Australian Government

MURRAY–DARLING BASIN AUTHORITY

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Hattah Lakes

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 Living Murray 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 Living Murray (TLM) Initiative is one of Australia's most significant river restoration programs. The program is delivered by six partner governments as outlined in the Murray–Darling Basin Intergovernmental Agreement (2004), which is facilitated through a formal governance framework coordinated by the Murray–Darling Basin Authority (MDBA) and ultimately overseen by the Murray–Darling Basin Ministerial Council. This overarching framework is underpinned by state-based governance arrangements.

Almost 500 GL (long term Cap equivalent) has now been recovered through TLM. This water will be used at six icon sites to improve environmental outcomes: Barmah–Millewa Forest; Gunbower–Koondrook–Perricoota Forest; Hattah Lakes; Chowilla Floodplain and Lindsay–Wallpolla Islands; Lower Lakes, Coorong and Murray Mouth; and the River Murray Channel.

The Hattah Lakes icon site is in north-west Victoria. It is an extensive complex of lakes and floodplain set within the Hattah–Kulkyne National Park and the Murray–Kulkyne Regional Park. Twelve of the lakes are listed as internationally important wetland systems under the Ramsar Convention on Wetlands of International significance (the Ramsar Convention), primarily for their value as waterbird habitat and importance in maintaining regional biodiversity.

The Hattah Lakes and the surrounding floodplain were selected as an icon site because of their extent, condition, diversity and habitat value, as well as their social and cultural importance. The system includes more than 20 perennial and intermittent freshwater lakes, ranging in size from less than 10 ha to about 200 ha. Surrounding vegetation communities include those that require frequent flooding, such as river red gum (*Eucalyptus camaldulensis*) woodland, to those that require only periodic inundation, such as black box (*E. largiflorens*) woodland and lignum (*Muehlenbeckia florulenta*) shrubland.

The Hattah Lakes have been severely degraded by regulation of the River Murray and the extraction of water for agriculture, industry and urban use. The resulting reduction in the frequency, magnitude and duration of high flows has affected the flow regime of the wetland system. The associated impacts include reductions in the health of river red gum and black box communities (including tree deaths and a demonstrated transition to a more terrestrial understorey (MDFRC 2009), a reduction in the availability of wetland habitat for waterbirds, fish, frogs and turtles, and in the diversity and abundance of wetland flora in the lakes.

An environmental water management plan has been produced for each icon site with the aim of describing TLM ecological objectives and targets and the site-specific watering regimes, works and water delivery arrangements. This plan supersedes the Hattah Lakes Environmental Management Plan 2006–07.

The ecological objectives for the Hattah Lakes are to:

- restore a mosaic of hydrological regimes, which represent pre-regulation conditions (to maximise biodiversity)
- maintain and, where practical, restore the ecological character of the Ramsar site with respect to the Strategic Management Plan (Victorian Department of Sustainability and Environment 2003)
- restore the macrophyte zone around at least 50% of the lakes to increase fish and bird habitat
- improve the quality and extent of deep freshwater meadow and permanent open freshwater wetlands so that species typical of these ecosystems are represented
- maintain habitat for the freckled duck (*Stictonetta naevosa*), grey falcon (*Falco hypoleucos*) and white-bellied sea-eagle (*Haliaeetus leucogaster*) in accordance with action statements[1]
- increase successful breeding events for colonial waterbirds to at least two years in 10; colonial waterbird species includespoonbills (*Threskiornithidae*), egrets (genera *Egretta* or *Ardea*), and night herons and bitterns (*Ardeidae*)
- provide suitable habitat for a range of migratory bird species (including Latham's snipe (*Gallinago hardwickii*), red-necked stint (*Calidris ruficollis*) and sharp-tailed sandpiper (*C. acuminata*)
- increase distribution, number and recruitment of local wetland fish—including hardyhead (*Craterocephalus stercusmuscarum*), Australian smelt (*Retropinna semoni*) and gudgeon (*Eleotridae* family) by providing appropriately managed habitat
- maximise use of floodplain habitat for recruitment of all indigenous freshwater fish.

1 The *Flora and Fauna Guarantee Act 1988* (Vic.) requires action statements to be prepared for all threatened species in Victoria. These are brief management plans that provide some background information about the species and describe previous and planned actions to conserve the species.

To achieve these objectives, a package of on-ground works has been developed to deliver environmental water to the lakes via natural inflows from the River Murray or pumping. These works include:

- lowering high points (sills) within Chalka Creek to increase the frequency of natural inflows
- construction of a permanent pump station to top up natural floods and fill the lakes during long dry periods
- construction of a single regulator that facilitates water delivery to Lake Kramen, a large episodic wetland some distance from the rest of the lakes
- construction of a system of regulators and stop banks that will allow water to be retained in the system to increase the duration of natural flood events and enable water to be pumped into the system to water red gum and black box at higher elevations.

The works will be operated in conjunction with natural high flows to provide three small floods every 10 years, filling wetlands and watering fringing river red gums, and one large flood every eight to 10 years, watering surrounding river red gum and black box woodland. Lake Kramen will be watered once every eight to 10 years.

Annual monitoring will be undertaken to determine the progress made towards achievement of the ecological objectives for the icon site. This will occur primarily through the icon site condition monitoring program; however, additional monitoring activities will be undertaken during and following watering events. Monitoring of specific risks associated with environmental water delivery will also occur as required.

The Environmental Water Management Plan promotes an adaptive management approach through 'learning by doing'. Ecological information collected during and after environmental watering events will be incorporated into the icon site operating strategy to ensure that it remains relevant and effective.

Several committees have been established for the Hattah Lakes icon site as part of the plan's governance arrangements. These committees (together with The Living Murray Indigenous facilitator, various project working groups, other established community groups and activities under communication plans and strategies) provide a mechanism for consulting with a range of community and agency stakeholders.

1. The Living Murray

The Living Murray (TLM) 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 2011–2012. 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 Hattah Lakes 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 The Living Murray 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 Hattah Lakes 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 Hattah Lakes 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.

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

The 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 the Environment, Water, Heritage and the Arts 2009).

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, 2011a).

Bonn Convention

The Convention on the Conservation of Migratory Species of Wild Animals (also known as the Bonn Convention) aims to conserve terrestrial, marine and avian migratory species throughout their range. It is an intergovernmental treaty, concluded under the aegis of the United Nations Environment Program, concerned with the conservation of wildlife and habitats on a global scale. These species are protected by the federal *Environment Protection and Biodiversity Conservation Act 1999*.

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, 2011b).

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.

Victorian legislation

The following pieces of legislation operate in conjunction with other Victorian legislation that influences the management and conservation of Victoria's natural resources as well as outlining obligations with respect to obtaining approvals for structural works within the icon sites.

Aboriginal Heritage Act 2006

The *Aboriginal Heritage Act 2006* provides for the protection of Indigenous cultural heritage in Victoria. The Act also provides for the introduction and management of a system of Registered Aboriginal Parties that allows Indigenous groups with connection to country and others to be involved in decision-making processes around cultural heritage. Regulations enabled under the Aboriginal Heritage Act require a cultural heritage management plan to be prepared when undertaking high impact activities in culturally sensitive landscapes.

Environmental Effects Act 1978

The *Environmental Effects Act 1978* aims to ensure that development occurs in an ecologically sustainable manner and provides for assessment of any project or development that could have significant effects on the environment. The Environmental Effects Act enables the Victorian Minister for Planning to decide whether an environmental effects statement should be undertaken for proposed projects. Projects should be referred to the minister if they meet any referral criteria, as set out in ministerial guidelines (Victorian Department of Sustainability and Environment 2006). A project can be referred by the proponent, a statutory authority or any minister.

Flora and Fauna Guarantee Act 1988

The aim of the *Flora and Fauna Guarantee Act 1988* is to conserve threatened flora and fauna species and communities, and to manage potentially threatening processes. The Flora and Fauna Guarantee Act provides for the establishment and maintenance of lists of threatened species, potentially threatening processes and excluded species, which are those not to be conserved because they constitute a serious threat to human welfare (i.e. human disease organisms).

The Act directs that action statements (brief management plans) are to be prepared for listed species to track the progress of management actions, and recovery plans are to be prepared for species also listed under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth).

Planning and Environment Act 1987

The *Planning and Environment Act 1987* establishes a framework for planning the use, development and protection of land in Victoria in the present and long-term interests of all Victorians. Local planning schemes are enabled under this Act.

Murray–Darling Basin Act 1993

The *Murray–Darling Basin Act 1993* enables the Murray–Darling Basin Agreement 2008, which was entered into by the Australian Government and the governments of New South Wales, Victoria, Queensland, South Australia and the Australian Capital Territory with regard to the water, land and other environmental resources of the Murray–Darling Basin. This Act provides for the referral of selected powers under the Victorian Constitution that enable the Australian Government to manage specific aspects of water resource management within the Basin.

National Parks Act 1975 and Parks Victoria Act 1998

In Victoria, national parks are managed by Parks Victoria. Under the *Parks Victoria Act 1998*, Parks Victoria's responsibilities are to provide services to the state and its agencies for the management of parks, reserves and other public land. Under s. 27 of the *National Parks Act 1975*, works by a public authority within a park reserved and managed under the provisions of the Act are subject to consent by the minister. A condition of this consent is that the proposed works comply with the management objectives and strategies for the park.

Water Act 1989

The Victorian *Water Act 1989* governs the way water entitlements are issued and allocated in that state. The Act defines water entitlements and establishes the mechanisms for managing Victoria's water resources. Part 10 of the Water Act establishes waterway management and general river health management as the responsibility of catchment management authorities and Melbourne Water (where applicable). For TLM works, s. 67 of the Water Act identifies catchment management authorities as the responsible authorities for issuing licences for conducting works in a designated waterway.

New South Wales legislation

While the Hattah Lakes icon site is considered to be located in Victoria, the left bank of the River Murray constitutes the Victoria–New South Wales state boundary. Construction of the proposed pump station will occur in New South Wales and, as such, relevant New South Wales legislation is included here.

Crown Lands Act 1989

The *Crown Lands Act 1989* (NSW) ensures that Crown land is managed for the benefit of the people of New South Wales and, in particular, to provide the management, proper development, conservation and regulation of the conditions under which Crown land is permitted to be used or otherwise dealt with. The Land and Property Management Authority is responsible for the sustainable and commercial management of Crown land in New South Wales. A Crown land licence is a contractual agreement that grants the licensee a personal right to occupy and use Crown land for a particular purpose.

Environmental Planning and Assessment Act 1979

The *Environmental Planning and Assessment Act 1979* forms the statutory framework for planning approval and environmental assessment in New South Wales. Implementation of the Act is the responsibility of the New South Wales Planning Minister, statutory authorities and local councils. The need or otherwise for development consent is set out in environmental planning instruments—state environmental planning policies, regional environmental plans or local environmental plans.

Fisheries Management Act 1994

The *Fisheries Management Act 1994* lists threatened aquatic species, endangered populations and ecological communities, and key threatening processes. Potential impacts on species, populations and communities subject to the Act are assessed by Industry and Investment New South Wales.

Water Management Act 2000

The *Water Management Act 2000* provides for the sustainable and integrated management of the water sources of the state to protect, enhance and restore water sources, their associated ecosystems, ecological processes and biological diversity, and their water quality. Any activity that affects the quantity or flow of water in a water source requires consent under this Act.

Governance and planning arrangements

State planning strategies

This section details existing plans and strategies for high-level integrated planning for, and provision of, the protection and enhancement of the Hattah Lakes icon site's natural and cultural values.

Northern Region Sustainable Water Strategy

Regional sustainable water strategies were legislated through 2005 amendments to the Water Act (Vic.) and fulfil Victoria's commitment to the National Water Initiative to carry out open, statutory-based water planning. Sustainable water strategies take a long-term view of water resource planning and, as such, they guide the development, integration and implementation of management plans prepared by water corporations and catchment management authorities operating within each region.

Victorian River Health Strategy

The Victorian River Health Strategy was released in 2002 with the statewide objective of achieving healthy rivers, streams and floodplains that meet the environmental, economic, recreational and cultural needs of current and future generations.
The Victorian River Health Strategy provides the policy direction and planning framework for communities to work in partnership with government to manage and restore Victoria's rivers over the long term.

Native vegetation management: A framework for action

The *Native vegetation management: A framework for action* was released in 2002. The framework establishes the strategic direction for the protection, enhancement and revegetation of native vegetation across the Victorian landscape.

Improving the quality and amount of native vegetation in Victoria is critical to maintaining land and water health. The framework's main goal is to achieve a reversal, across the entire landscape, of the long-term decline in the extent and quality of native vegetation, leading to a net gain.

Victoria's planning provisions

Established under the *Planning and Environment Act 1987* (Vic.), the provisions provide local governments with a means of protecting wetlands and waterways through the control of land use and development. Clause 15.09 of the state planning policy framework states:

- Planning and responsible authorities must ensure that any changes in land use or development would not adversely affect the habitat values of wetlands and wetland wildlife habitats designated under the Convention on Wetlands of International Importance.

Regional planning strategies

Mallee Regional Catchment Strategy

This overarching strategic document established under the *Catchment and Land Protection Act 1994* (Vic.) is aimed at halting declining biodiversity through the implementation of priority programs, including those that protect and manage wetlands. The Mallee Catchment Management Authority coordinates implementation of the Mallee Regional Catchment Strategy and its sub-strategies and action plans under the *Water Act 1989* (Vic.).

Mallee River health strategy and addendum

These documents provide a regional framework for the Mallee Catchment Management Authority to achieve river health outcomes as the regional caretaker of river health. The strategy is relevant to the riverine wetlands of the Hattah Lakes icon site.

Mallee Wetland Strategy

This provides a strategic program to inform and prioritise wetland management in the region, complementing existing strategies and action plans while providing specific direction for investment in wetland management.

Murray River Frontage Action Plan—Robinvale to Merbein

The frontage action plans were developed as a means of integrating and coordinating the management of Crown land frontages along the River Murray. This plan outlines a range of actions to enhance the management of frontages to the River Murray between Robinvale and Merbein.

Strategic management plan for the Hattah–Kulkyne Lakes Ramsar site

The primary purpose of this plan is to facilitate conservation and wise use of the Hattah–Kulkyne Lakes Ramsar site so as to maintain and, where practical, restore the ecological values for which it is recognised as a Ramsar wetland.

Mallee Parks Management Plan

This plan was released in 1996 and sets out the broad directions for future management of Mallee Parks and state management objectives and strategies to achieve a high standard of conservation and recreation management.

Governance 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, the MDBA, Basin Officials Committee, The Living Murray Committee and the Environmental Watering Group (see **Figure 1.2** for TLM governance structure)

The Victorian Department of Sustainability and Environment coordinates delivery of TLM across all Victorian icon sites. A statewide governance framework has been developed, with a state steering committee and state construction committee to ensure high-level engagement of stakeholder agencies (see **Appendix A** of this report).

The icon site manager for the Hattah Lakes is the Chief Executive Officer of the Mallee Catchment Management Authority, as catchment management authorities are responsible for river health and environmental water management in Victoria. The Mallee Catchment Management Authority therefore coordinates TLM delivery at the icon site level, working in partnership with Parks Victoria (the land manager) and supported by a number of icon site-specific committees (see **Appendix A**). These committees comprise relevant agency and community representatives. For more detail on the roles and responsibilites of individual committees and groups, refer to **Appendix A**.

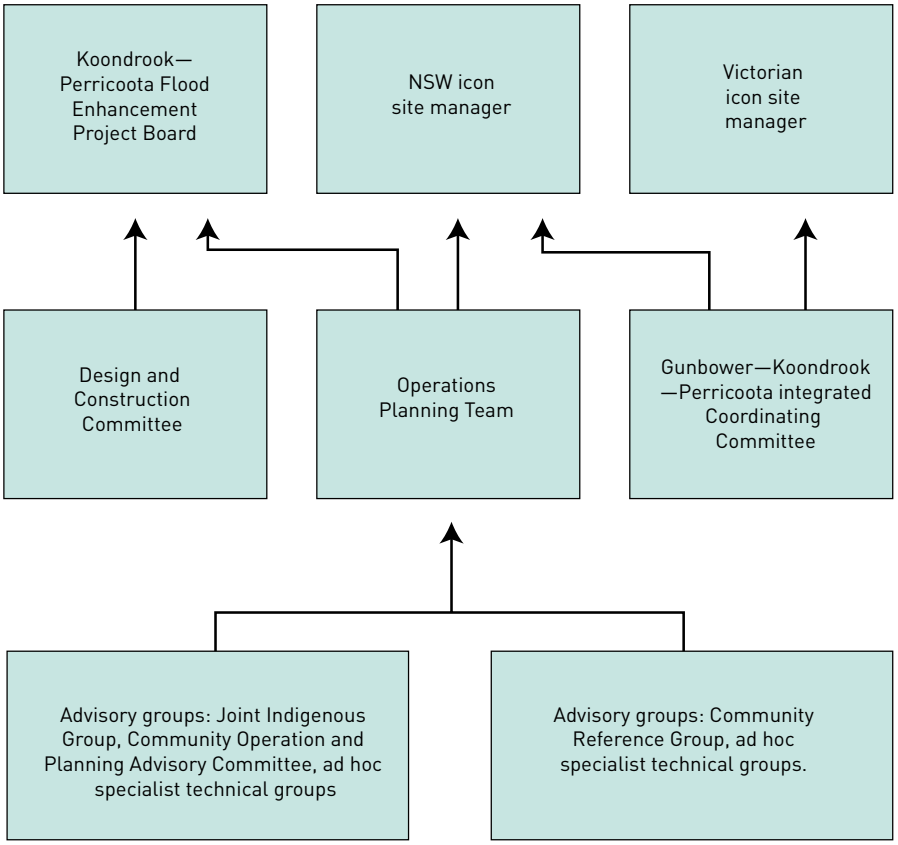

Figure 1.2: The Living Murray governance structure (MDBA 2010)

2. Icon site description

The Hattah Lakes are an extensive complex of approximately 13,000 ha of lakes and floodplain set within the 48,000 ha Hattah–Kulkyne National Park and the Murray–Kulkyne Park. The site is in north-west Victoria on the bank of the River Murray between Robinvale and Mildura.

The Hattah Lakes icon site comprises the Hattah Lakes wetland complex and the adjoining floodplain area, set within a Mallee landscape. The floodplain is defined by the largest flood on record (which occurred in 1956) (see **Figure 2.1**). Although the Hattah Lakes abut Murray–Sunset National Park and Murray–Kulkyne Park, the lakes are situated in a predominately agricultural landscape, with private land used primarily for irrigated horticulture, dryland cropping and stock grazing.

Description of key ecological assets of the icon site

The Hattah Lakes lie in the Robinvale Plains bioregion and the system comprises more than 20 perennial and intermittent freshwater lakes, ranging in size from less than 10 ha to about 200 ha. Surrounding vegetation communities range from those that require frequent flooding, such as river red gum woodland, to those that require only periodic inundation, such as black box woodland and lignum (*Muehlenbeckia florulenta*) shrubland. The lakes and creek lines provide important habitat for more than 47 waterbird species, including a number listed under international and national agreements. These include the Ramsar and Bonn conventions, the Japan–Australia, China–Australia, and Republic of Korea–Australia migratory bird agreements (described in chapter 1), and the Directory of Important Wetlands Australia.

The Hattah Lakes was selected as a TLM icon site on the basis of the extent, condition, diversity and habitat value of the lake and floodplain communities, as well as the social and cultural importance of the lakes. The park, together with the adjoining Murray–Kulkyne Park, was designated as a biosphere reserve in 1981 under the United Nations Educational, Scientific and Cultural Organisation's Man and the Biosphere Program (MDBC 2005) in recognition of its outstanding natural values. Biosphere reserves are areas significant on a world scale for their characteristic landforms, flora and fauna, and the way they have been used by people (Victorian Department of Sustainability and Environment 2010).

Twelve wetlands are listed as Wetlands of International Importance under the International Convention on Wetlands (Ramsar Convention). These are:

- Lake Arawak (40 ha)
- Lake Brockie (28 ha)
- Lake Bulla (40 ha)
- Lake Cantala (101 ha)
- Lake Hattah (61 ha)
- Lake Konardin (121 ha)
- Lake Kramen (161 ha)
- Lake Lockie (141 ha)
- Lake Mournpall (243 ha)
- Lake Yelwell (81 ha)
- Lake Yerang (65 ha)

To be listed as a Ramsar site, a wetland must meet one or more internationally accepted criteria in relation to its zoology, botany, ecology, hydrology or limnology and importance to waterfowl. The Hattah Lakes site met four criteria as outlined on the Ramsar wetlands website (Ramsar 2010).

Additional information on the specific ecology of the Hattah Lakes icon site is provided later in this chapter.

Values of the icon site

The Hattah Lakes icon site is recognised for its many environmental, social, cultural and economic values. The lake system is recognised for its waterbird breeding habitat, its value as a refuge for waterbirds during drought (a large wetland within an arid zone environment) and for the threatened flora and fauna present. Also of importance are the sites of Indigenous cultural significance.

The ecology of the lakes and floodplain communities of the Hattah Lakes is strongly influenced by their flooding regimes. The lakes have a common hydrology in that they are filled by peaks in river flow and then retain water for several years after floods recede. In contrast, the surrounding floodplains are inundated only for the duration of sufficiently large peaks in river flow; they are exposed as soon as river levels fall below that of the floodplain water level and water drains back into the river.

Ecological values

Flora

Flood-dependent vegetation at Hattah Lakes comprises 10 Victorian ecological vegetation classes, ranging from wetland communities that require frequent flooding to those that require periodic inundation, such as lignum- and black box-dominated communities. The bioregional conservation significance of the vegetation classes ranges from 'presumed extinct' to 'least concern' (see **Table 2.1**).

The icon site supports 115 significant flora species (considered rare or threatened in Victoria, and/or listed under the *Flora and Fauna Guarantee Act 1988* (Vic.) (see **Appendix B**). One of these species, winged peppercress (*Lepidium monoplocoides*), is listed as nationally endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth).

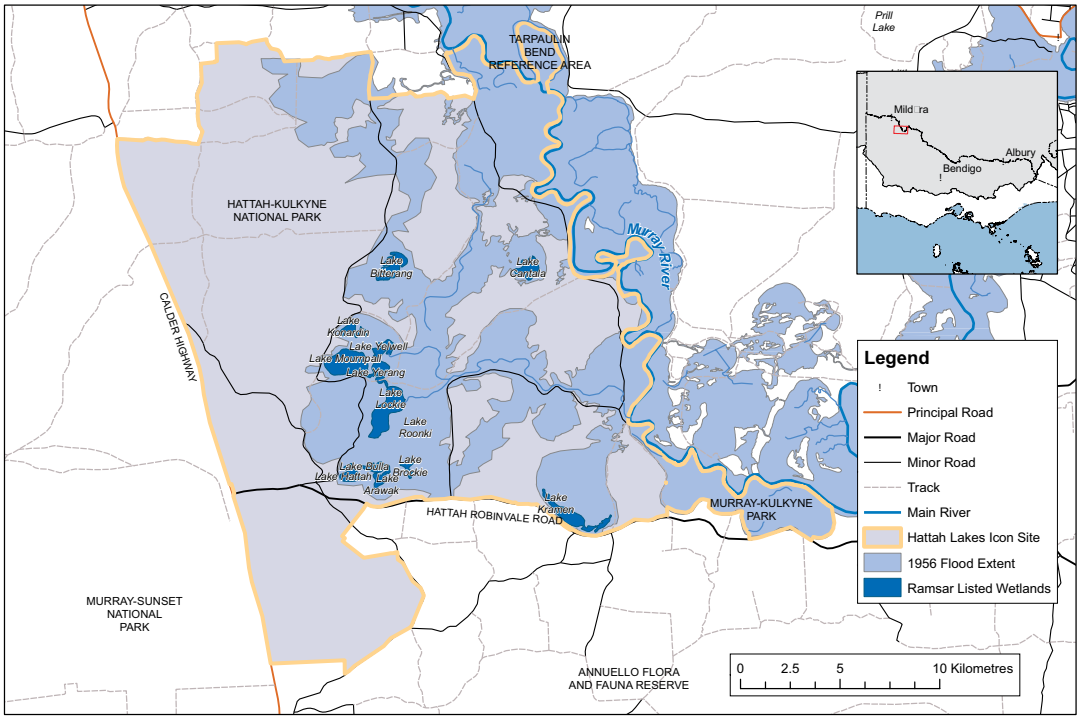

Figure 2.1: Jurisdictional boundaries and 1956 flood extent (1 in 100-year-flood): Hattah Lakes icon site

Table 2.1: Bioregional conservation significance of Hattah Lakes ecological vegetation classes within the influence of the Hattah Lakes

Ecological vegetation class (corresponding identification number)	Bioregional conservation significance
Grassy riverine forest (106)	Depleted
Grassy riverine forest/floodway/pond/herb-land complex (811)	Depleted
Intermittent swampy woodland (813)	Depleted
Shrubby riverine woodland (818)	Least concern
Riverine grassy woodland (295)	Depleted
Lignum swampy woodland (823)	Depleted
Riverine chenopod woodland (103)	Depleted
Lignum shrubland (808)	Least concern
Lignum swamp (104)	Vulnerable
Lakebed herbland (107)	Depleted

Fauna

Hattah–Kulkyne National Park supports a high diversity of vertebrate fauna, with 308 recorded within a 10 km radius of the area of the works and structures package (GHD 2009a). These include:

- 225 species of native birds (including 47 waterbirds), plus five exotic birds
- 27 species of mammal (plus six exotic mammals)
- 38 species of reptile
- five species of frogs.

Fifty-seven of these 308 fauna species are listed as threatened in Victoria or nationally (see **Appendix C**). Two Environment Protection and Biodiversity Conservation Act-listed species are dependent on flooding or floodplain vegetation: the regent parrot (*Polytelis anthopeplus monarchoides*), which nests in tree hollows in river red gums, and Australian painted snipe (*Rostratula australis*), a wader that forages around the fringes of the flooded lakes. Many of the recorded bird species are migratory and are protected under international migratory bird agreements with Japan and China, and the Bonn Convention.

The lake system supports waterbirds in large numbers and provides important breeding habitat, particularly for colonial nesting waterbirds. Sixteen waterbird species have been recorded breeding at the lakes and in excess of 20,000 waterbirds have been recorded when the lakes are flooded (Victorian Department of Sustainability and Environment 2003). Criterion 3 of the Ramsar Convention indicates that the Hattah Lakes maintain regional biodiversity by providing important habitat for more than 50 species of waterbirds. Up to 288 hoary-headed grebes (*Poliocephalus poliocephalus*), 101 freckled ducks (*Stictonetta naevosa*) (listed as threatened in Victoria under the Flora and Fauna Guarantee Act), 1,960 Pacific black ducks (*Anas superciliosa*), 2,550 grey teals (*A. gracilis*), 1,280 pink-eared ducks (*Malacorhynchus membranaceus*), 128 black-fronted dotterels (*Elseyornis melanops*) and 1,000 Australian pelicans (*Pelecanus conspicillatus*) have been recorded at any one time (Victorian Department of Sustainability and Environment 2003).

Historically, the lakes have held water for decades without drying and have supported mature fish populations, including large pelagic species such as golden perch (*Macquaria ambigua*) and silver perch (*Bidyanus bidyanus*). Nine fish species have been reported from the lakes, of which five have conservation significance in Victoria and four are listed under the Flora and Fauna Guarantee Act (Victorian Department of Sustainability and Environment 2003), including eel-tailed catfish *(Tandanus tandanus)* and fly-specked hardyhead (*Craterocephalus stercusmuscarum*).

The Flora and Fauna Guarantee Act-listed carpet python (*Morelia spilota metcalfei*) is also associated with the lakes and shelters in hollows of river red gum and black box tree branches and fallen logs. Ten bat species have been recorded in the Hattah–Kulkyne National Park, including the Environment Protection and Biodiversity Conservation Act-listed greater long-eared bat *(Nyctophilus timoriensis).*

Indigenous values

The Hattah Lakes hold great significance to the local Indigenous community. The area lies on the border of two documented language groups, the Latji Latji and the Jari Jari (SKM 2007). Historically, the lakes would have provided an abundant and reliable source of food and water for Indigenous populations. Early observations suggest the area was densely populated in the 1830s and continually occupied until at least

1914 (SKM 2007). The local Indigenous community still maintains strong connections to the land and its traditional resources such as native species used for food and medicine (K. Stewart, pers. comm., 2011).

More than 1,000 Indigenous archaeological sites at the Hattah Lakes have been registered with Aboriginal Affairs Victoria (SKM 2009b). These include burial sites, scarred trees, shell middens, artefact scatters, hearths and other topological sites. Additional sites were recorded during Cultural Heritage Management Plan surveys.

Culturally scarred trees are often a living remnant of traditional Indigenous Australian life and frequently occur along the edges of waterways and wetlands. Many of the scarred trees at the Hattah Lakes are stressed because of lack of flooding and ongoing drought conditions, and are likely to die without intervention. The package of environmental watering works will benefit these scarred trees by providing much-needed water to stressed riparian vegetation communities.

Indigenous Australian water objectives for the Hattah Lakes icon site have not yet been established. However, due to the close link between cultural values/use and the health of the Hattah Lakes, it is predicted that the ecological benefits derived from environmental watering will also result in cultural benefits. The operation of works will generate an overall increase in the condition of waterway and floodplain vegetation health at the Hattah Lakes. In time, this will be linked to an improvement in the condition and abundance of native flora and fauna species at the lakes.

Heritage values

The Hattah–Kulkyne and Murray–Kulkyne parks fall within three former pastoral runs—Kidds Station, Gayfield and Mournpall—all of which were first taken up in 1847 (SKM 2004).

By 1903, the rail line from Melbourne reached Hattah and the link to Mildura was completed the following year (SKM 2004). By 1908, Victorian Railways had constructed a pump station and tank on the southern shore of Lake Hattah to supply steam trains at the Hattah Station west of the icon site. It is thought that a channel linking lakes Lockie and Hattah was cut at the same time to augment the available supply of water (SKM 2004).

As early as 1914, the potential of Lake Hattah for irrigation supply was investigated but found to be inadequate. In general, the lakes have been a major local water source. A bank and regulator were constructed between Lake Hattah and Little Hattah to retain water in the lake and a dam was constructed in the park to supply the Hattah township (SKM 2004).

During the 19th century and much of the 20th century, the country was extensively grazed by sheep and cattle (and rabbits), damaging the natural vegetation and soils. In 1915, a sanctuary was formed (which became Hattah Lakes National Park in 1960) and in 1980 the adjacent Kulkyne State Forest was added to form Hattah–Kulkyne National Park and Murray–Kulkyne Park (Parks Victoria 2010).

Seven sites of significance have been recorded in the Hattah Lakes icon site on the Victorian Heritage Database (Heritage Victoria 2010).

Social and economic values

The Hattah–Kulkyne National Park is a popular destination for tourists, attracting more than 70,000 visitors annually (Victorian Department of Sustainability and Environment 2003). The direct economic value to the Hattah Lakes from recreation and tourism has been estimated at $1.5 million per year (Read & Sturgess, cited in Victorian Department of Sustainability and Environment 2003). Common activities include camping, bushwalking, bird watching and, when the lakes hold water, swimming, kayaking and canoeing.

Visitor numbers are linked to flooding, with tourists attracted to the Hattah Lakes when water is present. Recent visitor statistics are not available; however, anecdotal evidence from Parks Victoria staff indicates visitor numbers have increased significantly (by 50%) since environmental water was pumped into the lakes from 2005–10 (B. Rodgers, pers comm., 2011).

The adaptation of some local businesses to tourism and recreation (i.e. ecotourism ventures) means that an increase in visitor numbers will likely correspond to increased revenue for these businesses and, therefore, an increase in the economic value of the Hattah Lakes from recreation and tourism. This is likely to have flow-on benefits to the broader business base in towns such as Mildura and Ouyen, especially if those with increased revenue spend locally.

In contrast, the indirect economic values provided by the Hattah Lakes include flood control for the surrounding agricultural land and a potential emergency water supply for the Hattah township (NRE 1996, cited in Victorian Department of Sustainability and Environment 2003).

3. Ecological objectives and water requirements

The Living Murray First Step icon site objectives

Based on an understanding of the Hattah Lakes icon site's characteristics and ecological requirements First Step Decision interim ecological objectives were developed and approved by the Murray–Darling Basin Ministerial Council in 2003. Ecological objectives for the icon site include:

- restore healthy examples of all original wetland and floodplain communities
- restore the aquatic vegetation zone in and around at least 50% of the lakes to increase fish and bird breeding and survival
- increase the successful breeding events of colonial waterbirds to at least two years in 10; these species include spoonbills (Threskiornithidae family); little (*Egretta garzetta*), intermediate (*Ardea intermedia*)and great (*A. alba*) egrets; bitterns and night herons (Ardeidae family)
- increase the population size and breeding events of hardyhead (*Craterocephalus stercusmuscarum*), Australian smelt (*Retropinna semoni*), gudgeon (Eleotridae family) and other wetland fish.

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.

In consultation with communities, the First Step Decision objectives that relate to Victorian environmental water management plans have been extended to develop overarching objectives. These overarching objectives better reflect the specific icon site values that the environmental waterings aims to protect, as well as relevant jurisdictional management plans and obligations.

The objectives for the Hattah Lakes environmental water management plan are outlined in **Table 3.1**. In addition to the overarching objectives, more detailed objectives have been developed to guide icon site management. Targets to measure progress towards these objectives are under development for this icon site.

Table 3.1: The vision and refined site-specific ecological objectives for the Hattah Lakes icon site

Vision: *Preserve and where possible enhance the biodiversity values of Hattah Lakes; and restore healthy examples of all original wetland and floodplain communities which represents the communities which would be expected under natural flow conditions*		
Icon site objectives		Targets
Overaching objectives	Detailed objectives	
Vegetation Restore a mosaic of healthy wetland and floodplain communities to maintain the ecological character of the Ramsar site	Restore a mosaic of hydrological regimes, which represent pre-regulation conditions (to maximise biodiversity) Maintain and, where practical, restore the ecological character of the Ramsar site with respect to the Strategic Management Plan (2003) Restore the macrophyte zone around at least 50% of the lakes to increase fish and bird habitat Improve the quality and extent of deep freshwater meadow and permanent open freshwater wetlands so that species typical of these ecosystems are represented	Targets under development
Fish Maintain high quality habitat for native fish in wetlands and support successful breeding events	Increase distribution, number and recruitment of local wetland fish—including hardyhead, Australian smelt and gudgeon by providing appropriately managed habitat Maximise use of floodplain habitat for recruitment of all indigenous freshwater fish	Targets under development
Waterbirds Provide feeding and breeding habitat for a range of waterbird species, including threatened and migratory species Provide conditions for successful breeding of colonial nesters at least twice every ten years	Maintain habitat for the freckled duck, grey falcon and white-bellied sea-eagle in accordance with action statements Increase successful breeding events for colonial waterbirds to at least two years in 10 (including spoonbills, egrets, night herons and bitterns) Provide suitable habitat for a range of migratory bird species (including Latham's snipe, red-necked stint and sharp-tailed sandpiper)	Targets under development

A set of corresponding flow objectives were also developed, based on the water requirements of the floodplain vegetation communities and associated biota. These objectives were developed by scientists with expertise in floodplain and wetland vegetation and ecology and reviewed in light of the water requirements of fish, turtles, waterbirds and frogs.

Water requirements

The hydrological environments of the Hattah Lakes have been classified into water regime classes according to the vegetation communities and aquatic habitat present, their water regimes prior to river regulation (Ecological Associates 2007; see **Figure 3.1**). Water regime classes identify areas of the floodplain with common water regimes and ecological characteristics. The classes provide the basis to establish objectives for the location, extent and condition of components of the floodplain ecosystem, and therefore to set flow objectives.

Targets have been set for flooding duration and frequency to achieve particular ecological objectives and maintain ecosystem health. Ecological vegetation classes, as mapped and described by White et al (2003), have been amalgamated into five floodplain water regime classes and outlined in **Table 3.2** (Ecological Associates 2007). Ecological vegetation classes were amalgamated where there was no strong hydrological basis to treat the botanical differences reported in the ecological vegetation class descriptions separately.

The watering requirements of the Hattah Lakes icon site environmental objectives are outlined in **Table 3.2**.

Table 3.2: Floodplain water regime classes and their component ecological vegetation classes

Water regime class	Component Ecological Vegetation Class[a]
Floodplain vegetation	
Red gum forest	Grassy riverine forest (106)
	Grassy riverine forest/floodway-pond-herb land complex (811)
Fringing red gum woodland	Intermittent swampy woodland (813)
	Shrubby riverine woodland (818)
Red gum with flood-tolerant understorey	Riverine grassy woodland (295)
Black box woodland	Lignum swampy woodland (823)
	Riverine chenopod woodland (103)
Lignum shrublands	Lignum shrubland (808)
	Lignum swamp (104)
Wetland vegetation Ecological vegetation class mapping identifies all major wetlands as lakebed herb land (107). As this does not reflect the variable water regimes, Ecological Associates (2007) classified wetlands as episodic, intermittent, persistent temporary or semipermanent.	

Note
[a] Ecological vegetation class numbers in brackets.

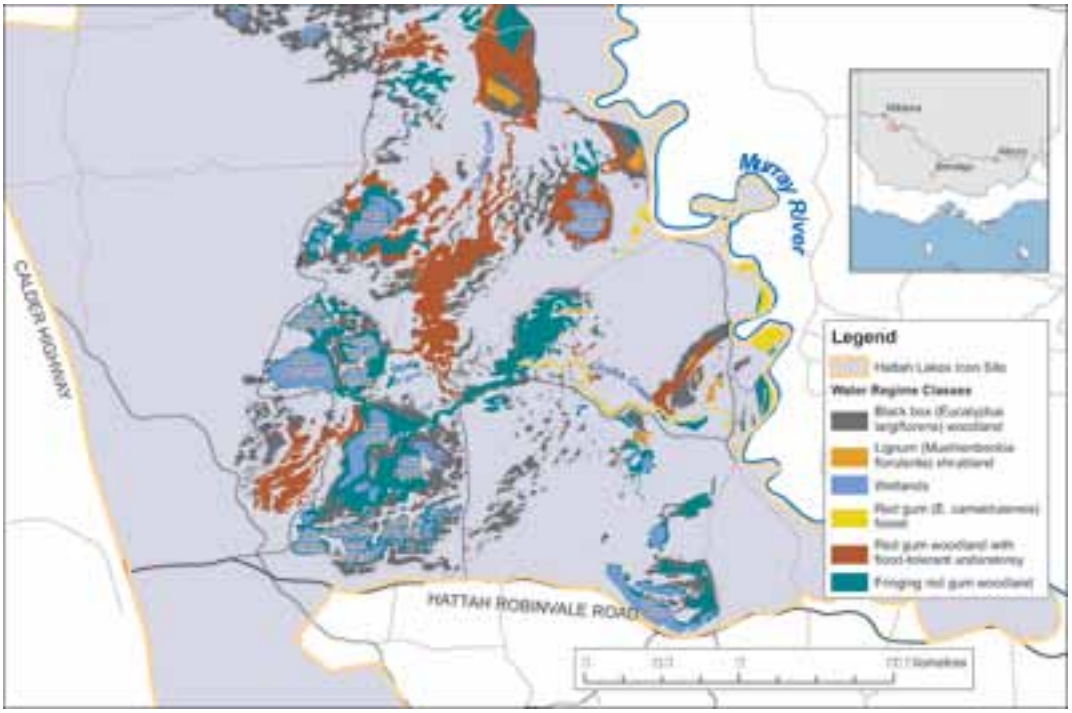

Figure 3.1: Water regime classes (note: all wetland water regime classes are shown as 'wetlands')

Table 3.3: Water requirements for the Hattah Lakes icon site environmental objectives

Required water regime								
Refined ecological objectives[a]	Vegetation community	Flow rate (ML/day)	Duration	Timing	Frequency (years in 10)	Maximum time between events	Works or other mechanisms to assist meeting objectives[b]	Area flooded with works (ha)
Restore a mosaic of hydrological regimes Maintain and restore ecological character of the Ramsar site Restore the macrophyte zone around at least 50% of the lakes Improve the quality and extent of deep freshwater meadow and permanent open freshwater wetlands Maintain habitat for the freckled duck, grey falcon and white-bellied sea-eagle Successful breeding events for colonial waterbirds at least two years in 10 Provide habitat for migratory bird species Increase distribution, number and recruitment of wetland fish Maximise use of floodplain habitat for fish recruitment	Semipermanent wetlands	>37,000	90 days	Winter–spring	6	4 years	Pumping station and regulators/ stop banks	1,127
	Temporary wetlands	>50,000	30 days	Winter–spring	4			
	Episodic wetlands	>150,000	7 days	Winter–spring	1 year in 8	10 years	Pumping station and Kramen regulator	To be confirmed[c]
Restore a mosaic of hydrological regimes Maintain and restore ecological character of the Ramsar site Maintain habitat for the freckled duck, grey falcon and white-bellied sea-eagle Successful breeding events for colonial waterbirds at least two years in 10 Provide habitat for migratory bird species Maximise use of floodplain habitat for fish recruitment	Fringing river red gum	>45,000	60 days	Winter–spring	4–6	7 years	Pumping station and regulators/ stop banks	1,563

Required water regime								
Refined ecological objectives[a]	Vegetation community	Flow rate (ML/day)	Duration	Timing	Frequency (years in 10)	Maximum time between events	Works or other mechanisms to assist meeting objectives[b]	Area flooded with works (ha)
Restore a mosaic of hydrological regimes Maintain habitat for the freckled duck, grey falcon and white-bellied sea-eagle Successful breeding events for colonial waterbirds at least two years in 10 Provide habitat for migratory bird species Maximise use of floodplain habitat for fish recruitment	River red gum woodland (flood-tolerant understorey)	>75,000	30 days	Winter–spring	2–4	7 years	Pumping station and regulators/ stop banks	1,396
Restore a mosaic of hydrological regimes Successful breeding events for colonial waterbirds at least two years in 10 Maximise use of floodplain habitat for fish recruitment	Black box woodland	>120,000	14 days	Winter–spring	1:3	10 years	Pumping station and regulators/ stop banks, Lake Kramen regulator	1,272

Notes

[a] Wording of ecological objectives has been condensed for this table.

[b] Sill lowering in Chalka Creek will be in effect all the time and so is not specified here. This will facilitate inflows at 20,000 ML/d (rather than 37,000 ML/d). Other works are as described in chapter 4.

[c] To be confirmed once designs are finalised for Lake Kramen option.

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.

Current condition

The lack of connectivity between the lakes and the River Murray and the complete drying of the lakes over the past decade has had detrimental effects on the Hattah Lakes ecosystem and its ability to act as a refuge during prolonged drought. The ecological productivity of the system has declined and the habitat value for fauna has been degraded. Recent surveys of river red gum forests along the Victorian River Murray corridor have shown a substantial decline in tree condition over the past two decades, with Hattah–Kulkyne National Park containing the highest proportion of area in poor to severely degraded condition (71%) (Cunningham *et al*. 2009).

These results align with previous surveys undertaken as part of The Living Murray Condition Monitoring Program, which reported a decline in condition for the floodplain vegetation communities at the Hattah Lakes including river red gum, black box and lignum, with the exception of sites that received water from emergency watering programs (Kattel *et al*. 2009). Recent monitoring at the Hattah Lakes indicates that the condition of red gum and black box trees has improved since 2008 (Walters *et al*. 2010). This improvement is likely to be the result of increased annual rainfall for 2007, 2008 and 2009, compared with the preceding six years (Walters *et al*. 2010).

Antecedent hydrological conditions

The floodplain's hydrology has changed substantially as a result of the regulation and diversion of River Murray flows, resulting in a reduction in the frequency and duration of flooding. The last major flood at the Hattah Lakes was in 1993 (Mallee Catchment Management Authority 2010) and there have been no natural inflows to the lakes since 2000. Many of the outlying lakes have not received water since 1996 and floodplain vegetation is in poor health (Kattel *et al.* 2009). Water has been pumped into the central lakes since 2004 to alleviate water stress and, in 2010, into Lake Kramen.

Rainfall

The Hattah Lakes are in a semi-arid environment, with an annual average rainfall of approximately 250 mm. Rainfall data for 2010 at Nulkwyne Kiamal Station (site number 076043), approximately 20 km from the Hattah Lakes, shows that above-average rainfall was received for March, April, May, August, September and October (Bureau of Meteorology 2010). This rainfall should assist in the recovery of the floodplain vegetation communities and improve overall ecosystem health at the icon site.

Climate change

Modelling of the average monthly flow downstream of Euston Weir for modelled pre-development scenario flow, modelled current scenario flow and predicted flow under the CSIRO 2030 median climate change scenario was undertaken as part of the development of the Victorian Northern Region Sustainable Water Strategy (Victorian Department of Sustainability and the Environment 2009). Pre-development flows represent the flows which would occur, based on 118 years of climate records, if there were no storages or diversions from the river.

Late winter and spring flows have been depleted as a result of current river management. Average September flows downstream of Euston Weir dropped from approximately 1930 GL/month under the pre-development scenario to 1070 GL/month under current conditions. Average flows for September are predicted to fall to approximately 820 GL/month by 2030 under CSIRO's median climate change scenario — this is only 42% of pre-development flows. There has been a minor shift in the seasonality of flows with the majority of peaks now occurring in August, one month later than under pre-development conditions.[2]

Under natural conditions, inflows occurred in most years with large flooding events occurring every five years on average. The reduction in River Murray flows has reduced the frequency of inflows to the Hattah Lakes that inundate the surrounding floodplain. **Table 3.4** is an overview of the changes in river hydrology. Under current conditions the frequency and duration of medium and large peaks have been significantly reduced, while the occurrence of low flows (less than the inflow threshold at Chalka Creek) has increased. These impacts are exacerbated under climate change scenarios.

2 REALM output from the Victorian Northern Region Sustainable Water Strategy (Victorian Department of Sustainability and Environment 2009) for Scenario B—based on CSIRO medium climate change predictions in RN Jones and PJ Durack, *Estimating the impacts of climate change on Victoria's runoff using a hydrological sensitivity model* (CSIRO Atmospheric Research, Melbourne, 2005).

Table 3.4 Frequency of key flows under various scenarios

River flow (GL/d)	Flood count (% of years with flow peaks above threshold)			Effective flood (% of years flow exceeds the threshold for at least three months)		
	Modelled pre-development	Modelled current	Median climate change scenario at year 2030	Modelled pre-development	Modelled current	Median climate change scenario at year 2030
40	82	47	37	48	20	11
60	59	31	22	21	7	3
75	47	23	12	16	7	3
100	36	12	8	19	8	4
150	18	6	2	4	2	1

Note: current inflow threshold of Chalka Creek South is 37,600 ML/d.

The frequency and duration of events that inundate the floodplain have been similarly depleted. Under current and 2030 medium climate change scenarios, floods are significantly less frequent and the longest spell between events is significantly greater than the pre-development (natural) scenario.

Past management actions and activities

Originally proclaimed as unreserved Crown land, the Hattah Lakes area has, over the years, been subject to various land uses—including grazing and logging—which have endangered its national status as an important conservation area. Other uses included beekeeping and gravel extraction (B. Rogers, pers comm., 2011).

Grazing and logging

As early as 1847 the area was grazed under lease and used for forest products. With the dedication of the Kulkyne State Forest in 1924, forestry became its prime purpose, although grazing continued. Sawlogs, sleepers and timber for farm use were removed.

Sheep grazing ceased in 1953 but limited cattle grazing continued until 1974. The Kulkyne area had the worst rabbit infestation on Crown land in Victoria, while goats and kangaroos have also degraded native vegetation. Feral goats are currently managed through trapping and opportunistic shooting (Victorian Department of Sustainability and Environment 2003).

Scientific research

Kangaroos

Research on kangaroo populations is being conducted in the Hattah–Kulkyne National Park to minimise the impact of kangaroos on the natural values of the park, particularly on vegetation cover and diversity. Native vegetation responses to kangaroo grazing pressure have been studied in the park since 1984, with kangaroo counts and vegetation monitoring occurring around the lakes (Victorian Department of Sustainability and Environment 2003). The kangaroo population is being managed to ensure the return of native vegetation cover and floristic diversity.

Rabbits and foxes

Hattah–Kulkyne National Park was involved in the national monitoring program to gauge the impact of the calicivirus release on the biodiversity assets affected by rabbits. Similarly, the park is involved in a fox adaptive experimental management program to determine the most effective strategy for fox control (Victorian Department of Sustainability and Environment 2003).

Environmental watering

The reduced frequency of flooding means that pumping has become a necessary management intervention to inundate the lakes in the current regulated conditions. Emergency environmental water has been pumped into the lakes on six occasions since 2005 to maintain existing river red gum communities and provide drought refuge.

Key benefits of the environmental watering were the exclusion of carp from the system, the steady introduction of native fish species and the immediate return of aquatic vegetation (Mallee Catchment Management Authority 2010). The response of river red gums to multiple watering events was extremely positive, as outlined in the condition monitoring report (Walters *et al*. 2010). As a result of these benefits, environmental watering is expected to remain an important long-term management intervention for the Hattah Lakes icon site (MDBC 2006).

4. Water delivery

Prioritising 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 TLM's environmental water portfolio.

The environmental watering priorities at the Hattah Lakes will be assessed annually based on the condition of the various water regime classes. The classes of the Hattah Lakes system were prioritised according to their conservation significance and the degree to which their water requirements are threatened (Ecological Associates 2007). The priority of water requirements from highest to lowest is:

- semipermanent wetlands
- persistent temporary wetlands
- fringing red gum woodland
- red gum flood-tolerant understorey
- lignum shrublands, temporary wetlands, black box woodlands and episodic wetlands.

The benefits of flooding lakes and their surrounding floodplain are linked and it is desirable to apply options that inundate woodlands surrounding the wetlands.

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 sites for Hattah Lakes	Semipermanent wetlands	Persistent temporary wetlands Semipermanent wetlands	Wetlands Fringing river red gum woodland River red gum forest with flood-tolerant understorey	Wetlands Temporary wetlands Black box woodland Fringing river red gum woodland River red gum forest with flood-tolerant understorey

The Living Murray 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 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 Living Murray's Water Portfolio, there may also be other sources of environmental water available to meet the proposed regimes.

Proposed and agreed works

The overall aim of the Hattah Lakes works is to provide a watering regime that contributes to meeting the ecological objectives. This will be achieved by a program of on-ground works (see **Figure 4.1**) that will increase the frequency, duration and extent of flooding in the lakes by:

- lowering the high points (sills) in Chalka Creek, to increase the frequency and duration of natural inflows, which would facilitate small flooding events
- pumping water from the River Murray to top up natural floods and fill the lakes during long dry periods to increase the frequency and extent of flooding
- using regulators and stop-banks to capture naturally occurring floods to increase the duration of flood events; water could be released to the river when the required flooding duration has been met.

The works will be used in conjunction with natural high flows to flood the lakes and fringing river red gum once every three years. This will maintain more than 1000 ha of wetland habitat for fish, frogs, turtles and waterbirds. Large floods will be provided once every eight years to water drier river red gum communities and black box woodland. Lake Kramen, an episodic wetland, will be flooded at a similar frequency (one year in eight).

Overall, the works will enable 5,583 ha to be watered across the icon site. The area of inundation has been determined using the Hattah Lakes hydraulic model and vegetation mapping.

Concept designs have been prepared for the package of works and an investment proposal was approved by the MDBA in March 2010. This provides funding for the development of detailed designs. Information about the proposed works is provided below, with further details outlined in the Hattah Lakes Environmental Flows Project Investment Proposal (Mallee Catchment Management Authority 2010) and the Concept Design Report (GHD 2009b). Figure 4.1 outlines the location of the proposed works.

Figure 4.2 illustrates the inundation extent that can be achieved through the proposed on-ground works.

Once constructed, works will be managed to achieve the ecological objectives by replicating characteristics of the natural hydrology of the River Murray. The project involves the works outlined in **Table 4.2** as well as some ancillary works required during construction.

Table 4.2: Description of TLM water management works: Hattah Lakes

Works	Function
Pumping station at Messengers Crossing	The pumping station will be used to deliver water to the floodplain in the absence of sufficient natural inflows. Pumping is required because of the height difference between the Chalka Creek entrance and current water levels in the river. The pumps will have sufficient capacity to replicate natural flooding events to a peak of 45 m Australian height datum (AHD) at a rate of rise and fall that matches natural flood peaks. The pumps will also be used to top up natural inflows, maximising environmental benefits and optimising the use of environmental water.
Sill lowering in Chalka Creek South	Lowering sills in the creek to 41.75 m AHD will reduce the inflow threshold from 37,600 ML/d to 20,000 ML/d, increasing the frequency of natural inflows. This will allow inflows to occur 24% of the time, compared with 13% of the time at the current sill level (under historic flows).
Messenger's Regulator	This regulator will be designed to allow fish passage and return flows to the River Murray. The regulator will also prevent water returning to the river during managed flood events, as the pump station (see below) will deliver water from the River Murray to Chalka Creek upstream of the new Messengers Regulator. The proposed regulator will remain open to allow inflows during natural flood events. It will also contribute to the drawdown of the floodplain in large, managed flood events and will have a release capacity of 750 ML/d.
Oatey's Regulator	This regulator will control outflows from the lakes region via Chalka Creek north and retain water to the target level of 45m AHD. The regulator will be closed to enable filling of the lakes, either for a planned flooding event or to enhance a natural flooding event. This regulator will be the principal release point from the flooded area to the River Murray and will have a regulated release capacity of 1,250 ML/d.
Cantala Regulator	This regulator will be operated to promote filling of the lakes by preventing water from the flooded area to the west draining to the River Murray. Regulator gates will usually be open to allow inflows from the River Murray, and will only be closed during planned flooding events to attain the desired inundation level of 45 m AHD. No releases to the River Murray are planned at this location due to the steep return path to the river and the likelihood of erosion.
Little Hattah Regulator	This will be a minor refurbishment of an existing regulator between Lakes Little Hattah and Lake Hattah. It will retain its original function to control levels of water between the two lakes.
Kramen Creek Regulator and associated works	Investigations are underway to confirm the scope of works and develop detailed designs. It is anticipated that one small regulator would be constructed on the alignment of the Chalka Creek Track to allow natural floods to flow into Kramen Creek and prevent water flowing back into Chalka Creek.
Breakout Stop Bank	This stop bank will prevent uncontrolled escape of water from Chalka Creek to the River Murray across low lying floodplain prior to reaching the target inundation level of 45 m AHD.
Bitterang Stop Bank	This stop bank will retain water in the target inundation area by preventing flow to Lake Boolca and the Dry Lakes to the north of Lake Bitterang during maximum inundation pumped events.
Cantala Stop Bank	This stop bank will prevent uncontrolled draining of water to the River Murray via Cantala Creek.
Rock beaching at the exit point at the northern end of Chalka Creek	This will prevent erosion during outflows from Oateys Regulator via Chalka Creek North.

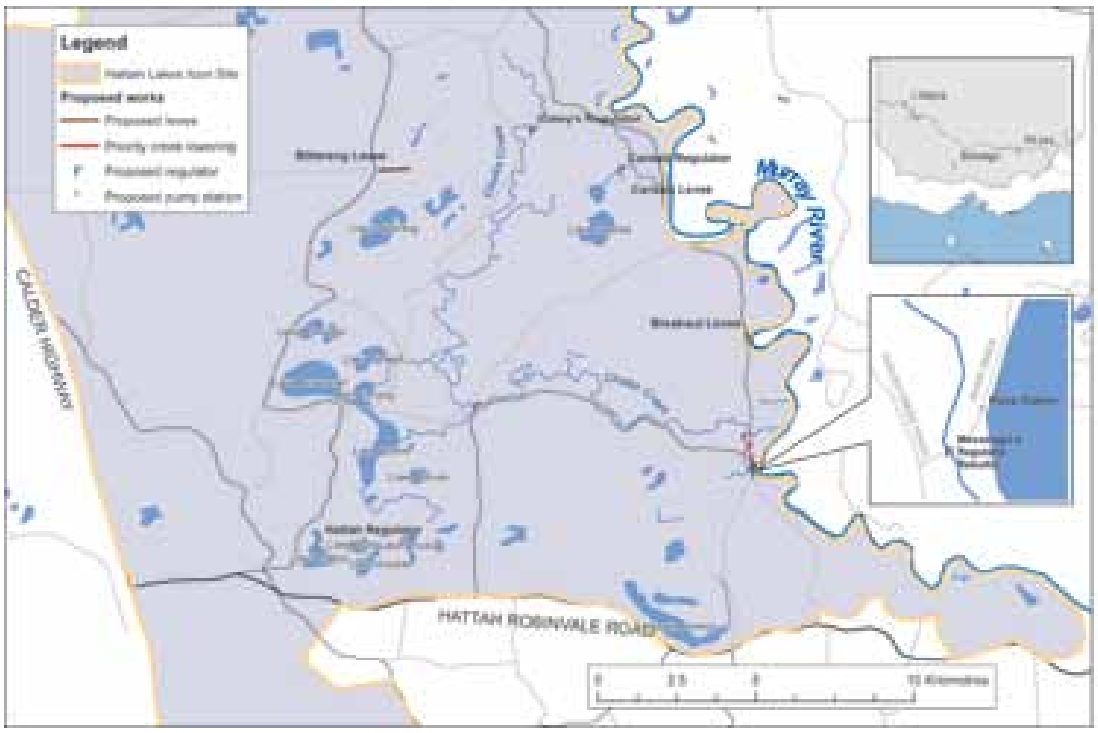

Figure 4.1: Proposed on-ground works at the Hattah Lakes

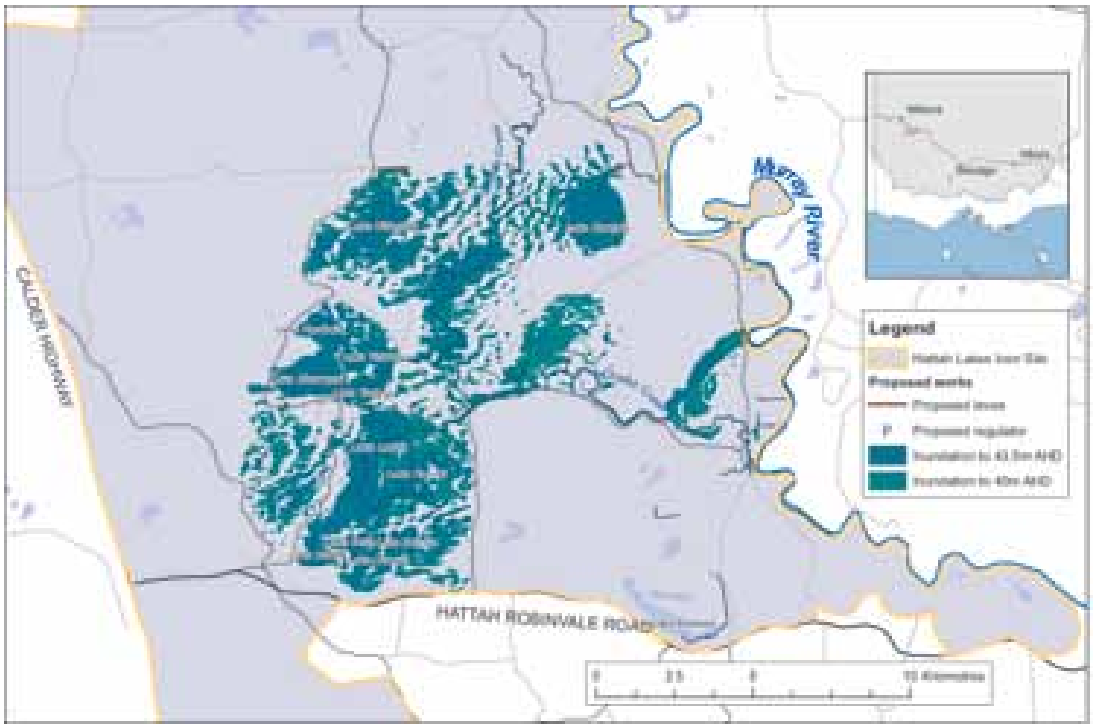

Figure 4.2: Extent of flooding that could be achieved with the proposed works: 2,592 ha at 43.5 m AHD and 5,583 ha at 45 m AHD

Operating regimes for environmental watering actions

A preliminary operating strategy was developed for the project's investment proposal (Mallee Catchment Management Authority 2010). This strategy outlines the likely operation of the structures under various scenarios. A more detailed operating strategy will be developed during the detailed design phase of the project, along with an operating manual for each structure on its completion. These will be included as Schedule 1 in the environmental water management plan when it is finalised.

As described earlier, the works can be operated in various ways to achieve specific flow objectives, managing the duration of flooding at target elevations. In general, the works will be operated to provide low-level flooding approximately one year in three (targeting wetlands and fringing river red gums) and large floods one year in eight (targeting river red gums with drought-tolerant understorey and black box). Intermediate levels will also be targeted, depending on the frequency, duration and magnitude of recent river flows, and the condition of floodplain vegetation.

Three primary watering actions have been developed to achieve the ecological objectives that have been set for the Hattah Lakes:

- inundation to 43.5 m AHD once every three years to flood lakes, waterways and fringing vegetation
- inundation of the surrounding floodplain to 45 m AHD once every eight years
- inundation of Lake Kramen and surrounding floodplain vegetation once every eight years.

As the works will be used to fill the lakes and water floodplain vegetation during long dry periods, as well as to augment natural floods, there are a number of potential operating scenarios (see **Table 4.2** for a detailed description of how the regulators and pump station would be operated):

- Increase frequency of natural inflows: sill lowering in Chalka Creek will reduce the commence-to-flow threshold from 37,600 ML/d to 20,000 ML/d.
- Extension of a natural flood: closing regulators on the flood recession to retain water on the floodplain.
- Enhancement of a natural flood: using pumps to top up a natural flow peak and closing regulator to retain water on the floodplain.
- Managed inundation event with all flows delivered by pumping: closing regulators and pump to desired elevation.
- Unmanaged inundation event with all structures open to allow a large natural flooding event to enter the site and recede without retention: all regulators open for the duration of the flood.

Table 4.3: Potential operating scenarios

Scenarios	Regulator and pump station operation	Outcome
Natural flood event—no management intervention	All regulators open. Stop banks overtopped if flood peak exceeds 45 m AHD with an additional .5 m freeboard.	Inflows commence once river flows > 20,000 ML/d. Lake hydrograph will mimic that of the river; inundation duration and extent will depend on duration and height of flow peak. Inflows cease once river level drops below water levels on the floodplain; flood recession commences. Water retained in wetlands once flood has receded. No impact on natural extent or duration of flooding. No environmental water used.
Natural flood event—extend duration	All regulators open to allow inflows. Oatey's and Messenger's regulators closed on the flood recession to prolong inundation. Little Hattah Regulator remains open. Oatey's and Messenger's regulators opened to allow outflows once target duration has been reached.	Inflows commence once river flows > 20,000 ML/d. Maximum flood extent will depend on height of flow peak. Closing regulators increases the duration of inundation at target levels, by retaining water after peak flows in the river have passed. No impact on natural extent of flooding; flood duration is increased. Environmental water use = additional seepage and evaporation losses due to increased duration (modelled).
Enhanced natural flood event—increase extent and duration	All regulators open to allow inflows. Oatey's and Messenger's regulators closed once natural flood peak has passed. Little Hattah Regulator remains open. Pumping commences to increase flood extent. Pumping ceases once target elevation has been reached. Regulators opened to allow outflows once target duration has been reached.	Inflows commence once river flows > 20,000 ML/d. Pumping will increase the extent of inundation to the target level. Closing regulators increases the duration of inundation at target levels, by retaining water after peak flows in the river have passed. Extent and duration of flooding is increased. Environmental water use = volume pumped into the lakes + additional seepage and evaporation losses because of increased duration (modelled).
Pumping from dry—increase frequency of inflows	Oatey's and Messenger's regulators closed. Pumping commences. Pumping ceases once target elevation is reached. Regulators opened to allow outflows once target duration has been reached.	Pumps are used to fill the lakes in the absence of natural floods, increasing the frequency of inundation. Regulators and stop banks allow target levels to be reached and increase the duration of inundation at these levels. Frequency of flooding is increased. Environmental water use = volume pumped into the lakes.
Topping up lakes—increase frequency of higher elevation floods	Oatey's and Messenger's regulators closed. Pumping commences. Pumping ceases once target elevation is reached Regulators opened to allow outflows once target duration has been reached.	Pumps are used to increase the extent and frequency of inundation at higher levels (i.e. greater than lake retention level). Regulators and stop banks allow target levels to be reached and increase the duration of inundation at these levels. Frequency of flooding at higher elevations is increased; extent of flooding is increased. Environmental water use = volume pumped into the lakes.

Water use

The operating strategy, which aims to deliver on the ecological objectives, will mimic the natural seasonality of flooding and inundation of the lakes between August and November. Water will be delivered to the system via natural inflows or pumping.

Water use at the site will vary from year to year depending on natural inflows and previous flooding history. **Table 4.4** summarises the annual water use of each operational scenario. To meet ecological objectives, wetlands and fringing river red gums will require inundation to 43.5 m AHD approximately once every three years. This will require approximately 41 GL of water. The amount of environmental water used will depend on whether any natural inflows occur.

Inundation to 45 m AHD to water the floodplain is required approximately once every eight years. Inundating the floodplain in a fully managed event (excluding Lake Kramen) will require 106 GL, of which 54 GL will be returned to the River Murray.

Water would also be delivered to Lake Kramen at a similar frequency. Preliminary modelling undertaken by the Murray–Darling Basin Authority suggests approximately 13.5 GL of water would be needed to inundate over 800 ha of wetland and floodplain vegetation. All water would be retained in the lake and would naturally evaporate.

As outlined in **Table 4.5**, the preferred operating scenario will water wetlands, fringing river red gum woodland, river red gum woodland and black box woodland at recommended frequencies. The benefits include breeding and foraging habitat in wetlands and fringing river red gum woodland being provided for waterbirds; habitat being provided for frogs and turtles in permanent and temporary wetlands; and large areas of black box woodland maintained.

In contrast, the minimum operating scenario no longer targets black box woodland for watering and reduces the area of red gum communities that is watered.

Table 4.4: Estimated water use of the operating strategy

Elevation (m, AHD)	Frequency	Volume per event (GL)	Volume per year (GL)	Net water use per event (GL)	Net water use per year (GL)
43.5	1:3 years	41	14	41	14
45	1:8 years	106	14	52	6.5
Lake Kramen	1:8 years	13.5	1.7	13.5	1.7
Combined net annual water use					**22.2**

Table 4.5: Operating regimes contribution to the ecological objectives

Refined ecological objectives	Vegetation community area inundated (ha)	Works or other mechanisms to assist meeting objectives	Frequency	Water availability scenario	Duration of water delivery	Estimated volume required per event (GL)	Estimated volume used per event (GL)
Preferred operating scenario							
Restore a mosaic of hydrological regimes Maintain and restore ecological character of the Ramsar site Restore the macrophyte zone around at least 50% of the lakes Improve the quality and extent of deep freshwater meadow and permanent open freshwater wetlands Maintain habitat for the freckled duck, grey falcon and white-bellied sea-eagle Successful breeding events for colonial waterbirds at least two years in 10 Provide habitat for migratory bird species Increase distribution, number and recruitment of wetland fish Maximise use of floodplain habitat for fish recruitment	Semipermanent and temporary wetlands (1,127 ha) Fringing river red gum (1,563 ha)	Sill lowering enables inflows at >20,000 ML/day Pump station used to fill lakes to 43.5 m AHD Regulators/stop banks used to retain water to 43.5 m AHD	1 year in 3	Dry, median	84 days	41	41
	River red gum woodland (flood-tolerant understorey) Black box woodland	Pump station used to fill lakes to 45 m AHD Regulators/stop banks used to retain water to 45 m AHD	1 year in 8	Median, wet	112 days	106	52
	Episodic wetlands (190 ha) Fringing river red gum (Area TBC[a]) Black box woodland (Area TBC[a])	Pump station used to pump water into Kramen Creek Kramen regulator closed to prevent draining back into Chalka Creek	1 year in 8	Dry-wet	90 days	14	14
Minimum operating scenario							
Restore a mosaic of hydrological regimes Maintain and restore ecological character of the Ramsar site Restore the macrophyte zone around at least 50% of the lakes Improve the quality and extent of deep freshwater meadow and permanent open freshwater wetlands Maintain habitat for the freckled duck, grey falcon and white-bellied sea-eagle Successful breeding events for colonial waterbirds at least two years in 10 Provide habitat for migratory bird species Increase distribution, number and recruitment of wetland fish Maximise use of floodplain habitat for fish recruitment	Semipermanent and temporary wetlands (1,127 ha) Fringing river red gum (1,563 ha)	Sill lowering enables inflows at >20,000 ML/d Pump station used to fill lakes to 43.5 m AHD Regulators/stop banks used to retain water to 43.5 m AHD	1 year in 3	Dry, median	84 days	41	41
	River red gum woodland (flood-tolerant understorey) Area TBC[a]	Pump station used to fill lakes to 44 m AHD Regulators/stop banks used to retain water to 44 m AHD	1 year in 8	Median, wet	Variable	57	57
	Episodic wetlands (190 ha) Fringing river red gum (Area TBC[a]) Black box woodland (Area TBC[a])	Pump station used to pump water into Kramen Creek Kramen regulator closed to prevent draining back into Chalka Creek	1 year in 8	Dry-wet	90 days	14	14

Notes

[a] To be confirmed once designs are finalised for Lake Kramen option.

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.

In the absence of natural high flows in the River Murray, environmental water will be used and accounted for. Potential sources of environmental water that could be used at the Hattah Lakes include:

- the Victorian Murray flora and fauna environmental entitlement (27.6 GL)
- shared environmental water recovered through the MDBA's The Living Murray Initiative
- water recovered through the Australian Government's Restoring the Balance water purchase program
- River Murray Unregulated Flows (RMUF).

Evaluation and management of potential risks

While reinstating regular flooding will have enormous ecological benefits for the Hattah Lakes, there will be risks associated with environmental water delivery that may require management. The Hattah Lakes risk management plan is currently under development and will be included as Schedule 2 of the environmental water management plan once finalised.

Salinity and groundwater

A detailed semi-quantitative analysis of the potential salinity impacts of the proposed operational scenarios has also been completed. This assessment concluded that a major salinity impact on the River Murray, the Hattah Lakes or surrounding floodplain is unlikely to occur and outlines a monitoring program to verify this (SKM 2009a).

The Victorian Department of Sustainability and Environment proposes to develop and implement a program to monitor surface flows and the response of groundwater to TLM environmental watering actions across all Victorian icon sites. This will allow a more robust assessment at the time of the mandated five-year review. The department will provide advice to the MDBA regarding the salinity impact of the proposed works in a form consistent with the requirements of Schedule B of the Basin Salinity Management Strategy Salinity Register and the protocols described in the *Water Act 2007* (Cwlth).

Other water quality issues

Eutrophic conditions may develop in the lakes after flooding, particularly in larger events when the adjacent floodplain is also inundated. This is not considered a key risk as blue-green algal blooms are common at the Hattah Lakes following natural floods. While blue-green algal blooms have resulted in the occasional closure of some lakes to recreational activities, these blooms are a natural phenomenon in floodplain ecosystems and Parks Victoria does not consider that active management is necessary.

Parks Victoria undertakes responsibilities under the Victorian Government's framework to manage the public health risk associated with blue-green algal blooms and will undertake frequent monitoring of algal concentrations during blooms. In the event of a bloom, cautionary signage is posted around affected lakes to alert the public. Regular flooding is also likely to reduce the incidence of algal blooms, because this will promote the establishment and expansion of aquatic vegetation, which competes with algae for nutrients and can assist in keeping algal populations at low levels.

Blackwater events may occur following floodplain inundation because of the breakdown of leaf litter and terrestrial vegetation by bacteria, which releases nutrients into the water. This can result in de-oxygenation of the water column and increase the risk of algal blooms. This is not considered a significant risk associated with the works, as blackwater events are a natural process. Operation of managed and natural watering events may actually reduce the incidence of blackwater events by restoring more frequent floods to the system and reducing the accumulation of leaf litter and nutrient loads between inundation events.

Erosion risks

Erosion of the Chalka Creek bed may occur but is likely to be minimal because of the bed's shallow grade. As such, localised erosion control works at the site of the regulators and the pump station outlet, and some flow training at selected locations along Chalka Creek, will provide excellent protection against erosion because of pumping. Details of this proposal can be found in the Concept Design Report (GHD 2009b).

Returning water to the River Murray following inundation flood events provides another potential cause of erosion. The Concept Design Report (GHD 2009b) also provides detailed hydraulic modelling of the velocities likely to be encountered under these conditions. The Cantala Regulator will not be operated to return flows to the River Murray because of the significant erosion risk—rather Messengers and Oateys regulators will be used. Each regulating structures will be beached with suitable material to minimise the risk of erosion.

The Cultural Heritage Management Plan identifies only one burial site that may be subject to inundation and therefore erosion via wave action. The plan recommends that this site be protected to prevent damage to it during flood events.

Pest plants

Operation of the works may provide a greater opportunity for pest plant invasions to occur on the floodplain. However, floodplain watering will occur no more frequently than it would have under natural conditions. Parks Victoria routinely monitors and manages pest plants in the Hattah–Kulkyne National Park, and develops and implements control programs as required. In a recent survey of the park (GHD 2009a), 53 introduced vascular plant species were recorded. In general, pest plants recorded at the Hattah Lakes can be divided into two categories (see **Table 4.6**).

Pest animals

Pest fish species recorded at the Hattah Lakes include common carp (*Cyprinus carpio)*, brown trout (*Salmo trutta*), goldfish (*Carassius auratus auratus*), tench (*Tinca tinca*), redfin (*Perca fluviatilis*) and mosquitofish (*Gambusia holbrooki*). These species are able to adapt quickly to changed environmental conditions, allowing them to establish quickly. This can lead to changes in species composition and exclusion of native species (SKM 2004).

Carp and other exotic fish will be able to enter the Hattah Lakes during natural flooding events when Messengers Regulator is open. This is currently the case and the proposed works are unlikely to alter the situation.

During a 'pumping only' flood event, large fish will not be able to pass through the pumps, so only small carp will enter the lakes system. This may allow aquatic native flora and fauna to establish and reproduce to sustain these native fish populations in the long term.

The adverse environmental impacts of carp on river and wetland ecosystems are well documented. There are currently no effective large-scale control or eradication measures, other than drying the lakes, which can be applied to reduce the impact of pest fish on the Hattah Lakes.

The major terrestrial pest animals are rabbits and kangaroos. An intensive program of grazing management has been required since declaration of the national park in 1980. Rabbit numbers are maintained at low levels through a combination of conventional control works and through the use of rabbit haemorrhagic disease virus. Kangaroo densities have been actively managed since 1992. A number of other pest animal species are present at Hattah Lakes, including foxes, pigs, goats, cats and European honey bees.

The reinstatement of more frequent flooding regimes through the Hattah Lakes is likely to provide and maintain more favourable conditions for many terrestrial animal pests, particularly pigs. Management of pigs and other pest animals will be addressed by Parks Victoria as required.

Table 4.6: Pest plants recorded at the Hattah Lakes (Victorian Department of Sustainability and Environment 2003)

Agricultural weeds	Environmental weeds
Thorn apple (*Datura stramonium*)	Horehound (*Marrubium vulgare*)
Field dodder (*Cuscuta* spp. *Campestris*)	Bridal creeper (*Asparagus asparagoides*)
Noogoora burr (*Xanthium strumarium* includes *X. occidentale* and *X. orientale*)	Common thornapple (*Datura stramonium*)
Bathurst burr (*X. spinosum*)	Paterson's curse (*Echium plantagineum*)
	Tree tobacco (*Solanum mauritianum*)
	Olive (*Olea europaea*)
	Various introduced annual grasses

Excessive flood durations

Appropriate water regimes have been defined for each water resource class in terms of maximum and minimum frequencies and durations of flooding that are required to sustain the vegetation species and associated biota (Ecological Associates 2009).

Frequency of flooding of water regime classes will be managed by complementing natural flooding, with pumping to augment natural floods or to provide the whole of a flooding event where the system has been dry for a period exceeding that required to maintain water regime classes in healthy condition. Once the desired duration of inundation is achieved, water will then be released back to the river through regulators at Messenger's and Oatey's.

The regulator structures will be designed so they do not impede natural inflows or outflows. When required the regulators will be used to hold water in the system to extend the duration of inundation.

Duration of flooding within the water regime classes will need to be managed to ensure that adequate duration of inundation can be achieved, and so that the duration of inundation does not exceed the physiological tolerances, beyond which the floodplain vegetation communities become unsustainable.

Flooding of wetland water regime classes can be managed by allowing them to naturally recede through (mainly) evaporation after an inundation event. Excessive duration of inundation only becomes a potential risk once flood elevation exceeds the retention level of the lakes and creek system, and begins to encroach into the vegetation fringing the wetlands at approximately 43 to 43.5 m AHD.

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 (Murray–Darling Basin Commission 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 3**). 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 Murray–Darling Basin Authority (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 Mallee Catchment Management Authority is responsible for all ecological monitoring under The Living Murray program at the Hattah Lakes icon site. A condition monitoring program has been prepared for the site (Wallace 2009) that has been designed to assess the overall condition of the icon site, based on the condition of fish and waterbird populations, and floodplain vegetation communities (see **Schedule 3**). **Table 5.1** outlines the conditioning monitoring program based on the three categories (A, B and O) described above.

Table 5.1: Hattah Lakes Monitoring Plan program

Category A—The Living Murray methods	
Bird	Event-based ground waterbird surveys
	Quarterly waterbird ground assessment
	Annual waterbird aerial assessment
	Annual waterbird ground-truthing assessment of aerial results
Fish	Annual fish surveys
Vegetation	Stand condition monitoring
	River red gum and black box tree condition assessment
Category B—Icon site methods	
Birds	Quarterly bush-bird ground assessment
Fish	Additional fish surveys (for small fish)
Vegetation	River red gum and black box distribution
	River red gum and black box tree condition
	River red gum and black box age, structure and recruitment
	Wetland and floodplain vegetation assemblages
	Lignum and cumbungi (*Typha* species)
Category O—Other methods	
Gauge boards	Flood extent assessment
Groundwater bores	Groundwater levels and salinity

At present, the site-specific ecological objectives for Hattah Lakes do not provide specific, measurable, achievable, realistic and time bound (SMART) targets, so reporting on ecological targets is generally not possible (Wallace 2009). In the interim, while site-specific ecological targets are being developed, reporting will focus on the specified ecological objectives by reporting against the variables identified in the outcomes and evaluation framework—that is, species diversity, spatial distribution, relative abundance and age structure (Wallace 2009).

More detailed monitoring may be required during the first few managed watering events, following completion of the proposed works. The existing condition monitoring program should provide sufficient information about the resulting ecological outcomes, but real-time monitoring of a range of parameters to identify and manage risks will also be needed.

In addition, under Victoria's Native Vegetation Framework, which aims to achieve a net gain in the extent and condition of native vegetation across the state, it has been agreed that any native vegetation clearing associated with The Living Murray can be offset using measured improvements in the condition of the areas watered by the works. This policy recognises that significant biodiversity gain will occur through large-scale environmental watering, but requires implementation of a monitoring program across proposed offset sites to demonstrate the maintenance, or improvement, of vegetation condition.

Intervention monitoring

To improve icon site management and enhance ecological outcomes, intervention monitoring investigates the links between environmental watering, works and measures, and ecological outcomes. Intervention monitoring targets environmental watering events that will inform key knowledge gaps and ecological questions. These results can be applied to other icon sites with similar ecological communities, hydrology and processes.

Groundwater monitoring

In addition to monitoring ecological outcomes and risks, groundwater and salinity monitoring will need to be undertaken, to provide information for Schedule B of the Basin Salinity Management Strategy (BSMS) Salinity Register. Additional groundwater bores will be installed during 2010–11 to facilitate groundwater monitoring.

6. Community consultation and communication

Community support for activities delivered under The Living Murray (TLM) at the Hattah Lakes icon site depends on effective engagement with a range of stakeholders. Engagement focuses on ensuring that the community is informed of the context, history, proposed processes, constraints and opportunities for water management at the icon site. In turn, this will enable the community to engage effectively in decisions about water management and ensure that community values and knowledge are considered in decision-making where possible. The Community Reference Group established for the icon site plays a key role in this process by providing advice on the most appropriate methods of engagement.

Ongoing communications and community engagement activities over recent years have been successful in building and maintaining community support for environmental watering at the Hattah Lakes.

A communication and community engagement strategy for the Hattah Lakes has been developed (Regional Development Company 2010—see **Schedule 4**). The strategy takes a proactive approach to engaging with the community to ensure that it is effectively informed of the TLM project proposed for the Hattah Lakes. Preliminary activities implemented as part of the strategy suggest that the local community is generally supportive of the project. One of the key objectives of the plan is to ensure interested community groups and individuals are kept well informed about the project and its progress and development.

Engagement to date has primarily involved visits to the Hattah Lakes and attendance at meetings in surrounding townships to discuss the proposed works. Additional communication activities are planned throughout the life of the project.

Broader community engagement has occurred through newspaper articles, fact sheets, radio broadcasts and distribution of a documentary DVD that details the value of the Hattah Lakes, its threats and potential for restoration through the TLM program. Appendix D outlines the communication material that has been developed and distributed to date for the Hattah Lakes icon site.

Community input into the Hattah Lakes Environmental Water Management Plan has occurred via the Community Reference Group (for details of this group, see **Appendix A**). Implementation of the plan will be communicated to relevant stakeholders on an ongoing basis through activities outlined in the communication and engagement strategy.

7. Indigenous engagement

Indigenous 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 Indigenous values and objectives in its environmental water planning and management. As Indigenous 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.

Indigenous engagement is a key part of the Hattah Lakes project. The Living Murray Indigenous Facilitator assists the project team in ensuring the local Indigenous community is fully engaged, involved and informed. This is critical to ensuring the success of TLM, particularly as there are a number of groups involved.

A cultural heritage management plan has been developed under the *Aboriginal Heritage Act 2006* (Vic.) to manage potential impacts to cultural heritage values during the construction and operation of the structures. The cultural heritage management plan was developed in close association with local Indigenous groups that are either Native Title claimants or Registered Aboriginal Party applicants (Latji Latji peoples, Tati Tati Traditional Owner Group, Robinvale Aboriginal Community Native Title Claimant Group, Nyeri Nyeri/Wergaia). Numerous information days and briefings have been held with Indigenous groups to build a solid working relationship and promote a common understanding of TLM and its progress.

Development of the final complex cultural heritage management plan (plan ID: 10455) was submitted to Aboriginal Affairs Victoria and approved by the Secretary of the Victorian Department of Planning and Community Development on 25 March 2010. With the recent addition of Lake Kramen to The Living Murray works program at Hattah, additional cultural heritage surveys will be required and a new cultural heritage management plan will be developed.

8. Adaptive management and reporting

An adaptive approach is critical in managing water-dependent ecosystems because it enables land managers and policymakers 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 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.

Adaptive management

A close relationship is required between water management and monitoring to ensure that the system is operated to optimise ecological outcomes and minimise environmental risks.

Management of environmental water delivery at Hattah Lakes will occur adaptively in line with the following process (**Figure 8.1**).

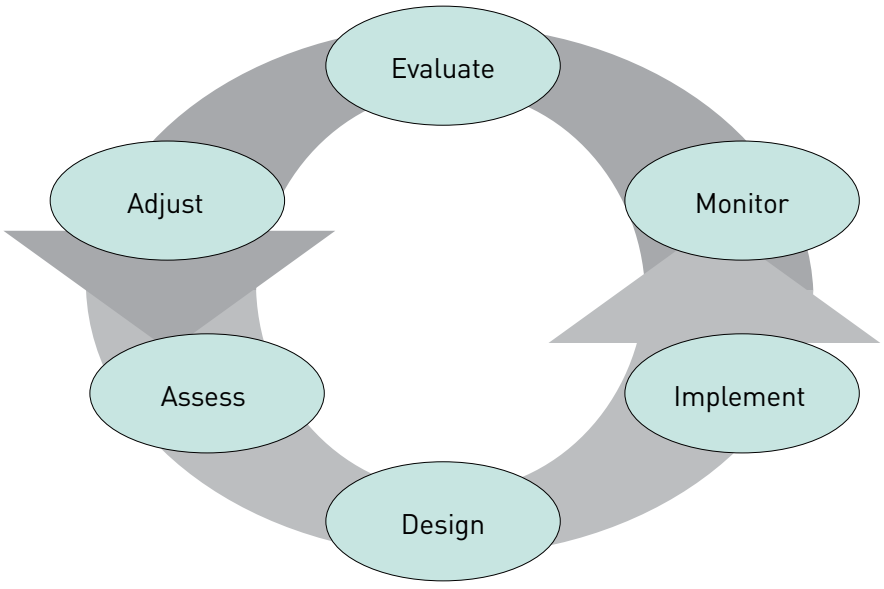

Figure 8.1: Adaptive management cycle

Assess

The ecological issues, objectives, water requirement, priority areas and actions, and associated risks for restoring the floodplain are assessed. This stage requires community and expert input.

Design

Knowledge on floodplain condition and ecology are used to develop hypotheses in terms of expected responses and set objectives and targets. Interventions are designed, including the proposed package of works and operating rules.

Implementation

The recommended interventions are implemented.

Monitoring

The monitoring program will be coordinated by the Mallee Catchment Management Authority in conjunction with land managers. The different types of monitoring are discussed in Chapter 5.

Evaluation

The monitoring results will be evaluated in light of the expected outcomes—ecological response. Triggers will be identified to inform if/how management needs to adjust (e.g. the size of flood event adopted depending on water availability). Both short- and long-term triggers will be used. Short-term triggers include water movement into or out of structures and whether specific biota (flora and fauna) begin to appear; longer-term triggers will include more detailed targets for ecological response.

Adjust

The Icon Site Management Committee will consider the monitoring outcomes (and any new knowledge on the issues) to determine whether changes are required to the operating strategy and to re-define the expected outcomes from the operation (i.e. the objectives).

Assess

Proposed changes will be assessed by the Icon Site Management Committee to consider if such changes still meet their expectations. Additional information provided through this step will be reviewed and considered.

Design

The program then moves back to the design stage where agreed changes are converted into changes to structural, operation or procedural plans.

Reporting

Improvements to actions and practices at the icon site (identified through the adaptive management process) will be reported to stakeholders through the existing governance arrangements described in Chapter 1. This environmental water management plan will be reviewed periodically to capture the key lessons and changes in icon site management practices.

The outcomes achieved against the environmental water management plans will provide evidence of the progress of The Living Murray Initiative. This information will be incorporated into the annual TLM implementation report and presented to the Murray–Darling Basin Ministerial Council. This meets the obligation to report on annual TLM progress under clause 199 of The Living Murray Business Plan.

Appendix A: Victorian icon site governance arrangements

In Victoria, The Living Murray program is delivered by the Department of Sustainability and Environment, which provides high-level policy input and coordinates the delivery of TLM across all Victorian icon sites.

With the exception of the Hattah Lakes, all TLM icon sites in Victoria are multi-jurisdictional. Interstate coordination for these cross-border sites occurs through the integrated coordinating committees and icon site management committees.

The chief executive officers of the Mallee, North Central and Goulburn–Broken catchment management authorities act as regional icon site coordinators for relevant icon sites. Icon site coordinators are responsible for delivering TLM at each icon site. Accordingly, the Department for Sustainability and Environment has entered into a memorandum of understanding with the Mallee, North Central and Goulburn–Broken catchment management authorities that:

- establishes a collaborative working relationship between the organisations
- sets out a common understanding of intent
- commits the organisations to sub-jurisdictional arrangements for delivery of The Living Murray Business Plan.

State water authorities (Goulburn–Murray Water and SA Water) are Murray–Darling Basin Authority-delegated constructing authorities for the icon sites. As such, they are responsible for detailed design and construction under the environmental water management plan once investment proposals have been approved by the MDBA.

Victoria has set up a TLM steering committee to oversee delivery of TLM in that state (see **Figure A1**). This high-level committee, which is chaired by the Department of Sustainability and Environment, comprises representatives from key agencies responsible for implementing TLM. Goulburn–Murray Water has also convened a state construction committee to oversee the detailed design and construction phases.

Specific icon site arrangements and committees for the Hattah Lakes are set out here.

Relevant agencies

Most agencies responsible for managing the Hattah Lakes are involved in one or more of the committees or groups described here. The broad roles and responsibilities of relevant agencies are:

- Murray–Darling Basin Authority—coordinates TLM; River Management Division of MDBA will own all infrastructure constructed under TLM.
- Department of Sustainability and Environment—is responsible for implementing TLM in Victoria. The department is the project owner and site owner of all public land (including Gunbower State Forest); it also manages approval and referral processes and interaction with statutory planning processes.
- Mallee Catchment Management Authority—the authority's chief executive officer is the icon site coordinator; the authority is the strategic regional planner for natural resource management.
- Goulburn–Murray Water—Victorian constructing authority for TLM; the authority operates and maintains works constructed under TLM on behalf of the MDBA.
- Parks Victoria—land manager for Gunbower National Park.
- Victorian Environmental Water Holder—manager of the water entitlements held by the state.

Hattah Lakes Icon Site Management Committee

The Hattah Lakes Icon Site Management Committee is composed of representatives from the Mallee Catchment Management Authority, Goulburn–Murray Water, the Murray–Darling Basin Authority, the Department of Sustainability and Environment, and Parks Victoria.

The committee is responsible for:

- overseeing implementation of Victoria's TLM obligations at the Hattah Lakes icon site
- providing a forum for the cooperative delivery of TLM at the Hattah Lakes
- advising the icon site coordinator (the Chief Executive Officer of the Mallee Catchment Management Authority) on the Hattah Lakes TLM matters
- facilitating and monitoring progress of TLM delivery.

Committee members facilitate TLM implementation through their respective agencies by:

- generating support for The Living Murray initiative planned for the Hattah Lakes within their own agencies and assisting to resolve issues relevant to their agency
- ensuring agency TLM commitments are fulfilled
- attending meetings with the Icon Site Management Committee and Icon Site Coordinator as required
- disseminating information on long-term obligations and annual deliverables to relevant agency officers, including engaging staff more broadly within their organisations
- providing advice to the Icon Site Coordinator on implementation, policy or legislative issues, as relevant to their respective agencies, which may affect program delivery
- providing advice regarding the progress of TLM implementation, as required
- nominating appropriate representatives from their agencies to participate on working groups as requested
- ensuring that their nominated working group representative participates in TLM implementation in an active and timely way, and undertakes broader engagement within their organisation, including providing updates to the relevant committee member.

Icon Site Construction Committee

The Icon Site Construction Committee consists of representatives from the Mallee Catchment Management Authority, Goulburn–Murray Water, Department of Sustainability and Environment and the Murray–Darling Basin Authority (Chair).

The committee's objective is to:

- oversee the development of detailed designs and construction of works funded under TLM at the Hattah Lakes, ensuring works are consistent with the approved investment and construction proposals and addressing any issues identified in the assessment of these documents
- foster expertise-sharing to ensure that environmental works are designed, constructed, operated and commissioned efficiently and effectively to deliver the agreed environmental functionality.

The specific tasks of the Committee include providing technical oversight, identifying and addressing all land management issues associated with the works, regularly reviewing project costs and timelines, reviewing risks and mitigating measures and seeking endorsement from the State Construction Committee for any project changes.

Icon Site Community Reference Group

The Hattah Lakes Community Reference Group was established in 2008 as a requirement of The Living Murray Business Plan. The group provides a platform to seek advice and a community perspective on the communication and engagement activities proposed for the project. The group will continue to be engaged as an advisory body for the implementation of communications tools and actions. Membership of the group includes representatives of the local community plus the Mallee Catchment Management Authority Board Chairperson. The group reports to the Icon Site Coordinator. The Hattah Lakes and Lindsay–Mulcra–Wallpolla community reference groups have merged and meet as one group.

Icon Site Indigenous Stakeholder Group

The Mallee Catchment Management Authority engages directly with the Indigenous Stakeholder Group on The Living Murray at the Hattah Lakes. The stakeholder group has been involved in the cultural heritage field surveys associated with the development of the cultural heritage management plan for the site and includes members from local Indigenous groups that are either Native Title claimants or Registered Aboriginal Party applicants (Latji Latji peoples, Tati Tati Traditional Owner Group, Robinvale Aboriginal Community Native Title Claimant Group, Nyeri Nyeri/Wergaia).

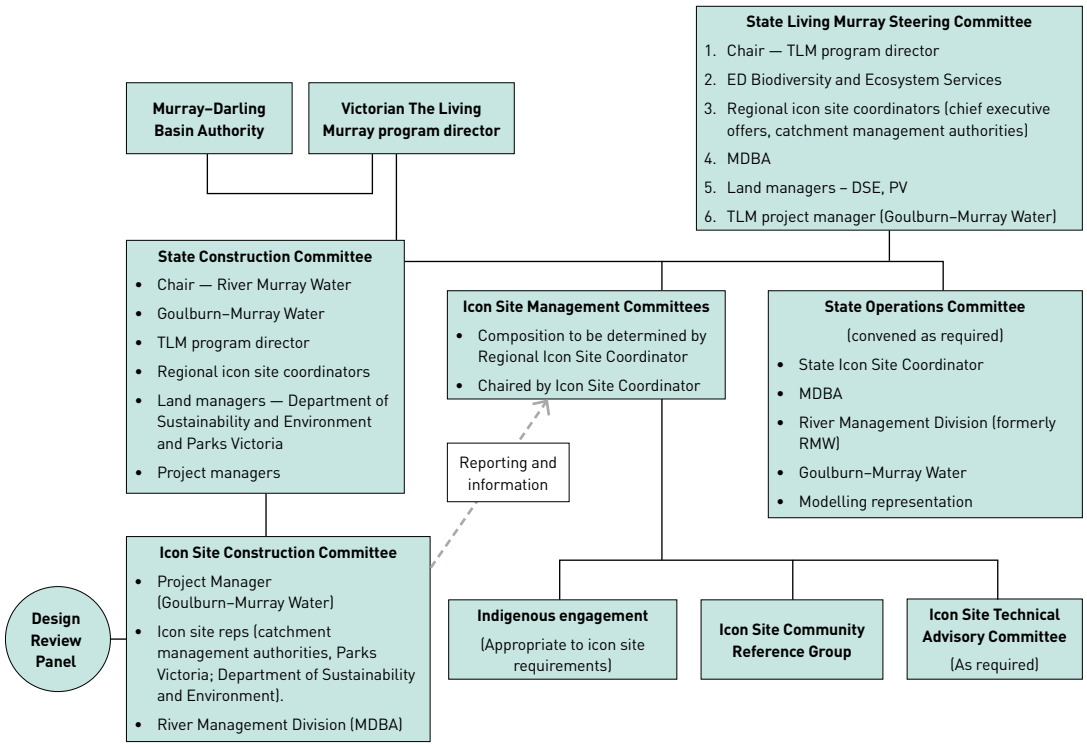

Figure A.1: The Living Murray program management arrangements: Victoria

Appendix B: Flora and fauna species list

Table B.1: Significant flora species identified by the FIS database as potentially occurring in the Hattah–Kulkyne area

Common name (scientific name)	Listing under *Flora and Fauna Guarantee Act 1998* (Vic.)	Listing under *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth)	Victorian rare or threatened species (Department of Sustainability and Environment)
Desert lantern (*Abutilon otocarpum*)			Vulnerable
Wait-a-while (*Acacia colletioides*)			Rare
Umbrella wattle (*Acacia oswaldii*)			Vulnerable
Buloke (*Allocasuarina luehmannii*)	Listed		
Common joyweed (*Alternanthera nodiflora*)			Poorly known
Plains joyweed (*Alternanthera* sp.1 (plains))			Poorly known
Dwarf amaranth (*Amaranthus macrocarpus* var. *macrocarpus*)			Vulnerable
Jerry-jerry (*Ammannia multiflora*)			Vulnerable
Buloke mistletoe (*Amyema linophylla* subsp. *orientale*)			Vulnerable
Tall kerosene grass (*Aristida holathera* var. *holathera*)			Vulnerable
Twin-leaf bedstraw (*Asperula gemella*)			Rare
Pop saltbush (*Atriplex holocarpa*)	Listed		Vulnerable
Baldoo (*Atriplex lindleyi* subsp. *conduplicata*)			Rare
Flat-top saltbush (*Atriplex lindleyi* subsp. *lindleyi*)			Poorly known
Coral saltbush (*Atriplex papillata*)			Rare
Mealy saltbush (*Atriplex pseudocampanulata*)			Rare
Small water-fire (*Bergia trimera*)			Vulnerable
Finger-leaved daisy (*Brachyscome exilis*)			Rare
Sand brome (*Bromus arenarius*)			Rare
Strap purslane (*Calandrinia coronilloides*)			Rare
Prickly bottlebrush (*Callistemon brachyandrus*)			Rare
Garland lily (*Calostemma purpureum* s.s.)			Rare
Blue burr-daisy (*Calotis cuneifolia*)			Rare
Cotton sneezeweed (*Centipeda nidiformis*)			Rare
Desert sneezeweed (*Centipeda thespidioides* s.l.)			Rare
Wingwort (*Ceratogyne obionoides*)			Rare
Common hornwort (*Ceratophyllum demersum*)			Poorly known
Frosted goosefoot (*Chenopodium desertorum* subsp. *desertorum*)			Rare
Broom milkwort (*Comesperma scoparium*)			Rare
Sand lily (*Corynotheca licrota*)			Rare
Hoary scurf-pea (*Cullen cinereum*)	Listed		Endangered
Woolly scurf-pea (*Cullen pallidum*)			Endangered
Spreading scurf-pea (*Cullen patens*)	Listed		Endangered
Tough scurf-pea (*Cullen tenax*)	Listed		Endangered
Bear's-ear (*Cymbonotus lawsonianus*)			Rare

Common name (scientific name)	Listing under *Flora and Fauna Guarantee Act 1998* (Vic.)	Listing under *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth)	Victorian rare or threatened species (Department of Sustainability and Environment)
Native couch (*Cynodon dactylon* var. *pulchellus*)			Poorly known
Lax flat-sedge (*Cyperus flaccidus*)			Vulnerable
Annual flat-sedge (*Cyperus nervulosus*)			Endangered
Dwarf flat-sedge (*Cyperus pygmaeus*)			Vulnerable
Curly flat-sedge (*Cyperus rigidellus*)			Endangered
Riverine flax-lily (*Dianella porracea*)			Vulnerable
Silky umbrella-grass (*Digitaria ammophila*)			Vulnerable
Flycatcher (*Drosera indica*)			Vulnerable
Smooth elachanth (*Elachanthus glaber*)			Rare
Small elachanth (*Elachanthus pusillus*)			Rare
Pale spike-sedge (*Eleocharis pallens*)			Poorly known
Cane grass (*Eragrostis australasica*)			Vulnerable
Purple love-grass (*Eragrostis lacunaria*)			Vulnerable
Bristly love-grass (*Eragrostis setifolia*)			Vulnerable
Spreading emu-bush (*Eremophila divaricata* subsp. *divaricata*)			Rare
Woolly mantle (*Eriochlamys behrii* s.l.)			Rare
Green-leaf mallee (*Eucalyptus phenax*)			Rare
Summer fringe-sedge (*Fimbristylis aestivalis*)			Poorly known
Hoary sea-heath (*Frankenia crispa*)			Rare
Leafy sea-heath (*Frankenia foliosa*)			Rare
Bristly sea-heath (*Frankenia serpyllifolia*)			Rare
Silky glycine (*Glycine canescens*)	Listed		Endagered
Dwarf cup-flower (*Gnephosis tenuissima*)			Rare
Toothed raspwort (*Haloragis odontocarpa* f. *octoforma*)			Vulnerable
Wiry glasswort (*Halosarcia lylei*)			Rare
Shining glasswort (*Halosarcia nitida*)			Rare
Inland club-sedge (*Isolepis* australiensis)			Poorly known
Slender club-sedge (*Isolepis congrua*)	Listed		Vulnerable
Desert jasmine (*Jasminum didymum* subsp. *lineare*)			Vulnerable
Bundled peppercress (*Lepidium fasciculatum*)			Poorly known
Winged peppercress (*Lepidium monoplocoides*)	Listed	Endangered	Endangered
Warty peppercress (*Lepidium papillosum*)			Poorly known
Native peppercress (*Lepidium pseudohyssopifolium*)			Poorly known
Button rush (*Lipocarpha microcephala*)			Vulnerable
Austral trefoil (*Lotus australis*)			Poorly known
Heathy bluebush (*Maireana oppositifolia*)			Rare
Three-wing bluebush (*MaireanaM. triptera*)			Rare
Goat head (*Malacocera tricornis*)			Rare
Doubah (*Marsdenia australis*)			Vulnerable
Large-fruited millotia (*Millotia macrocarpa*)			Rare
Small monkey-flower (*Mimulus prostrates*)			Rare
Bush minuria (*Minuria cunninghamii*)			Rare
Smooth minuria (*Minuria integerrima*)			Rare
Spiny lignum (*Muehlenbeckia horrida* subsp. *horrid*)			Rare

Common name (scientific name)	Listing under *Flora and Fauna Guarantee Act 1998* (Vic.)	Listing under *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth)	Victorian rare or threatened species (Department of Sustainability and Environment)
Mallee cucumber (*Mukia micrantha*)			Rare
Lime daisy-bush (*Olearia calcarea*)			Rare
Shiny daisy-bush (*Olearia passerinoides*)			Rare
Spiked daisy-bush (*Olearia subspicata*)			Vulnerable
Upright adder's-tongue (*Ophioglossum polyphyllum*)			Vulnerable
Australian broomrape (*Orobanche cernua* var. *Australiana*)			Vulnerable
Velvet knotweed (*Persicaria attenuate*)			Poorly known
Lagoon spurge (*Phyllanthus lacunarius*)			Vulnerable
Sandhill spurge (*Phyllanthus lacunellus*)			Rare
Desert rice-flower (*Pimelea simplex* subsp. *simplex*)			Rare
Williamson's rice-flower (*Pimelea williamsonii*)			Vulnerable
Knotted poa (*Poa drummondiana*)			Rare
Grey podolepis (*Podolepis canescens*)			Rare
Crimson tails (*Ptilotus sessilifolius* var. *sessilifolius*)			Poorly known
Purple pentatrope (*Rhyncharrhena linearis*)			Vulnerable
Dwarf bitter-cress (*Rorippa eustylis*)			Rare
Sarcozona (*Sarcozona praecox*)			Rare
Skeleton fan-flower (*Scaevola depauperata*)			Endangered
Tangled copperburr (*Sclerolaena divaricata*)			Poorly known
Black roly-poly (*Sclerolaena muricata* var. *muricata*)			Poorly known
Spear-fruit copperburr (*Sclerolaena patenticuspis*)			Vulnerable
Sand sida (*Sida ammophila*)			Vulnerable
Pin sida (*Sida fibulifera*)			Vulnerable
Twiggy sida (*Sida intricate*)			Vulnerable
Trident spyridium (*Stenanthemum notiale* subsp. *notiale*)			x
Prickly cudweed (*Stuartina hamata*)			Rare
Small-leaf swainson-pea (*Swainsona microphylla*)			Rare
Dwarf swainson-pea (*Swainsona phacoides*)			Endangered
Silky swainson-pea (*Swainsona sericea*)			Vulnerable
Round templetonia (*Templetonia egena*)			Vulnerable
Desert spinach (*Tetragonia eremaea* s.s.)			Poorly known
Annual spinach (*Tetragonia moorei)*			Poorly known
Small burr-grass (*Tragus australianus*)			Rare
Sweet fenugreek (*Trigonella suavissima*)			Rare
Needle grass (*Triraphis mollis*)			Rare
Cup velleia (*Velleia connate*)			Rare
Club-hair New Holland daisy (*Vittadinia condyloides*)			Rare
Rabbit-ears twin-leaf (*Zygophyllum compressum*)			Vulnerable
White twin-leaf *Zygophyllum simile*)			Rare

Source: GHD (2009)

Table B.2: Significant fauna species identified by the Wildlife Atlas as potentially occurring in the Hattah–Kulkyne area

Common name (species name)	AVW	PMST	*Environment Protection and Biodiversity Conservation Act 1999* (Cwlth)	*Flora and Fauna Guarantee Act 1998* (Vic.)	Victorian Department of Sustainability and Environment
Birds					
Apostlebird (*Struthidea cinerea*)	√			Listed	
Australian painted snipe (*Rostratula benghalensis*)	√		VU	Listed	CE
Australasian bittern (*Botaurus poiciloptilus*)	√			Listed	EN
Australasian shoveler (*Anas rhynchotis*)	√				VU
Black-eared cuckoo (*Chrysococcyx osculans*)	√				NT
Black-eared miner (*Manorina melanotis*)	√		EN	Listed	EN
Black falcon (*Falco subniger*)	√				VU
Blue-billed duck (*Oxyura australis*)	√			Listed	EN
Brown quail (*Coturnix ypsilophora*)	√				NT
Bush stone-curlew (*Burhinus grallarius*)	√			Listed	EN
Caspian tern (*Sterna caspia*)	√			Listed	NT
Chestnut quail-thrush (*Cinclosoma castanotus*)	√				NT
Common sandpiper (*Actitis hypoleucos*)	√				VU
Crested bellbird (*Oreoica gutturalis*)	√			Listed	NT
Elegant parrot (*Neophema elegans*)	√				NT
Freckled duck (*Stictonetta naevosa*)	√			Listed	EN
Glossy ibis (*Plegadis falcinellus*)	√				NT
Great egret (*Ardea alba*)	√			Listed	VU
Grey-fronted honeyeater (*Lichenostomus plumulus*)	√				VU
Ground cuckoo-shrike (*Coracina maxima*)	√			Listed	VU
Gull-billed tern (*Sterna nilotica*)	√			Listed	EN
Hardhead (*Aythya australis*)	√				VU
Hooded robin (*Melanodryas cucullata*)	√			Listed	NT
Intermediate egret (*Ardea intermedia*)	√			Listed	CR
Little bittern (*Ixobrychus minutus*)	√			Listed	EN
Little button quail (*Turnix velox*)	√				NT
Little egret (*Egretta garzetta*)	√			Listed	EN
Major Mitchell's cockatoo (*Cacatua leadbeateri*)	√			Listed	VU
Mallee emu wren (*Stipiturus mallee*)	√		VU	Listed	VU
Mallee fowl (*Leipoa ocellata*)	√		VU	Listed	EN
Musk duck (*Biziura lobata*)	√				VU
Nankeen night heron (*Nycticorax caledonicus*)	√				NT
Painted honeyeater (*Grantiella picta*)	√			Listed	VU
Pied cormorant (*Phalacrocorax varius*)	√				NT
Plains wanderer (*Pedionomus torquatus*)	√		VU	Listed	CR
Purple-gaped honeyeater (*Lichenostomus cratitius*)	√				VU
Red-backed kingfisher (*Todiramphus pyrrhopygia*)	√				NT
Red-lored whistler (*Pachycephala rufogularis*)	√		VU	Listed	EN
Regent parrot (eastern form) (*Polytelis anthopeplus monarchoides*)	√		VU	Listed	VU

Common name (species name)	AVW	PMST	*Environment Protection and Biodiversity Conservation Act 1999* (Cwlth)	*Flora and Fauna Guarantee Act 1998* (Vic.)	Victorian Department of Sustainability and Environment
Royal spoonbill (*P. regia*)	√				VU
Scarlet-chested parrot (*Neophema splendida*)	√			Listed	VU
Spotted harrier (*Circus assimilis*)	√				NT
Square-tailed kite (*Lophoictinia isura*)	√			Listed	VU
Striated grasswren (*Amytornis striatus*)	√				NT
Swift parrot (*Lathamus discolor*)		√	EN	Listed	EN
Whiskered tern (*Chlidonias hybridus*)	√				NT
White-bellied sea-eagle (*Haliaeetus leucogaster*)	√			Listed	VU
White-browed treecreeper (*Climacteris affinis*)	√			Listed	VU
Mammals					
Common dunnart (*Sminthopsis murina*)	√				VU
Eastern long-eared bat (*Nyctophilus timoriensis*) (south-eastern form)	√		VU	Listed	VU
Fat-tailed dunnart (*Sminthopsis crassicaudata*)	√				NT
Mallee ningaui (*Ningaui yvonneae*)	√				NT
Mitchell's hopping mouse (*Notomys mitchelli*)	√				NT
Reptiles					
Carpet python (*Morelia spilota metcalfei*)	√			Listed	EN
Coral snake (*Simoselaps australis*)	√				NT
Desert skink (*Egernia inornata*)	√				NT
Eastern hooded scaly-foot (*Pygopus schraderi*)[a]				Listed	CR
Lace monitor (*Varanus varius*)	√				VU
Western blue-tongued skink (*Tiliqua occipitalis*)	√				DD
Western brown snake (*Pseudonaja nuchalis*)	√				DD
Frogs					
Growling grass frog (*Litoria raniformis*)			VU	Listed	EN

Notes
[a] Species predicted to occur within the study area based on local knowledge of the author.

Key
EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth)
Department of Sustainability and Environment = Victorian Department of Sustainability and Environment, Advisory List of Threatened Vertebrate Fauna of Victoria 2003
AVW = Species identified by the Atlas of Victorian Wildlife
PMST = Species identified by the Protected Matters Search Tool
EPBC status of species
EN = endangered
VU = vulnerable
Victorian Department of Sustainability and Environment advisory status of species
CE = critically endangered
EN = endangered
VU = vulnerable
NT = near threatened
DD = data deficient

Appendix C: Communication material

Table C.1: Communication material that has been developed and distributed for the Hattah Lakes icon site

Material		Distribution
Fact sheets	*Hattah Lakes and The Living Murray Program*	Hattah Visitors Centre
		Lock masters in the region
		Indigenous stakeholders via information package
		Available at public screening of Hattah Lakes Storylines
	Environmental Regulators	Hattah Visitors Centre
		Lock masters in the region
		Indigenous stakeholders via information package
		Available at public screening of Hattah Lakes Storylines
	Indigenous Facilitator	Indigenous stakeholders
	Ken Stewart	Further distribution planned through Indigenous facilitator and at the Hattah Lakes Visitor Centre and local displays about The Living Murray program
	Hattah Lakes—Environmental Watering	Hattah Visitors Centre
		Community Reference Group members
		Mallee Catchment Management Authority website
		Available for collection at Mallee Catchment Management Authority reception
Hattah documentary DVD		Indigenous stakeholders
Hattah Lakes—A landscape in recovery		Interest groups
		Hattah residents
Hattah Lakes oral history		Involved 20–30 participants
		Distributed to 75 people
Environment Victoria's digital storytelling DVD		Public screening in Mildura (attended by approx. 60 people). All attendees received a copy of the DVD.
Hattah Lakes Storylines		Melbourne launch in July 2008, attended by approximately 160 people.
		Available free of charge from Hattah Store
		Mildura Tourism
		Screening daily at Mildura Visitor Information and Booking Centre
Information package on proposed TLM works at Hattah Lakes icon site		Indigenous stakeholders involved in cultural heritage management plan creation.
Indigenous News		Quarterly newsletter produced by Mallee Catchment Management Authority to update Indigenous stakeholders on the progress of cultural heritage management plans at the icon sites and other relevant news.
		Distributed to Indigenous stakeholders who have been involved in the development of cultural heritage management plans in the Mallee Catchment Management Authority region.
Catchment News		Quarterly newsletter produced by Mallee Catchment Management Authority that includes updates on The Living Murray program and the works planned for the Hattah Lakes.
		Available from Mallee Catchment Management Authority website. Hard copies are available from Mallee Catchment Management Authority reception.
		Emailed to 146 people.
Media releases outlining proposed works, released as part of the visit of the then federal Environment Minister, Penny Wong, to Hattah on 3 September 2009.		Media releases
ABC Television, *Landline* story on delivery of environmental water—'How green is my valley'.		Broadcast nationally on 18 September 2009 and available through i-view, **<www.abc.net.au/landline/content/2008/s2684347.htm>**.

Schedules

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

Schedule 1: Operating Plan for the Hattah Lakes icon site

Schedule 2: Risk management plan for the Hattah Lakes icon site

Schedule 3: Condition monitoring plan for the Hattah Lakes icon site

Schedule 4: Communication and community engagement strategy for the Hattah Lakes icon site

Figures and tables

Figures

Tables

Abbreviations and acronyms

AHD	Australian height datum
EWMP	Environmental water management plan
GL/mo	gigalitres a month.
MDBA	Murray–Darling Basin Authority.
MDBC	Murray–Darling Basin Commission.
ML/d	megalitres a day
LTCE	long-term Cap equivalent
TLM	The Living Murray

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.
Basin Officials Committee	A jurisdictional committee to coordinate the management of Basin water resources between the Australian Government, the Murray–Darling Basin Authority and the Basin states.
Bioregional conservation significance	A Victoria-wide classification of the degree of depletion in the extent and/or quality of an ecological vegetation class within a particular bioregion, compared to an estimation of its pre-1750 extent and condition.
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.
EC	Electrical conductivity is the ability of water or soil solution to conduct an electric current; commonly used as a measure of salinity or total dissolved salts.
Environmental water	Water that is available for the environment.
Environmental Watering Group	A jurisdictional committee that develops and implements the annual TLM Environmental Watering Plan. The Environmental Watering Group recommends annual TLM watering priorities and proposals to ensure consistency between icon sites.
Eutrophic	Characterised by waters rich in mineral and organic nutrients that promote a proliferation of plant life, especially algae, which reduces the dissolved oxygen content and often causes the extinction of other organisms.
Ecological vegetation class	A component of a vegetation classification system. Ecological vegetation classes are groupings of vegetation communities based on floristic, structural, and ecological features.
Icon site environmental water management plan	A plan that details the aims, objectives and management actions at an icon site that are in accord with The Living Murray program. These plans complement state-based plans and processes.
Murray–Darling Basin Authority	Murray–Darling Basin Authority absorbed the functions of the former Murray–Darling Basin Commission.
Murray–Darling Basin Commission	Now the Murray–Darling Basin Authority.
Murray–Darling Basin Ministerial Council (Ministerial Council)	A ministerial council that develops and agrees to intergovernmental agreements, approves The Living Murray Business Plan and makes key decisions (e.g. approving the Natural Resource Management program's budget in the MDBA Corporate Plan).
Objective	Refer Ecological objectives.
Parameter	A measurable or quantifiable characteristic or feature.
Ramsar Convention on Wetlands of International Importance	A global treaty adopted in Ramsar, Iran in 1971 that focuses on the conservation of internationally important wetlands.

River Murray Operations	A business unit of the MDBA responsible for operating the River Murray system under the Murray-Darling Basin Intergovernmental Agreement. River Murray Operations manages the River Murray system to ensure that available water is continuously accounted for and distributed to New South Wales, Victoria and South Australia in accordance with the Murray–Darling Basin agreement.
Target	Refer Ecological targets.
The Living Murray Committee	A jurisdictional committee responsible for implementing The Living Murray Business Plan.
Water requirements	Includes the flow, volume, timing, duration, velocity, depth, quality or any other attribute required to meet ecological targets.

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