma crassifolium ssp. *clavellatum* very open mat plants	*Disphyma crassifolium* ssp. *clavellatum* very open mat plants over *Atriplex lindleyi* ssp. *lindleyi*
Polycalymma stuartii herbland	*Polycalymma stuartii* herbland +/– *Enchylaena tomentosa* var. *tomentosa*
Other	
Willows	Willows

Appendix C: Plants and fauna of the Chowilla Floodplain

Table C.1: Functional classification of plant species based on water regime preferences

Functional group	Water regime preference	Examples of species
Amphibious fluctuation responders floating	Static or fluctuating water levels, responds to fluctuating water levels by having some or all organs floating on the water surface. Most species require permanent water to survive.	*Azolla* spp. *Lemna* spp. *Potamogeton tricarinatus*
Amphibious fluctuation responders plastic	Fluctuating water levels, plants respond morphologically to flooding and drying (e.g. increasing above to below ground biomass ratios when flooded).	*Persicaria lapathifolium* *Ludwigia peploides* *Rumex bidens,* *Myriophyllum* spp.
Amphibious fluctuation tolerators emergent	Fluctuating water levels, plants do not respond morphologically to flooding and drying and will tolerate short-term submergence (<2 weeks).	*Cyperus gymnocaulos* *Juncus usitatus* *Juncus aridicola* *Cyperus difformis* *Cyperus exaltatus*
Amphibious fluctuation tolerators low growing	Fluctuating water levels, plants do not respond morphologically to flooding and drying and are generally small herbaceous species.	*Limosella australis* *Crassula helmsii* *Cyperus pygmaeus*
Amphibious fluctuation tolerators woody	Fluctuating water levels, plants do not respond morphologically to flooding and drying and are large perennial woody species.	*Eucalyptus camaldulensis* *Eucalyptus largiflorens* *Acacia stenophylla*
Emergent	Static shallow water <1 m or permanently saturated soil.	*Typha* spp. *Phragmites australis* *Schoenoplectus validus* *Bolboschoenus caldwellii*
Submerged k-selected	Permanent water.	*Vallisneria Americana* *Potamogeton crispus* *Zanichellia palustris*
Submerged r-selected	Temporary wetlands that hold water for longer than 4 months.	*Ruppia tuberose* *Lepilaena australis* *Lamprothamnium macropogon*
Flood-dependent	Temporary inundation, plants germinate on newly exposed soil after flooding but not in response to rainfall.	*Epaltes australis* *Centipeda minima* *Glinus lotoides*
Terrestrial damp species	Will tolerate inundation for short periods (<2 weeks) but require high soil moisture throughout their life cycle.	*Carduus tenuiflorus* *Chenopodium murale*
Terrestrial dry species	Will not tolerate inundation and tolerates low soil moisture for extended periods.	*Atriplex vesicaria* *Rhagodia spinescens* *Enchylaena tomentosa*
Salt tolerant	Water regime preference can vary from permanent shallow water to dry 90% of the time but all species are tolerant to high soil or water salinity.	*Halosarcia pergranulata* *Pachycornia triandra* *Sclerolaena brachyptera*

Source: Modified from Brock & Casanova (1997)

Table C.2: Plant species list: Chowilla anabranch system

Species	Status		Comments
Abutilon theophrasti[a]	Exotic		Common pest plant in temporarily flooded areas throughout the South Australian Murray–Darling Basin
Acacia ligulata[b]	None		Dryland species
Acacia nyssophylla[b]	None		Dryland species
Acacia oswaldii[b]	None		Dryland species
Acacia stenophylla	None		Common riparian tree
Actinobole uliginosum[b]	None		Not recorded since 1989
Agrostis avenacea	None		Common native of temporarily flooded areas
Ajuga australis	None		Dryland species
Alectryon oleifolium ssp. canescens	None		Dryland species
Allocasurina cristata[b]	None		Dryland species
Alopecurus geniculatus[a, b]	Exotic		Not recorded since 1989
Alternanthera denticulata	None		Common native of temporarily flooded areas, especially areas with clay soils
Alternanthera nodiflora	None		Common native of temporarily flooded areas, especially areas with clay soils
Ammania multiflora	None		Common native of temporarily flooded areas
Amphibromus nervosa[b]	None		Not recorded since 1989
Amyema miquelii	None		Mistletoe
Angallis arvensis[a]	Exotic		Not recorded since 1989
Angianthus tomentosus	None		Uncommon
Arabidella eremigena[b]	None		Not recorded since 1989
Arctotheca calendula[a]	Exotic		Winter annual
Aristida contorta[b]	None		Not recorded since 1989
Asperula gemella[b]	None		Not recorded since 1989
Asphodelus fistulosus[a]	Exotic		Uncommon
Aster subulatus[a]	Exotic		Common pest plant in temporarily flooded areas and on the edges of permanent waterbodies throughout the South Australian Murray–Darling Basin
Atriplex eardleyae	None		Dryland species
Atriplex holocarpa	None		Dryland species
Atriplex leptocarpa	None		Dryland species
Atriplex limbata	None		Dryland species
Atriplex lindleyi	None		Dryland species
Atriplex nummularia	None		Dryland species
Atriplex pseudocampanulata	Tdr	None	Dryland species
Atriplex semibaccata	None		Dryland species
Atriplex stipitata	None		Dryland species
Atriplex suberecta	None		Common in temporarily flooded areas on the Murray floodplain upstream of Blanchetown
Atriplex velutinella	None		Dryland species
Atriplex vesicaria	None		Dryland species
Avena fatua[a]	Exotic		Common terrestrial weed
Azolla filiculoides	None		*Azolla* species difficult to differentiate
Azolla pinnata	None		*Azolla* species difficult to differentiate
Boerhavia dominii[b]	None		Not recorded since 1989

Species	Status	Comments
Bolboschoenus caldwellii	None	*Bolboschoenus* species are difficult to differentiate
Bolboschoenus medianus	None	*Bolboschoenus* species are difficult to differentiate
Brachycome basaltica var. gracilis	Rare in SA	Common plant in watered areas
Brachycome ciliaris var. ciliaris[b]	None	Not recorded since 1989
Brachycome ciliaris var. lanuginosa[b]	None	Not recorded since 1989
Brachycome dentata[b]	None	Not recorded since 1989
Brachycome linearilobia	None	Common plant in watered areas
Brassica tournifortii[a, b]	Exotic	Common terrestrial weed in high rainfall areas of SA
Bromus arenarius[b]	None	Not recorded since 1989
Bromus rubens[a]	Exotic	Common weed of mildly salt-affected areas
Bulbine semibarbata	None	Dryland species
Calandrina eremaea[b]	None	Not recorded since 1989
Callitriche stagnalis[a, c]	Exotic	Not recorded since 1989
Callitriche umbonata[b]	Vulnerable in SA	Not recorded since 1989
Callitris columellaris	None	Dryland Species
Callitris glaucophylla	None	Dryland Species
Callitris preissii	None	Dryland Species
Calocephalus citreus[b]	None	Not recorded since 1989
Calocephalus sonderi[b]	Rare in SA	Not recorded since 1989
Calotis cuneifolia	None	Common plant in watered areas
Calotis hispidula	None	Common plant in watered areas
Calotis porpyroglossa	None	Common plant in watered areas
Calotis scapigera	Rare in SA	Common plant in watered areas
Carduus tenuiflorus[a]	Exotic	Common terrestrial weed in high rainfall areas of SA
Carrichtera annua	Exotic	Uncommon, only recorded in Coppermine after last watering
Carthamus lanatus[a, b]	Exotic	Not recorded since 1989
Centaurea melitensis[a]	Exotic	Uncommon
Centipeda cunninghamii	None	Uncommon
Centipeda minima	None	Common plant in watered areas
Centipeda thespidioides[b]	None	Not recorded since 1989
Chara sp.	None	Submergent, common in shallow areas in permanent waterbodies
Chenopodium cristatum[b]	None	Not recorded since 1989
Chenopodium curvispicatum	None	Uncommon
Chenopodium desertorum[b]	None	Not recorded since 1989
Chenopodium murale[a]	Exotic	Uncommon
Chenopodium nitrariaceum	None	Common floodplain shrub
Chenopodium pumilio	None	Common plant in watered areas
Chrysocoryne pusilla[b]	None	Not recorded since 1989
Cirsium vulgare[a]	Exotic	Common terrestrial weed in high rainfall areas of SA
Citrullus lanatus[a]	Exotic	Common on sandy soils at higher elevations
Convolvulus remotus[b]	None	Not recorded since 1989
Conyza bonariensis[a]	Exotic	Common pest plant in damp situations throughout the South Australian Murray–Darling Basin
Cotula australis	None	Uncommon
Cotula bipinnata[a, b]	Exotic	Not recorded since 1989

Species	Status	Comments
Cotula coronopifolia[a]	Exotic	Salt tolerant but requires high soil moisture.
Craspedia glauca	None	Common after high winter/spring rainfall, does not persist into summer very often
Craspedia pleiocaphala[b]	None	Not recorded since 1989
Crassula colorata var. acuminata[b]	None	Not recorded since 1989
Crassula helmsii	None	Common on the edges and in shallow areas of permanent waterbodies
Crassula peduncularis[b]	Rare in SA	Not recorded since 1989
Crassula sieberana ssp. tetramera	Endangered in SA	Common on the edges and in shallow areas of permanent waterbodies
Cressa cretica	None	Uncommon
Crinum flaccidum	None	Common on sandy soils at higher elevations
Cuscuta campestris[a]	Proclaimed pest plant in SA	Parasitic plant, host is usually terrestrial or flood-dependent
Cymbopogon obtectus[b]	None	Not recorded since 1989
Cynodon dactylon[a]	Exotic	Uncommon
Cyperus difformis	None	Common in Coppermine complex after watering
Cyperus exaltatus	None	Uncommon
Cyperus gilesii	None	Uncommon
Cyperus gymnocaulos	None	Common in and around temporary and permanent wetlands
Cyperus hamulosus	None	Recorded by DEH in 1997
Cyperus involucratus[b]	None	Not recorded since 1989
Cyperus pygmaeus	None	Uncommon
Cyperus rigidellus	None	Recorded by DEH in 1997
Damasonium minus	None	Uncommon
Danthonia caespitosa[b]	None	Not recorded since 1989
Danthonia setacea[b]	None	Not recorded since 1989
Daucus glochidiatus[b]	None	Not recorded since 1989
Dianella longifolia var. porracea[b]	None	Not recorded since 1989
Digitaria ciliaris[a, b]	Exotic	Not recorded since 1989
Diplachne parviflora[b]	None	Not recorded since 1989
Disphyma crassifolium ssp. clavellatum	None	Common floodplain species, especially in mildly salt-affected areas
Dissocarpus paradoxus var. paradoxus	None	Uncommon
Dittrichia graveolens[a]	Exotic	Common in several watering sites
Dodonea viscosa ssp. angustissima	None	Uncommon
Dysphania glomulifera ssp. glomulifera	None	Uncommon
Echium plantagineum[a]	Exotic	Winter annual
Eclipta platyglossa	None	Uncommon
Einadia nutans	None	Uncommon
Elatine gratioloides	Rare in SA	Uncommon
Eleocharis acuta	None	Common emergent in shallow areas of permanent waterbodies
Elodea canadensis	Proclaimed pest plant in SA	Common in Lock 6 weir pool
Emex australis[a]	Proclaimed pest plant in SA	Uncommon
Enchylaena tomentosa	None	Common floodplain species
Enneapogon nigricans[b]	None	Not recorded since 1989
Enteropogon acicularis[b]	None	Very drought tolerant
Epaltes australis	None	Common plant in watered areas

Species	Status	Comments
Epaltes cunninghamii[b]	None	Not recorded since 1989
Eragrostis australasica	None	Uncommon
Eragrostis dielsii	None	Common plant in watered areas
Eragrostis elongata[b]	None	Not recorded since 1989
Eragrostis lacunaria	Rare in SA	Uncommon
Eremophila bignoniifolra[b]	None	Uncommon
Eremophila divaricata	None	Uncommon
Eremophila sturtii[b]	None	Not recorded since 1989
Eriochiton slceroilenoides	None	Uncommon
Erodium botrys[a]	Exotic	Uncommon
Erodium cicutarium[a]	Exotic	Uncommon
Erodium crinatum[b]	None	Not recorded since 1989
Eucalyptus camaldulensis var. camaldulensis	None	Common floodplain tree
Eucalyptus gracilis	None	Dryland species
Eucalyptus largiflorens	None	Common floodplain tree
Eucalyptus largiflorens x gracilis hybrid	None	Green hybrid, common floodplain tree easily confused with *E. largiflorens*
Eucalyptus oleosa[b]	None	Not recorded since 1989
Euchiton sphaericus	None	Uncommon
Euphorbia drummondii	None	Common plant in watered areas
Exocarpus aphyllus[b]	None	Not recorded since 1989
Exocarpus sparteus[b]	None	Not recorded since 1989
Exocarpus strictus[b]	Rare in SA	Uncommon
Fimbristylis velata[b]	None	Not recorded since 1989
Frankenia cupularis[b]	None	Uncommon
Frankenia pauciflora var. gunnii	None	Increased in abundance on the floodplain in recent years
Frankenia serpyllifolia	None	Increased in abundance on the floodplain in recent years
Galenia pubescens[a]	Exotic	Uncommon
Galenia secunda[a]	Exotic	Uncommon
Glinus lotoides	None	Difficult to differentiate between *Glinus* species
Glinus oppositfolia[b]	None	Difficult to differentiate between *Glinus* species, not recorded since 1989
Glossostigma diadnrum[b]	None	Not recorded since 1989
Glycyrrhiza acanthocarpa	None	Common in watered areas, especially Werta Wert
Gnaphalium sphaericum[b]	None	Not recorded since 1989
Goodenia gracilis	None	Uncommon
Goodenia fasicularis[b]	None	Not recorded since 1989
Goodenia heteromera[b]	Rare in SA	Not recorded since 1989
Grevillea huegelii[b]	None	Not recorded since 1989
Gunniopsis septifraga	None	Uncommon
Gypsophila australis[b]	None	Not recorded since 1989
Hakea leucoptera[b]	None	Not recorded since 1989
Haloragis aspera	None	Uncommon
Halosarcia indica ssp. leiostachya	None	Common in salt-affected areas
Halosarcia pergranulata ssp. divaricata	None	Common in salt-affected areas
Halosarcia pergranulata ssp. pergranulata	None	Common in salt-affected areas
Hedypnois rhagoidioloides[a, b]	Exotic	Not recorded since 1989
Helichrysum apiculatum var. apiculatum[b]	None	Not recorded since 1989

Species	Status	Comments
Helichrysum bracteatum[b]	None	Not recorded since 1989
Heliotropium amplexicaule[a]	Exotic	Will recruit after floodwaters recede, uncommon in Chowilla
Heliotropium curassivicum[a]	Exotic	Common pest plant throughout the lower Murray and Darling floodplains
Heliotropium europaeaum[a]	Exotic	Will recruit after floodwaters recede, common in watered areas
Heliotropium supinum[a]	Exotic	Common in watered areas, easily confused with *H. europaeum*
Helipterum corymbiflorum[b]	None	Not recorded since 1989
Helipterum floribundum[b]	None	Not recorded since 1989
Helipterum moschatum[b]	None	Not recorded since 1989
Helipterum pygmaeum	None	Uncommon
Herniaria cinerea[a]	Exotic	Uncommon
Herniaria hirsuta[a, b]	Exotic	Not recorded since 1989
Hordeum glaucum	Exotic	Uncommon
Hordeum leporinum[a]	Exotic	Uncommon
Hordeum vulgare[a]	Exotic	Uncommon
Hydrilla verticillata	Rare in SA	Present in River Murray upstream of Lock 6 and Isle of Mann growing with *Elodea canadensis*
Hypochoeris glabra[a]	Exotic	Uncommon
Hypochoeris radicata[a]	Exotic	Uncommon
Iseotopsis graminifolia	None	Common in watered areas
Isolepis australiensis	None	Uncommon
Isolepis hookeriana	None	Common in watered areas
Isolepis platycarpa[b]	None	Not recorded since 1989
Isolepis producta[b]	Vulnerable in SA	Not recorded since 1989
Isolepis victoriensis	None	Uncommon
Ixiolaena leptolepis[b]	None	Not recorded since 1989
Juncus aridicola	None	Common in and around the shallow areas of permanent waterbodies, easily confused with *J. usitatus*
Juncus bufonius[b]	None	Not recorded since 1989
Juncus pauciflorus[b]	None	Not recorded since 1989
Juncus subsecundus[b]	None	Not recorded since 1989
Juncus usitatus	None	Common in and around the shallow areas of permanent waterbodies
Lactuca saligna[a]	Exotic	Common terrestrial weed in high rainfall areas of SA
Lactuca serriola[a]	Exotic	Common terrestrial weed in high rainfall areas of SA
Lamarkia aurea[a, b]	Exotic	Not recorded since 1989
Lawrencia glomerata[b]	None	Not recorded since 1989
Lepidium fasciculatum[b]	None	Not recorded since 1989
Lepidium papillosum[b]	None	Not recorded since 1989
Lepidium pseudohyssopifolium[b]	None	Not recorded since 1989
Limonium lobataum[ab]	Exotic	Not recorded since 1989
Limosella australis	None	Common in and around the shallow areas of permanent waterbodies
Lolium rigidum[a]	Exotic	Common terrestrial weed in high rainfall areas of SA
Lophochloa cristata[b]	None	Not recorded since 1989
Lophochloa pumila[b]	None	Not recorded since 1989

Species	Status	Comments
Ludwigia peploides ssp. montevidensis	None	Common species in and around permanent waterbodies
Lycium australe	None	Uncommon
Lysiana exocarpi ssp. exocarpi	None	Mistletoe
Lythrum hyssopifolia	None	Uncommon
Maireana apressa[b]	None	Not recorded since 1989, common dryland species in the region
Maireana brevifolia	None	Uncommon
Maireana erioclada[b]	None	Not recorded since 1989, common dryland species in the region
Maireana pentagona[b]	Rare in SA	Not recorded since 1989
Maireana pentatropis[b]	None	Not recorded since 1989, common dryland species in the region
Maireana pyramidata[b]	None	Not recorded since 1989, common dryland species in the region
Maireana turbinata	None	Uncommon
Malacocera tricornis	None	Common dryland species in the region
Malva parviflora[a]	Exotic	Present in large numbers in Werta Wert
Marrubium vulgare[a]	Exotic	Uncommon
Marsilea angustifolia	None	Common in watered areas
Marsilea drummondii	None	Common in watered areas
Medicago minima[a]	Exotic	Common in watered areas
Medicago polymorpha[a]	Exotic	Common in watered areas
Medicago spp.[a]	Exotic	Common in watered areas
Melaleuca lanceolata ssp. lanceolata	None	Uncommon tree sometimes present on floodplains
Melilotus indica[ab]	Exotic	Not recorded since 1989
Mentha australis	None	Uncommon although present in low numbers in a lot of watered area
Mesembryanthemum crystallinum[a]	Exotic	Common floodplain weed, especially after high winter and spring rainfall
Mesembryanthemum nodiflorum[a]	Exotic	Common floodplain weed, especially after high winter and spring rainfall
Mimulus repens	None	Common in watered areas, especially abundant in Lake Littra and Punkah Horseshoes
Minuria cunninghamii	None	Uncommon
Minuria integerrima	None	Uncommon
Mollugo cerviana	None	Common in watered areas
Morgania floribunda	None	Common in watered areas and on the edges of permanent waterbodies
Muehlenbeckia florulenta	None	Common floodplain shrub
Muehlenbeckia horrida	Rare in SA	Uncommon
Myoporum platycarpum	None	Dryland tree
Myoporum parvifolium	Rare in SA	Uncommon
Myosurus minimus var. australis[a, b]	Exotic	Not recorded since 1989
Myriocephalus stuartii	Exotic	Uncommon
Myriophyllum crispatum[b, c]	Vulnerable in SA	Not recorded since 1989
Myriophyllum papillosum[b]	Rare in SA	Not recorded since 1989
Myriophyllum salsugineum	None	Uncommon
Myriophyllum verucossum	None	Common in permanent and watered areas, especially Werta Wert
Neatostema apulum[a, b]	Exotic	Not recorded since 1989
Nicotiana glauca[a]	Exotic	Uncommon
Nicotiana velutina	None	Uncommon

Species	Status	Comments
Nitella sp.	None	Submergent, common in shallow areas in permanent waterbodies
Nitraria billardierei[b]	None	Not recorded since 1989
Nothoscordum borbonicum[a]	Exotic	Submergent, common in shallow areas in permanent waterbodies
Nymphoides crenata[b]	Rare in SA	Not recorded since 1989
Olearia pimeloides ssp. pimeloides[b]	None	Not recorded since 1989
Omphalolappula concava[b]	None	Not recorded since 1989
Onopordum acaulon[a]	Exotic	Common terrestrial weed in high rainfall areas of SA
Osteocarpum acropterum var. acropterum	Rare in SA	Uncommon
Osteocarpum salsuginosum[b]	None	Not recorded since 1989
Oxalis perennans	None	Uncommon
Oxalis pes-caprae	Exotic	Common terrestrial weed in high rainfall areas of SA
Pachycornia triandra	None	Common in salt-affected areas, currently increasing in abundance
Papaver hybridum[a, b]	Exotic	Not recorded since 1989
Parapholis incurva[a, b]	Exotic	Not recorded since 1989
Parietaria debilis[b]	None	Not recorded since 1989
Paspalidium jubiflorum[b]	None	Not recorded since 1989
Paspalum distichum	None	Common around the edges of permanent waterbodies, especially the main channel
Pentaschistis airoides[a, b]	Exotic	Not recorded since 1989
Persicaria lapathifolium	None	Uncommon
Phragmites australis	None	Common around the edges of permanent waterbodies
Phyla canescens[a]	Exotic	Common floodplain pest plant throughout the South Australian Murray–Darling Basin
Phyllanthus lacunaris	None	Common in watered areas, especially Gum Flat and Coppermine Complex
Picris squarrosa	Rare in SA	Uncommon
Pimelea microcephala ssp. microcephala[b]	None	Not recorded since 1989
Pimelea trichostachya[b]	None	Not recorded since 1989
Pittosporum phylliraoides var. microcarpa[b]	None	Not recorded since 1989
Plagiobothrys plurisepaleus[b]	None	Not recorded since 1989
Plantago cunninghamii[b]	None	Not recorded since 1989
Plantago turrifera	None	Uncommon
Poa fordeana[b]	None	Not recorded since 1989
Podotheca angustifolia[b]	None	Not recorded since 1989
Pogonolepis muelleriana[b]	None	Not recorded since 1989
Polycalymma stuartii	None	Uncommon
Polycarpon tetraphylla[a, b]	Exotic	Not recorded since 1989
Polygonum aviculare[a]	Exotic	Uncommon, except around areas of human habitation
Polygonum plebium	None	Common in watered areas, especially Werta Wert and Brandy Bottle
Polypogon monspeliensis[a]	Exotic	Widespread, although rarely abundant pest plant usually present on the edges of permanent waterbodies
Potamogeton crispus	None	Common submergent
Potamogeton tepperi[b]	None	Not recorded since 1989
Potamogeton tricarinatus	None	Common submergent
Pratia concolor[b]	Rare in SA	Not recorded since 1989
Psoralea tenax	None	Uncommon

Species	Status	Comments
Psuedoraphis spinescens[b]	None	Not recorded since 1989
Psuedognaphalium luteo-album	None	Common in watered areas
Pterocaulon sphacelatum	None	Uncommon
Ptilotus spathulatus[b]	None	Not recorded since 1989
Ranunculus peltandrus var. platycarpus[b]	None	Not recorded since 1989
Ranunculus pumilio[b]	Vulnerable in SA	Not recorded since 1989
Ranunculus scleratus[a]	Proclaimed pest plant in SA	Weed of national significance, abundant around the edges of Pilby Lagoon
Rhagodia spinescens	None	Uncommon
Rhodanthe polygalifolia	None	Uncommon
Ricciocarpus natans[c]	None	Not recorded since 1989
Riechardia tingitana[a]	Exotic	Uncommon
Rorippa eusylis	None	Uncommon
Rorippa palustris[a]	Exotic	Uncommon
Rostraria cristata[a]	Exotic	Uncommon
Rostraria pumila[a]	Exotic	Uncommon
Rumex bidens	None	Locally abundant in Boat Creek and a few other spots throughout the system in permanent waterbodies
Rumex crispus[a, b]	Exotic	Not recorded since 1989
Rumex tenax[b]	None	Not recorded since 1989
Salix babylonica[a]	Exotic	Abundant immediately upstream of Lock 6 in the Main Channel but not common in the anabranches
Salsola kali	None	Uncommon until 2007–08 and is increasing in abundance on salt-affected areas of the floodplain
Salvia verbenaca[a, b]	Exotic	Not recorded since 1989
Sarcocornia quinqueflora	None	Uncommon
Scaevola spinescens[b]	None	Not recorded since 1989
Schismus barbatus[b]	None	Not recorded since 1989
Schoenoplectus validus	None	Widespread throughout the system on the edges of permanent waterbodies but rarely highly abundant
Scleranthus minusculus[b]	None	Not recorded since 1989
Sclerolaena brachyptera	None	Common plant across the floodplain
Sclerolaena decurrens	None	Uncommon
Sclerolaena dicantha	None	Common dryland species
Sclerolaena divaricata	None	Common plant in areas of the floodplain not salt affected
Sclerolaena limbata	None	Uncommon
Sclerolaena muricata var. muricata	None	Uncommon
Sclerolaena muricata var. semiglabra	None	Uncommon
Sclerolaena obliquicuspis	None	Uncommon
Sclerolaena patenticuspis[b]	None	Not recorded since 1989
Sclerolaena stelligra	None	Common plant, increasing in abundance in recent years
Sclerolaena tricuspis	None	Uncommon
Senecio cunninghamii	None	Common in watered areas, especially Punkah Horseshoes
Senecio glossanthus	None	Common in watered areas
Senecio lautus	None	Common in watered areas
Senecio pinnatifolius	None	Common in watered areas
Senecio quadridentatus	None	Common in watered areas

Species	Status	Comments
Senecio runcifolius	None	Common in watered areas, especially Punkah Horseshoes
Senna nemophylla var. platypoda[b]	None	Not recorded since 1989
Sida ammophila	None	Not recorded since 1989
Sida intricata	None	Uncommon
Silene apetula[a, b]	Exotic	Not recorded since 1989
Silene gallica[a, b]	Exotic	Not recorded since 1989
Sisymbrium erysimoides[a, b]	Exotic	Not recorded since 1989
Sisymbrium irio[a, b]	Exotic	Not recorded since 1989
Solanum esuriale	None	Common on Monoman Island Floodplain
Solanum lacunarium[b]	None	Uncommon
Solanum nigrum[a]	Exotic	Uncommon
Solanum oliganthum	None	Uncommon
Soliva anthemifolia[a, b]	Exotic	Not recorded since 1989
Sonchus asper[a]	Exotic	Uncommon
Sonchus oleraceus[a]	Exotic	Uncommon
Sonchus tenerrimus[a, b]	Exotic	Not recorded since 1989
Spergularia diandra[a]	Exotic	Salt-tolerant species, increasing in abundance in recent years
Spergularia marina[a]	Exotic	Salt-tolerant species, increasing in abundance in recent years
Spirodella punctata	None	Very small floating plant, easily overlooked especially when large amount of *Lemna* and *Azolla* are present
Spirodella pusilla	None	Very small floating plant, easily overlooked especially when large amount of *Lemna* and *Azolla* are present
Sporobolus mitchelli	None	Common in watered areas and around the edges of permanent waterbodies
Stipa drummondii[b]	None	Not recorded since 1989
Stipa nitida[b]	None	Not recorded since 1989
Stipa scabra ssp. falcata[b]	None	Not recorded since 1989
Stipa scabra[b]	None	Not recorded since 1989
Swainsona greyana	None	Common around the edges of permanent waterbodies
Swainsona microphylla[b]	None	Not recorded since 1989
Swainsona microphylla ssp. minima[b]	None	Not recorded since 1989
Swainsona oroboides[b]	None	Not recorded since 1989
Swainsona phacoides ssp. phacoides[b]	None	Not recorded since 1989
Taraxacum officinale[a]	Exotic	Uncommon
Tetragonia eremaea	None	Uncommon
Tetragonia tetragonoides	None	Common in watered areas, especially Coppermine
Teucruim racemosum	None	Common in watered areas
Threlkeldia diffusa	None	Uncommon
Thysanotus baueri[b]	None	Not recorded since 1989
Trachymene cyanopetula	None	Common in watered areas
Trichanthodium skirrophorum	None	Uncommon
Triglochin calcitrapum[b]	None	Not recorded since 1989
Triglochin procerum	None	Uncommon emergent
Triptilodiscus pygmaeus[b]	None	Not recorded since 1989
Typha domingensis	None	Common in shallow water and around the edges of permanent waterbodies
Urospermum picroides[a, b]	Exotic	Not recorded since 1989

Species	Status	Comments
Urtica urens[a, b]	Exotic	Not recorded since 1989
Vallisneria spiralis	None	Common submergent, abundant throughout the system in shallow permanent water
Verbena officinalis[a, b]	Exotic	Not recorded since 1989
Veronica peregrina ssp. xalapensis[a, b]	Exotic	Not recorded since 1989
Vittadinia australasica[b]	Vulnerable in SA	Not recorded since 1989
Vittadinia cervicularis[b]	None	Not recorded since 1989
Vittadinia cuneata[b]	None	Not recorded since 1989
Vulpia muralis[a, b]	Exotic	Not recorded since 1989
Vulpia myuros[a, b]	Exotic	Not recorded since 1989
Wahlenbergia communis	None	Common in watered areas
Wahlenbergia fluminalis	None	Common in watered areas
Wahlenbergia multicaulis	None	Common in watered areas
Wahlenbergia tumidifructa	None	Common in watered areas
Waitzia acuminata[b]	None	Not recorded since 1989
Wilsonia rotundifolia[b]	None	Not recorded since 1989
Xanthium californicum[a]	Proclaimed pest plant in SA	Common floodplain weed, especially in watered areas and along the edges of permanent waterbodies
Xanthium occidentale[a]	Proclaimed pest plant in SA	Common floodplain weed, especially in watered areas and along the edges of permanent waterbodies
Zanichellia palustris	Rare in SA	Uncommon submergent although there is a large localised population downstream of Lock 6
Zygophyllum ammophilum[b]	None	Not recorded since 1989
Zygophyllum auranitacum[b]	None	Not recorded since 1989
Zygophyllum eremaeum[b]	None	Not recorded since 1989
Zygophyllum glaucum[b]	None	Not recorded since 1989
Zygophyllum iodocarpum[b]	None	Not recorded since 1989

Notes
[a] Exotic species; [b] only observed by O'Malley (1990); [c] only observed by Roberts and Ludwig (1991).

Table C.3: Fauna species of conservation significance recorded on the Chowilla Floodplain

		Conservation status	
Common name	Scientific name	State (SA and/or NSW)	National
Mammals			
Common brush-tail possum	*Trichosurus vulpecula*	R	
Feather-tailed glider	*Acrobates pygmaeus*	E	
Western pygmy possum	*Cercartetus concinnus*	E	
Southern free-tail bat	*Mormopterus planiceps*	V	
Reptile and amphibians			
Southern bell frog	*Litoria raniformis*		V
Long-thumbed frog	*Limnodynastes fletcheri*	V	
Broad-shell tortoise	*Chelodina expansa*	V	
Murray tortoise	*Emydura macquarii*	V	
Eastern tiger snake	*Nolechis scutatus*	R	
Carpet python	*Morelia spilota variegata*	R	
Lace monitor	*Varanus varius*	R	
Birds			
Apostlebird	*Struthidea cinerea*		
Regent parrot	*Polytelis anthopeplus monarchoides*		V
Darter	*Anhinga melanogaster*	R	
Australian bittern	*Botaurus poiciloptilus*	V	
Musk duck	*Biziura lobata*	R	
Blue-billed duck	*Oxyura australis*	R	
Australasian shoveler	*Anas rhynchotis*	R	
Freckled duck	*Stictonetta naevosa*	R	
White-faced heron	*Egretta novaehollandiae*	R	
Banded stilt	*Cladorhynchus leucocephalus*	V	
Bush stone-curlew	*Burhinus grallarius*	R	
Square-tailed kite	*Lophoictinia isura*	E	
Peregrine falcon	*Falco peregrinus*	R	
White-bellied sea-eagle	*Haliaeetus leucogaster*	E	
Major Mitchell's cockatoo	*Cacatua leadbeateri*	R	
Gilbert's whistler	*Pachycephala inornata*	R	
Blue-faced honeyeater	*Entomyzon cyanotis*	R	
Little friarbird	*Philemon citreogularis*	R	
Striped honeyeater	*Plectorhyncha lanceolata*	R	
Fish			
Murray cod	*Maccullochella peeli*		V
Silver perch	*Bidyanus bidyanus*	V	
Freshwater catfish	*Tandanus tandanus*	V	
Fly specked hardyhead	*Craterocephalus stercusmuscarum*	R	
Crimson-spotted rainbowfish	*Melanotaenia fluviatilis*	R	
Dwarf flat-headed gudgeon	*Philypnodon* sp. 2	R	

Notes
Conservation status codes: E – endangered; R – rare; V – vulnerable.

Appendix D: Legislation

Australian Government

- *Water Act 2007*
- *Aboriginal and Torres Strait Islander Heritage Protection Act 1984*
- *Australian Heritage Council (Consequential and Transitional Provisions) Act 2003*
- *Environment Protection and Biodiversity Conservation Act 1999*
- *Native Title Act 1993*
- *National Water Commission Act 2004*
- Murray–Darling Basin Intergovernmental Agreement (Agreement on Murray–Darling Basin Reform 2008)
- Inter-governmental Agreement for a National Water Initiative
- Wetlands policy of the Commonwealth of Australia 1997
- National Strategy for Ecologically Sustainable Development 1992
- National Strategy for the Conservation of Australia's Biological Diversity 1996
- National Principles for the Provision of Water for Ecosystems 1996
- National Water Quality Management Strategy 1992
- National Weeds Strategy
- Weeds of national significance

South Australia

- *Aboriginal Heritage Act 1988*
- *Development Act 1993*
- *Environmental Protection Act 1988*
- *Fisheries Management Act 2007*
- *Heritage Act 1993*
- *Mining Act 1971*
- *Harbours and Navigation Act 1993*
- Australia International Council on Monuments and Sites — the Burra Charter (the Australia International Council on Monuments and Sites charter for places of cultural significance) 1979
- *Murray–Darling Basin Act 1993*
- *National Parks and Wildlife Act 1972*
- *Native Title (South Australia) Act 1994*
- *Native Vegetation Act 1991*
- *Natural Resources Management Act 2004*
- *Pastoral Land Management and Conservation Act 1989*
- *Petroleum Act 1940*
- South Australian River Murray Salinity Strategy 2001–15
- *River Murray Act 2003*
- State Water Plan 2002
- Wetland Strategy for South Australia 2003
- *Water (Commonwealth Powers) Act 2008*
- South Australian State Water Plan 2000
- No species loss: A nature conservation strategy for South Australia 2007–17
- Naturelinks — Implementing the wild country philosophy in South Australia
- Responsible nature-based tourism strategy 2004–09
- People and parks: A visitor strategy for South Australia's national parks and reserves 2010–15
- South Australian Tourism Plan 2009–14.

New South Wales

- *Water Management Act 2000*
- *National Parks and Wildlife Act 1974*
- *Rural Lands Protection Act 1998*
- *Fisheries Management Act 1994*
- *Threatened Species Conservation Act 1995*
- *Native Vegetation Act 2003*
- *Environmental Planning and Assessment Act 1979*
- *Western Lands Act 1901*
- *Crown Lands Act 1989*
- Murray Regional Environmental Plan No. 2 1994
- *Noxious Weeds Act 1993*
- *Mining Act 1992*
- *Heritage Act 1977*
- *Protection of the Environment Operations Act 1997*
- *Rural Fires Act 1997*
- *Catchment Management Authorities Act 2003*
- Water Sharing Plan for the Murray and Lower Darling Regulated Rivers Water Sources 2004
- New South Wales wetlands management policy

Murray–Darling Basin-specific legislation

- *Water Act 2007* (Cwlth)
- Murray–Darling Basin Agreement 1915
- Basin Salinity Management Strategy 2001–15
- Integrated Catchment Management Policy in the Murray–Darling Basin 2001–10
- Native Fish Strategy 2001–13
- Floodplain Wetlands Management Strategy for the Murray–Darling Basin 2004
- The Living Murray Initiative 2002
- Algal Management Strategy 1994
- Human Dimension Strategy 1999
- Murray–Darling Basin Biodiversity Plan 2001

South Australian statutory bodies

- Native Vegetation Council (implementation of the Native Vegetation Act)
- South Australian Murray–Darling Basin Natural Resources Management Board
- South Australian National Parks and Wildlife Council
- South Australia Water as the contracting authority for the Murray–Darling Basin Authority

New South Wales statutory bodies (not exhaustive)

- NSW Office Of Water
- Department of Environment Climate Change and Water
- Livestock Health and Pest Authority
- Lower Murray Darling Catchment Management Authority Wentworth Shire Council
- NSW Fisheries
- Department of Industry and Investment
- Land Planning and Management Authority

Schedules

For the following schedules see ←www.mdba.gov.au/programs/tlm/icon_sites/emp.→

Schedule 1: Risk management plan

Schedule 2: Communication and engagement strategy

Schedule 3: Condition monitoring plan

Schedule 4: Operating plan

Glossary

Aquatic ecosystem	Any water environment from small to large, from pond to ocean, in which plants and animals interact with the chemical and physical features of the environment.
Baseline condition	An environmental quality or condition that is defined at a point in time and used as a benchmark for determining a change in the environmental quality or condition. For The Living Murray, the baseline condition is 2003 when the program was announced.
Benchmark	A standard or point of reference.
Ecological objectives	An objective is a statement of the desired condition. It is not necessary to quantify an objective.
Ecological targets	A target is generated from the ecological objective and will ideally be quantitative.
Environmental water	Water that is available for the environment.
Icon site environmental water management plan	A plan that details the aims, objectives and management actions at an icon site in accordance with The Living Murray program. The plan complements state-based plans and processes.
Objective	Refer to Ecological objectives.
Parameter	A measurable or quantifiable characteristic or feature.
Ramsar Convention on Wetlands of International Importance (the Ramsar Convention)	A global treaty adopted in Ramsar, Iran in 1971 that focuses on the conservation of internationally important wetlands.
River Management Division	A business unit of the Murray–Darling Basin Authority responsible for operating the River Murray system in accordance with the Murray–Darling Basin Intergovernmental Agreement. River Management Division manages the River Murray system to ensure that the available water is continuously accounted for and distributed to New South Wales, Victoria and South Australia in accordance with the Murray–Darling Basin Agreement.
River Murray Increased Flows (RMIF)	The component of the water recovered under the Snowy Water Inquiry Outcomes Implementation Deed (SWOID) that is returned to the River Murray System as an environmental flow.
Unregulated Flow	The volume of water surplus to regulated requirements and determined by the volume of flow in the River Murray exceeding (or predicted to exceed) the inlet channel capacity for Lake Victoria and entitlement flow for South Australia
Water requirements	Includes the flow, volume, timing, duration, velocity, depth, quality or any other attribute that is required to meet the ecological target.

Figures and tables

Figures

Tables

Abbreviations and acronyms

AHD	Australian Height Datum
GL	gigalitres
GL/d	gigalitres a day
LTCE	long-term Cap equivalent
MDBA	Murray–Darling Basin Authority
MDBC	Murray–Darling Basin Commission
ML/d	megalitres a day
TLM	The Living Murray

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