Margooya Lagoon Environmental Water Management Plan

mallee catchment management authority

Department of Environment, Land, Water & Planning

State Government Victoria

DOCUMENT CONTROL

Revision and Distribution

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Executive Summary

Environmental Water Management Plans (EWMPs) have been developed for key sites in the Mallee region. This Environmental Water Management Plan (EWMP) sets out the long-term objectives for the priority environmental values of Margooya Lagoon. The EWMP will help to guide future environmental watering activities for this area. It is an important part of the Victorian Environmental Water Planning Framework and provides the long-term management intentions, based on scientific information and stakeholder consultation that can be used by the respective agencies; Mallee Catchment Management Authority (CMA), Department of Environment, Land, Water and Planning (DELWP) and the Victorian Environmental Water Holder (VEWH); for both short and longer-term environmental water planning.

Margooya Lagoon is located in the Robinvale Plains bioregion within the Mallee Catchment Management Authority (Mallee CMA) region, 10 km south-east of Robinvale and covers approximately 44 ha. Margooya lagoon is part of the area covered by the Murray River Park as defined in the VEAC River Red Gum Investigation (2008).

Margooya Lagoon is a wetland that provides habitat for a large range of flora and fauna, including listed flora and fauna species. Species recently recorded at the site include the Growling Grass Frog, (*Litoria raniformis)* Regent Parrot (*Polytelis anthopeplus monarchoides*), White-bellied Sea-Eagle (*Haliaeetus leucogaster*), and Diamond Firetail (*Stagonopleura guttata*).

Margooya Lagoon was permanently inundated under the influence of the Lock 15 weir pool at Euston until a regulator was installed in 2009. This has allowed a drying phase to be re-instated for the lagoon. The water regime now requires management to achieve the best environmental outcomes.

The long term management goal of the Margooya Lagoon EWMP is

To provide a water regime that improves River Red Gum health and maintains and enhances key habitats for native fish, frogs, waterbirds and threatened birds.

The ecological objectives for Margooya Lagoon are to:

- Maintain and enhance the condition of River Red Gum with chenopod understorey
- Maintain and enhance the condition of River Red Gum with flood tolerant understorey (littoral RRG)
- Exclude carp from the wetland and provide habitat for small-bodied fish
- Provide nursery habitat for Silver and Golden Perch
- Provide periodic frog habitat
- Provide periodic habitat for waterbirds – piscivores, deep water foragers
- Provide periodic habitat for waterbirds – dabbling ducks, grazing waterfowl, waders
- Provide conditions to enhance littoral vegetation zones – broad and diverse
- Introduce a periodic drying phase to promote nutrient cycling

Infrastructure is in place to allow the hydrological objectives of this EWMP to be implemented.

This EWMP is not a holistic management plan for Margooya Lagoon but is focused on environmental water management. A regional context document provides further information on the region and has been created to complement the Mallee CMAs EWMPs and should be read in conjunction with this document (Sunraysia Environmental, 2014).

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Acknowledgements

The EWMP was produced by the Mallee Catchment Management Authority, with funding from the Victorian Government. The valuable contributions of Parks Victoria, Jane Roberts, Terry Hillman, other agencies and community members are also acknowledged.

1. INTRODUCTION

This Environmental Water Management Plan (EWMP) has been prepared to establish the long-term management goals of Margooya Lagoon.

The key purposes of the EWMP are to:

- Identify the long-term objectives and water requirements for the wetland, identified as a high priority by the Mallee CMA;
- Provide a vehicle for community consultation, including for the long-term objectives and water requirements of the wetlands;
- Inform the development of seasonal watering proposals and seasonal watering plans;
- Inform long-term watering plans that will be developed under Murray-Darling Basin Plan requirements.

Key documents that support this Margooya Lagoon EWMP are shown in Table 1.

Table 1 - Key support documents to the Margooya Lagoon EWMP

Name	Author	Summary
Mallee Waterway Strategy	Mallee CMA 2014	• Sets regional goals for waterway management that align with the Mallee RCSs broader objectives • Identifies high value waterways • Details strategic work programs for priority waterways • Identifies the roles and responsibilities of regional stakeholders • Establishes principles to guide the implementation
Regional Context Document for Environmental Water Management Plans; Mallee CMA Region	Sunraysia Environmental 2014	• Background context the region • Outlines significant wetlands and river • Sources of environmental water • Policy, legislative and planning frameworks
Investigation of Water Management Options for the Murray River – Nyah to Robinvale	Ecological Associates 2007	• Identifies management units • Identifies ecological values • Develops objectives • Defines water regimes • Identifies threats • Proposes management actions
Water Management Options for the Murray River – Nyah to Robinvale, Stage II	Ecological Associates 2007	• Costs designs • Proposes alternative water management options • Documents environmental impacts • Documents Cultural heritage values
Margooya Lagoon Watering Plan **Environmental Water Allocation and River Murray operational accounting**	Mallee CMA 2009	• Plans for the delivery of river operations and delivery of environmental water • Agreed roles and responsibilities for management
Environmental Water Management Plan for the River Murray at the Lock 15 Weir Pool	Ecological Associates 2015	• An EWMP for River Murray and its floodplain in the Lock 15 weir pool

2. Site Overview

The Mallee CMA region is located in the north-west of Victoria covering approximately 39,000 km² with an estimated regional population of 65,000. The catchment runs along the Murray River from Nyah to the South Australian border, and as far south as Birchip and Rainbow (MCMA 2014). Major towns include Mildura, Birchip, Sea Lake, Ouyen, Robinvale, Red Cliffs and Merbein. The region has a semi-arid climate, with an annual mean rainfall of around 250 mm and average daily temperatures (at Mildura) ranging from 32°C in summer to 15°C in winter (MCMA 2006).

The mean annual rainfall at Nyah is 303 mm with average daily temperatures (at Swan Hill) ranging from 33°C in summer to 14.7°C in winter (Bureau of Meteorology 2015).

The Mallee CMA region consists of 38% of public land which is mainly national parks, reserves and large reaches of riverine and dryland state forest. The rest of the region is important for dryland farming of sheep and cereals, and irrigated horticulture (MCMA 2006)

In 2006 the Mallee CMA engaged consultants Ecological Associates to investigate water management options for the Murray River floodplain from Robinvale to Wallpolla Island. One of the major outcomes of these investigations was the development of a system of Floodplain Management Units (WMUs). These divide the floodplain into management units in which water regimes can be managed independently of another WMU. WMUs are relatively consistent in their ecological values and land uses. The Mallee CMA has used WMUs to inform planning and development of environmental water management plans to achieve more effective management of hydrologically connected systems. In addition to this the Mallee CMA has also used individual WMUs or groupings of WMUs to form Waterway Management Units (WMU) for planning within its Mallee Waterway Strategy (MCMA 2014). See Figure 1.

Margooya Lagoon is within a floodplain area of the Murray River approximately 10 km south east of Robinvale and 15 km upstream of Lock 15 at Euston. It was part of the Beggs Bend State Forest and Murray River Reserve which has now become a section of the Murray River Park under the VEAC (2008) recommendations. The lagoon occurs within the Robinvale Plains Bioregion and has a maximum extent of approximately 44 Ha.

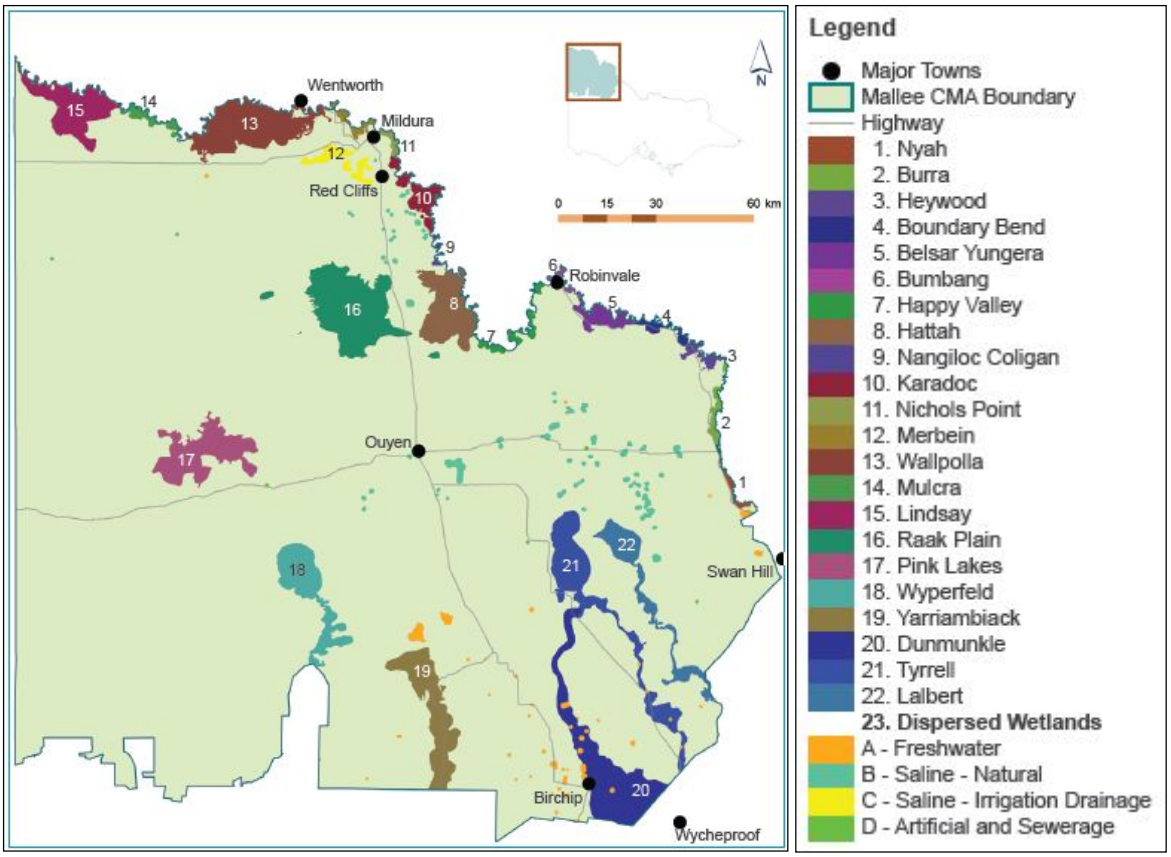

Figure 1 - Mallee Water Management Units (Mallee CMA, 2014)

2.3 Catchment setting

Margooya Lagoon is located within the Robinvale Plains Bioregion. The Robinvale Plains Bioregion is characterised by a narrow gorge confined by the cliffs along the Murray River, which is entrenched within older up-faulted Cainozoic sedimentary rocks. Alluvial deposits from the Cainozoic period gave rise to the red brown earths, cracking clays and texture contrast soils (Dermosols, Vertosols, Chromosols and Sodosols) this supports Riverine Grassy Forest and Riverine Grassy Chenopod Woodland ecosystems (http://www.DEPI.vic.gov.au/conservation-and-environment/victorias-bioregions#bioregion (November 2011)).

The lagoon has a maximum extent of approximately 44 ha and is connected to the river by a narrow creek which is controlled by an environmental regulator installed by Mallee CMA in 2009. Previously the lagoon was permanently inundated by the Lock 15 weir pool levels. Irrigation and domestic drainage from adjoining horticultural properties contribute small amounts of water to the levels in the lagoon although recent dry conditions have decreased this input. When river levels are higher the lagoon also receives water through a channel further upstream. The lagoon is surrounded by low banks (excluding the western bank) which when water levels reach a specific level allow water to penetrate into the surrounding River Red Gum communities (fringing River Red Gum initially with flood tolerant understorey followed by Red Gum with a chenopod understorey in larger flooding events).

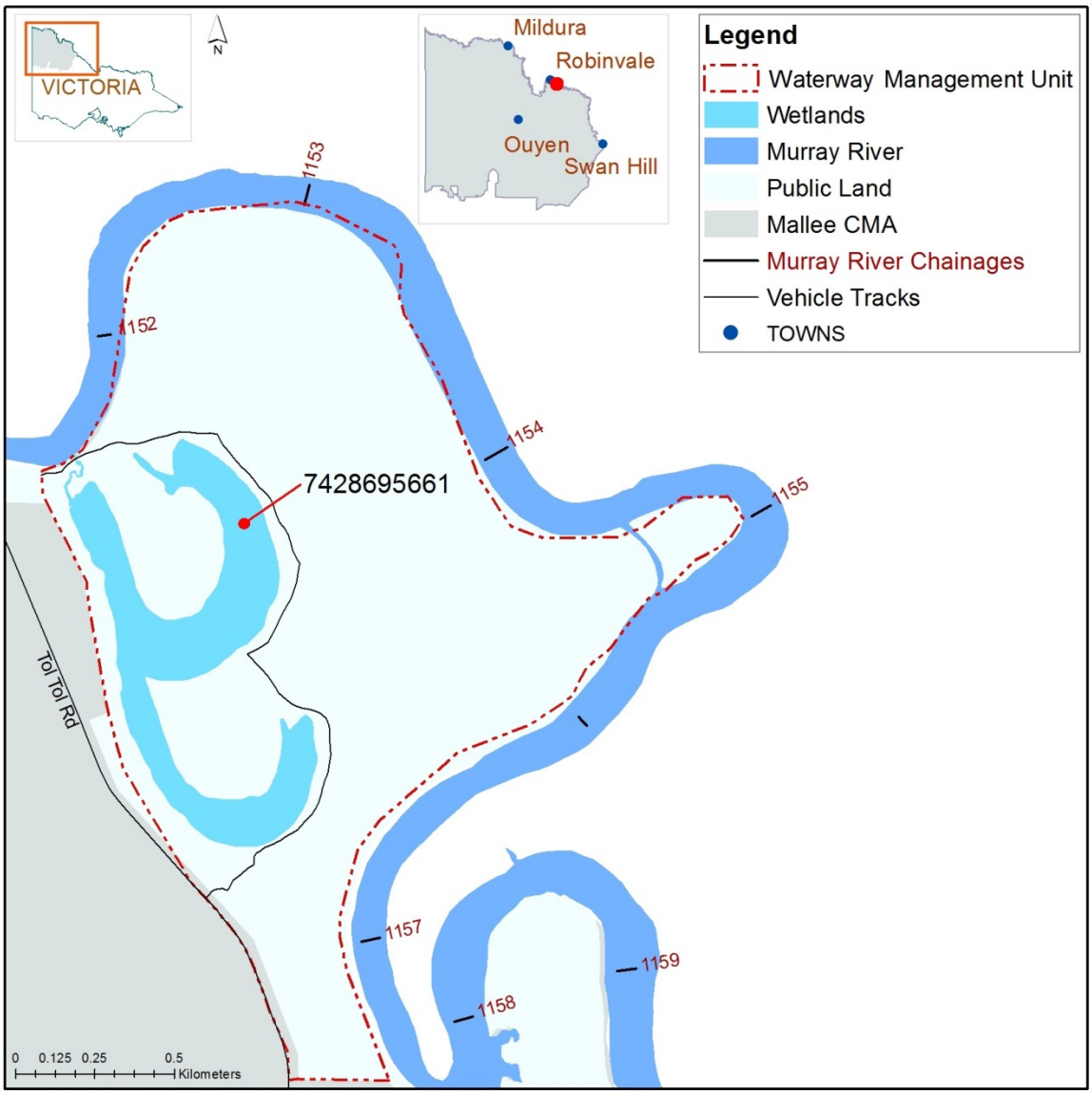

Figure 2 - Map of Margooya Lagoon Floodplain

2.2 Conceptualisation of the Site

A conceptual model of the site (Figure 3) has been developed which describes how the ecological processes and water dependent values interact. The model highlights some of the limiting factors and threats associated with the current water regimes of the wetlands.

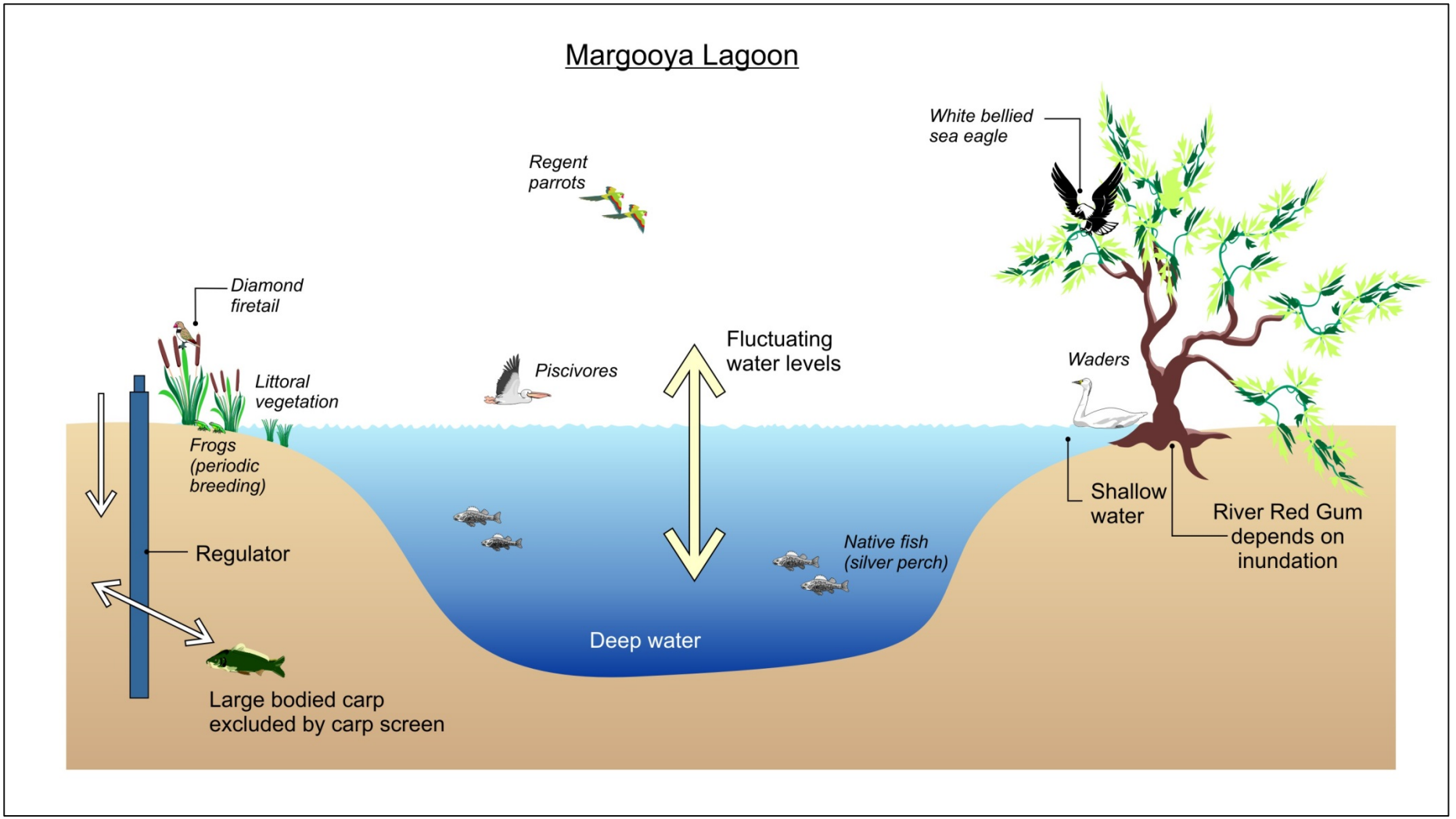

Figure 3 - Values, threats and processes associated with Margooya Lagoon

Key ecological values and processes of Margooya Lagoon are:

- River Red Gum is habitat for the listed (CAMBA, FFG Act and DELWP) White-bellied Sea-eagle. The White-bellied Sea-eagle requires healthy River Red Gum for nesting as well as relying on the lagoon itself for feeding (fish).
- Wetting and drying phases are beneficial. They promote high levels of aquatic productivity which support, native frogs, fish recruitment and a range of habitat for waterbird feeding and breeding.
- Native fish (Silver Perch, Carp Gudgeon, Unspecked Hardyhead) during periods of inundation. The lagoon also provides nursery habitat for native fish species including Golden and Silver Perch.
- Regent Parrot are likely to forage, nest and seek refuge at Margooya Lagoon utilising River Red Gum hollows for nesting. Vegetation corridors in the area to provide access to areas of mallee away from the floodplain for feeding.
- Littoral vegetation creating habitat for frog species and the threatened Diamond Firetail. The species is reliant on the habitat provided by the River Red Gum communities which fringes Margooya Lagoon and on native grasses fringing the lagoon for foraging

2.4 Land status and management

There are many agencies and individuals involved in managing the public and private land in Margooya Lagoon. Land management boundaries are shown in Figure 4.

The Margooya Lagoon Floodplain has historically been managed by the Department of Environment, Land, Water and Planning as State Forest but under recommendations from the Victorian Environmental Assessment Council River Red Gum Forests Investigation (VEAC 2008, p 63) the area has been declared Murray River Park with Parks Victoria as the land manager. This recommendation came into effect in July 2010.

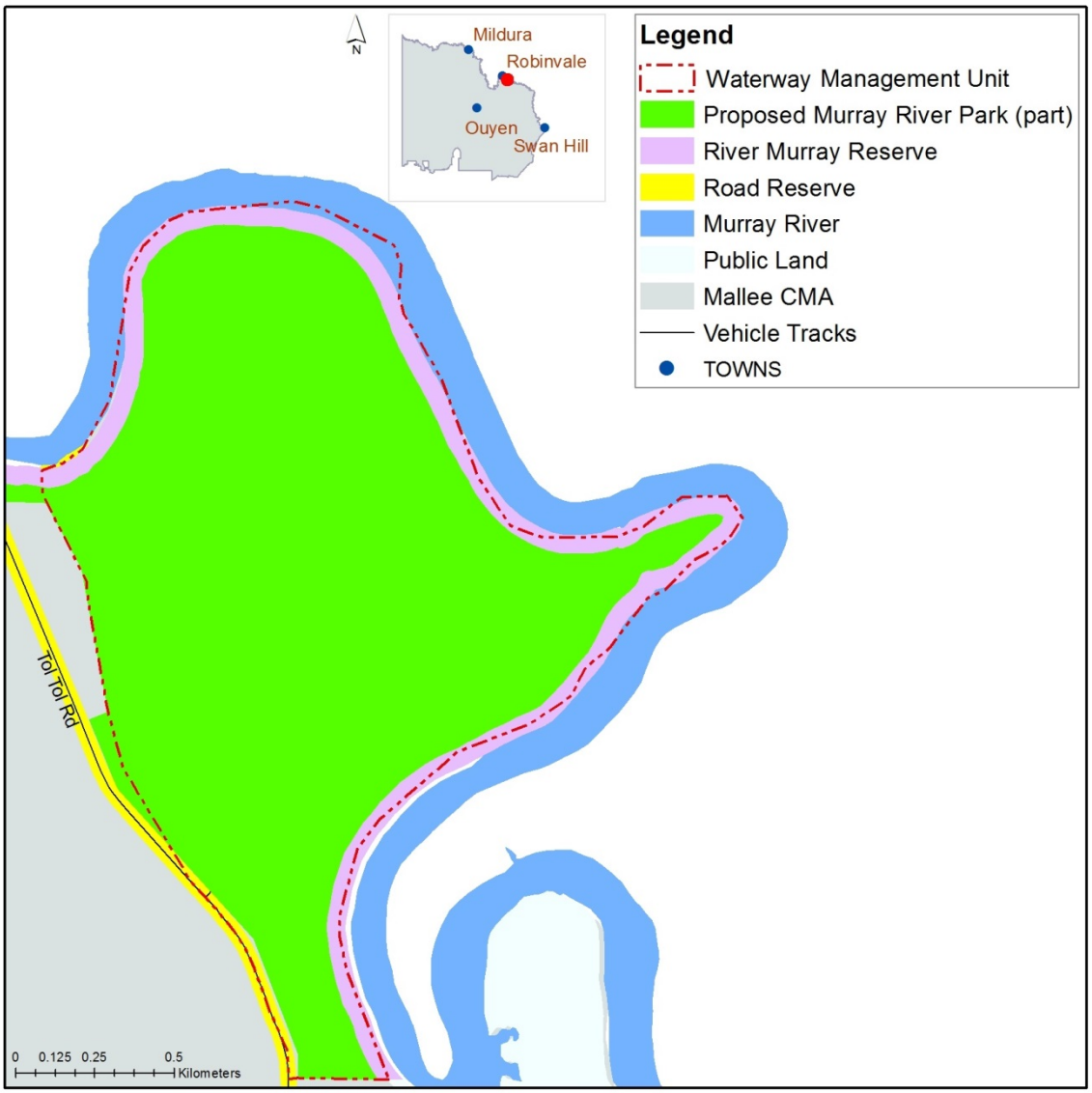

Figure 4 - Margooya Lagoon Land Tenure

Stakeholders associated with or interested in environmental water management outcomes for Margooya Lagoon are listed in Table 2.

Table 2 - Stakeholders for Margooya Lagoon

Group	Role
Parks Victoria	Land Manager. Parks Victoria is responsible for Conserving Victoria's Special Places with the aim to ensure that our valued parks, and the natural assets and cultural heritage they hold, can be enjoyed now and by future generations.
Mallee CMA	The Mallee CMA's responsibility is to ensure that natural resources in the region are managed in an integrated and ecologically sustainable way.
Department of Environment, Land, Water and Planning	State level environmental water management planning, land manager, threatened species manager
Victorian Environmental Water Holder	Management of environmental water holdings since July 1 2011.
Mildura Rural City Council	Local Government. Mildura Rural City Council has a number of Water Management Programs to save water resources and improve the health of our waterways.
Aboriginal Stakeholders	Aboriginal Stakeholders. Provides assistance in planning and implementation of programs.
Lower Murray Water	Lower Murray Water continues implementation and development of their Environmental Management System to promote continual environmental improvement and sustainable development in the surrounding area.
Local Landholders	One licensed water user extracts water from the lagoon

2.6 Wetland characteristics

Victoria's wetlands are currently mapped and are contained within a state wetland database, using an accepted state-wide wetland classification system, developed by Corrick and Norman. Mapping was undertaken from 1981 using 1:25,000 colour aerial photographs, along with field checking and developed into spatial geographic information system layers. This database is commonly known as the 1994 wetland layer and contains the following information:

- Categories (primary) based on water regime; and
- Subcategories based on dominant vegetation.

At the same time, an attempt was made to categorise and map wetland areas occupied prior to European settlement. This was largely interpretive work and uses only the primary category, based on water regime. This is known as the 1788 layer (DSE, 2007).

Victoria's wetland classification and inventory was updated in 2013 and replaces the system developed by Corrick and Norman. The updated classification is based on the Australian National Aquatic Ecosystem (ANAE) Classification Framework with data on wetlands and their classification attributes converted into spatial Geographic Information System (GIS) layers.

The Framework structure produces 37 wetland categories that were adopted to distinguish naturally-occurring from human-made wetlands in the first level of the classification hierarchy. Aquatic ecosystem habitats: palustrine, lacustrine and estuarine distinguish wetlands in the second level of the classification hierarchy and wetland attributes: water regime, salinity, landscape context, soils and wetland vegetation distinguish wetlands in the third level of the hierarchy (DEPI, 2014).

Utilising the 1994 inventory, Margooya Lagoon wetlands have been classified as Open Freshwater - shallow.

An overview of the main characteristics of the target area under these layers is given in Table 3 and Figure 5.

Table 3 - Wetland characteristics of Margooya Lagoon

Characteristics		Description
Name		Margooya Lagoon Floodplain Management Unit
Mapping ID within area (numbers follow Corrick and Norman numbering system)		7428695661
Current wetland Id		11207
Area		320 Ha of which 44 Ha is Lagoon
Bioregion		Robinvale Plains
Conservation status		Mallee Regional River Health Strategy Priority Wetland
Land status		Murray River Park
Land manager		Parks Victoria
Surrounding land use		Irrigated horticulture and olive processing
Water supply		Regulated inflows from Murray River ctf<8000ML/day downstream of Euston weir (river gauge #414203)
1788 wetland category		Permanent Open Freshwater
1994 wetland category and sub-category		Open Freshwater - shallow
Current wetland classification	**Aquatic system**	Palustrine
	Salinity regime	Fresh
	Water regime	Permanent
Wetland depth at capacity		4 m maximum

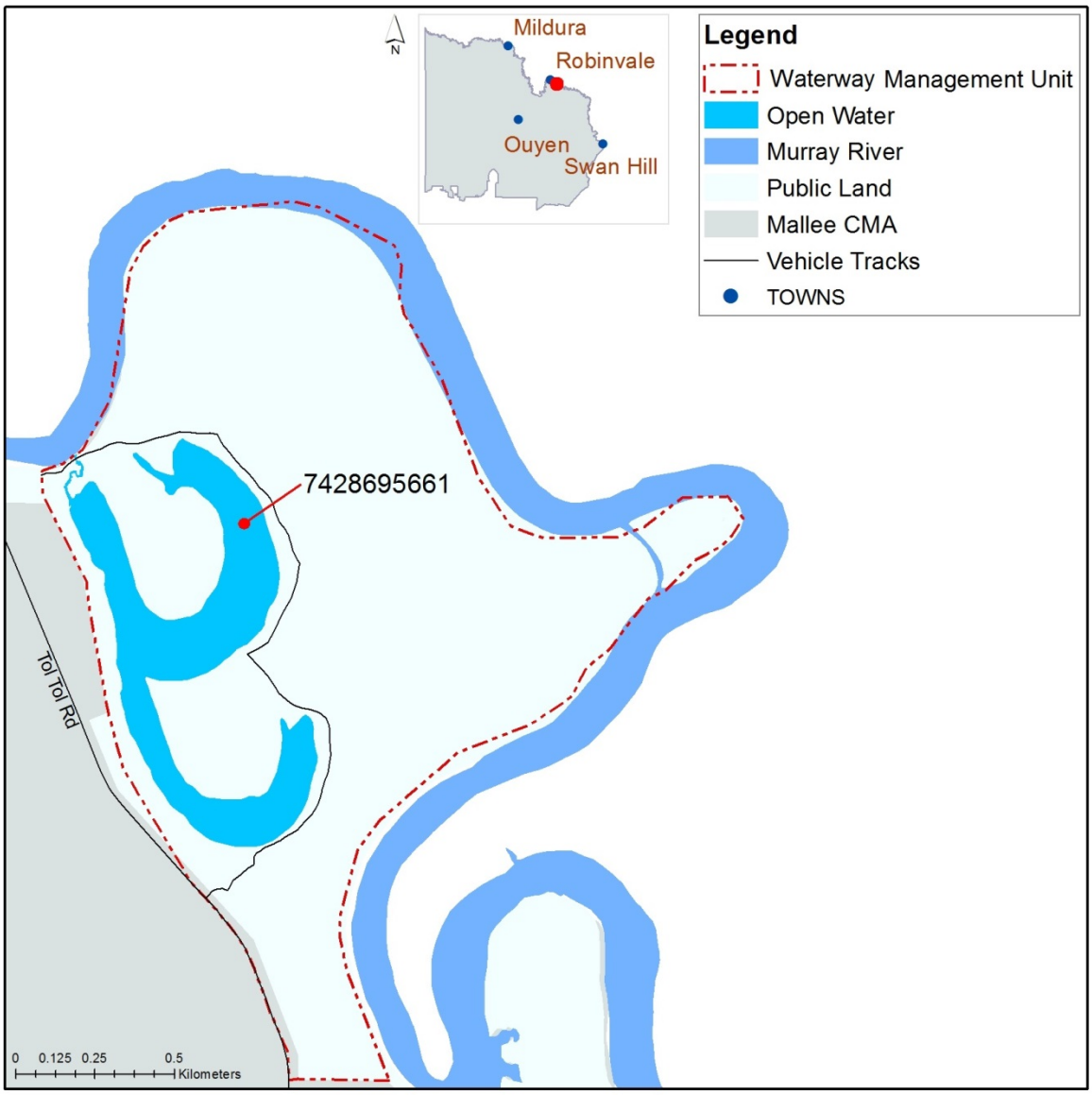

Figure 5 - Margooya Lagoon Wetland Classification

2.7 Management Scale

The Margooya Lagoon floodplain comprises 320 hectares and has a water requirement as a floodplain complex (Mallee CMA, 2014). The focus for this plan is restricted to the maximum extent of the Margooya Lagoon wetland of approximately 44ha (see Figure 6).

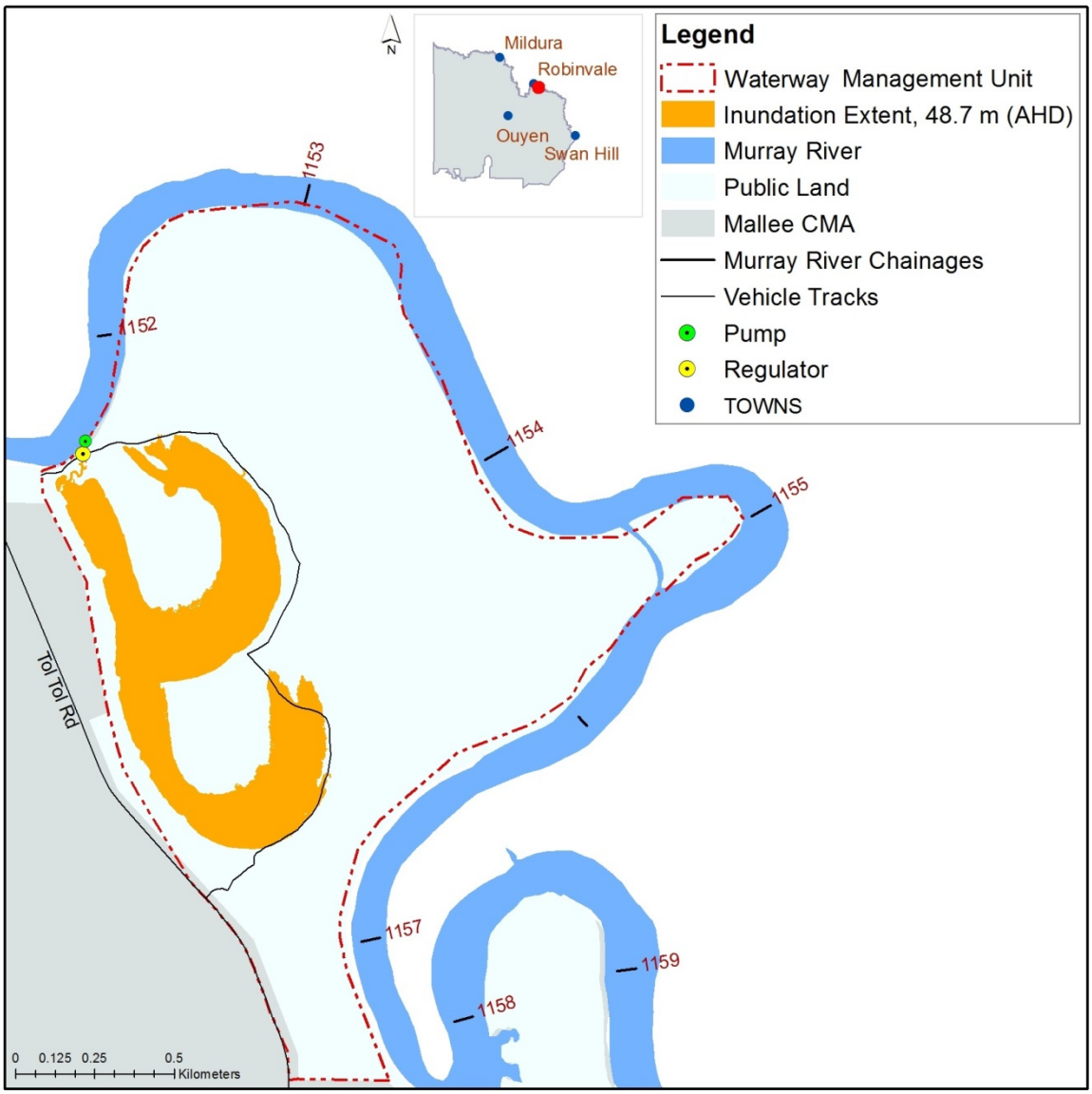

Figure 6 - Margooya Lagoon target area (Inundation areas)

2.8 Environmental Water Sources

The Environmental Water Reserve (EWR) is the legally recognised amount of water set aside to meet environmental needs. The Reserve can include minimum river flows, unregulated flows and specific environmental entitlements. Environmental entitlements can be called out of storage when needed and delivered to wetlands or streams to protect their environmental values and health.

The Victorian Minister for Environment, Climate Change and Water appoints Commissioners to Victoria's independent body for holding and managing environmental water – the Victorian Environmental Water Holder (VEWH). The VEWH is responsible for holding and managing Victoria's environmental water entitlements, and making decisions on their use.

Environmental Water for Margooya Lagoon may be sourced from the water entitlements and their agencies listed in Table 4 which is further explained in the Regional Context Document for Environmental Water Management Plans (Sunraysia Environmental 2014).

Table 4 - Summary of environmental water sources available to Margooya Lagoon*

Water Entitlement	Responsible Agency
River Murray Unregulated Flows	Murray Darling Basin Authority
Murray River Surplus Flows	
Victorian River Murray Flora and Fauna Bulk Entitlement	Victorian Environmental Water Holder
Commonwealth water	Commonwealth Environmental Water Holder
Donated Water	Victorian Environmental Water Holder

* Other sources of water may become available through water trading or changes in water entitlements.

2.9 Related Agreements, Policy, Plans and Activities

There are a range of international treaties, conventions and initiatives, as well as National and State Acts, policies and strategies, that determine management of the target area. Those with particular relevance to Margooya Lagoon and the management of its environmental values are listed in Table 5. For the functions and major elements of each refer to the Regional Context Document (Sunraysia Environmental 2014).

Table 5 - Legislation, agreements, convention and listings relevant to Margooya Lagoon

Legislation, Agreement or Convention	Jurisdiction
China-Australia Migratory Bird Agreement (CAMBA)	International
Environment Protection and Biodiversity Conservation Act 1999 (EPBC)	National
Flora and Fauna Guarantee Act 1988(FFG)	State
Department of Environment, Land, Water and Planning advisory lists (DELWP)	State

Margooya Lagoon is situated on the Victorian floodplain of the Murray River, an area where there have been multiple environmental investigations. These include fish surveys, flora and fauna surveys. An investigation into River Red Gum Health by the Victorian Environmental Assessment Council (VEAC) in 2008 resulted in Margooya Lagoon being declared as Regional Parks in 2010.

Margooya Lagoon has received significant investment through the Mallee CMA Wetland Restoration program. An environmental water regulator was constructed in July 2009 in partnership with Parks Victoria and the local indigenous community. The regulator enables the lagoon to be operated independently of the operation of the Lock 15 weir pool. The regulator can be used to extend the inundation extent to the floodplain and excludes carp (facilitating establishment of aquatic plant species and improvement in water quality). Environmental water was delivered and maintained in the lagoon in the spring and autumn 2009/10 allocations. An adaptive management plan was prepared to guide operation of water levels, responses to flood flows and operation of the carp screen.

An extensive monitoring program was established to assess the restoration of the lagoon and surrounding floodplain. Waterbird monitoring surveys began in November 2009, by the Mid-Murray Field Naturalists. Aquatic vertebrate surveys (fish, turtles and frogs) were conducted in October and December 2009 (MDFRC 2010). Frog surveys have been conducted at one site since September 2008. Opportunistic fauna sightings were recorded during the GHD surveys in May 2008 (GHD 2008). Macroinvertebrates have been monitored twice, in October 2008 and December 2009, at 3 sites (GHD, 2008). Photopoints, water quality monitoring and vegetation transects have also been established by the Mallee CMA. White-bellied Sea-Eagles, Regent Parrots and Diamond Firetails, all of which are threatened species, were recorded during these surveys. These reports form a valuable source of baseline data on which future monitoring can be compared.

A recent survey (MDFRC 2011) of fish movement between the lagoon and the main river channel has highlighted the importance of these connected wetlands as nursery habitat for the recruitment of native fish including some species of conservation significance. The report recognises not only the importance of maintaining water quality but that the timing of the filling and draining of the lagoon need to be considered to maximise the recruitment opportunities for native fish.

The following plans and activities are relevant to the environmental management of Margooya Lagoon.

Investigation of Water Management Options for the River Murray – Robinvale to Wallpolla Island

In 2006, Mallee CMA engaged consultants Ecological Associates to investigate water management options for the floodplain of the Murray River from Nyah to Robinvale. This investigation proposed infrastructure to enable greater inundation of the target area in Margooya Lagoon which is outlined as part of this plan.

Mallee Catchment Management Authority Frontage Action Plan

The Mallee CMA has established a program to monitor frontage works sites and associated control sites on the River Murray (GHD 2015). The Mallee CMA can utilise this data when determining funding for future frontage works, capacity building in the community and assessing biophysical change within the river frontage.

Margooya Lagoon is within the area covered by the Mallee CMA Frontage Action Plan Nyah to Robinvale (MCMA 2003) and has the potential to attract future funding and works through that project.

This action plan incorporates a range of actions to enhance riparian frontage of the Murray River. (Mallee CMA, 2003).

3. Hydrology and System Operations

Wetland hydrology is the most important determinant in the establishment and maintenance of wetland types and processes. It affects the chemical and physical aspects of the wetland which in turn affects the type of flora and fauna that the wetland supports (DEPI 2005). A wetland's hydrology is determined by its morphology, surface and groundwater inflows and outflows in addition to precipitation and evapotranspiration (Mitsch and Gosselink, 2000 in DEPI 2005). Duration, frequency and seasonality (timing) are the main components of the hydrological regime for wetlands and rivers.

The target area within the Margooya Lagoon floodplain management unit is located on the Victorian floodplain of the Murray River (chainage 1,158 km to 1,151 km) between river gauges at Boundary Bend (#414201) and Euston Weir (#414203).

3.1 Water management and delivery

3.1.1 Pre-regulation

Margooya Lagoon is within a meander loop of the Murray River. Prior to river regulation the floodplain experienced inundation during high flow periods, more frequently than it currently does. Under natural conditions inundation events were more frequent (Ecological Associates, 2006) and would have receded to include dry phases between these high flow events. This wetting and drying cycle provided conditions for the recruitment and preservation of the floodplain and wetland species of episodic floodplain wetlands. The natural commence to fill (ctf) for the lagoon is <8,000 ML/day downstream of Euston weir (River gauge # 414203).or 47.6m AHD upstream of the weir (Green and Alexander, 2006).

3.1.2 Post-regulation

Margooya Lagoon has been permanently inundated since the lock and weir were installed in Euston in 1937. Whilst some variability in the weir pool levels occurs, this has resulted in inundation periods which have long duration and short intervals between spells (Ecological Associates, 2006).

The commence to fill (ctf) for the lagoon is <8000ML/day downstream of Euston weir (River gauge # 414203).or 47.6 mAHD upstream of the weir (Green and Alexander, 2006) which is less than the operating level of the river.

The seasonal pattern of flow has remained the same with higher flows in winter and spring, lower during autumn and summer but at elevated levels throughout the year compared with natural conditions (Figure 7).

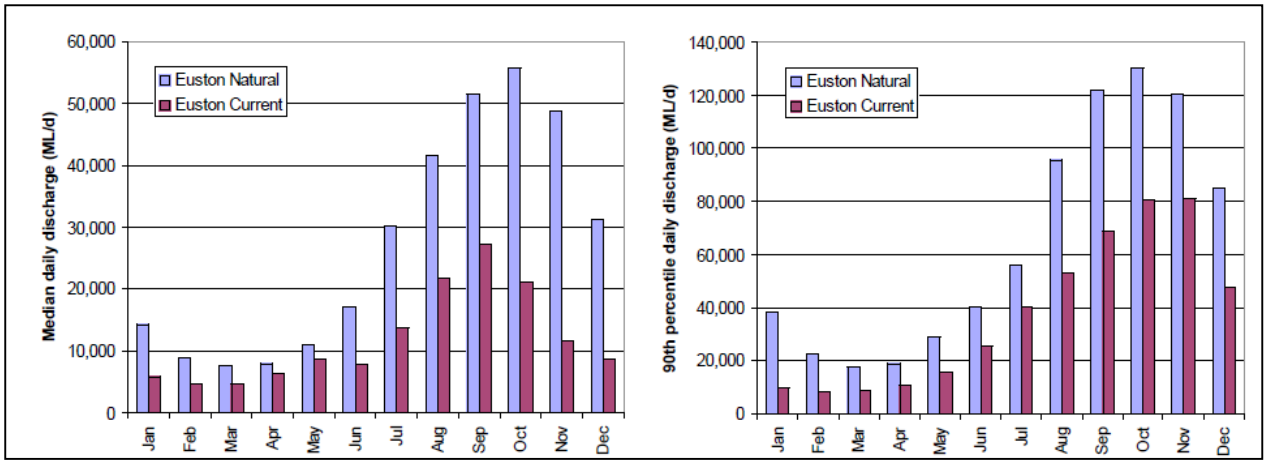

Figure 7 - Distribution of median flows and 90th percentile flows for each month in the River Murray through Euston Weir for natural and current (benchmark) conditions
*Source: derived from MDBC MSM-Bigmod 109-year-data (EA 2007b).

Temporary earth banks were used to disconnect Margooya Lagoon from the river and allowed a drying period of 15 months in 2007/2008.

In 2009, a permanent regulator was installed in the inlet to disconnect the wetland from the Murray River (Figure 8). The regulator enables the lagoon to be operated independently of the operations of the Euston weir pool. It also extends the inundation extent to the Margooya floodplain. A screen within the regulator reduces the number of carp entering the lagoon facilitating establishment of aquatic plant species and improvement in water quality.

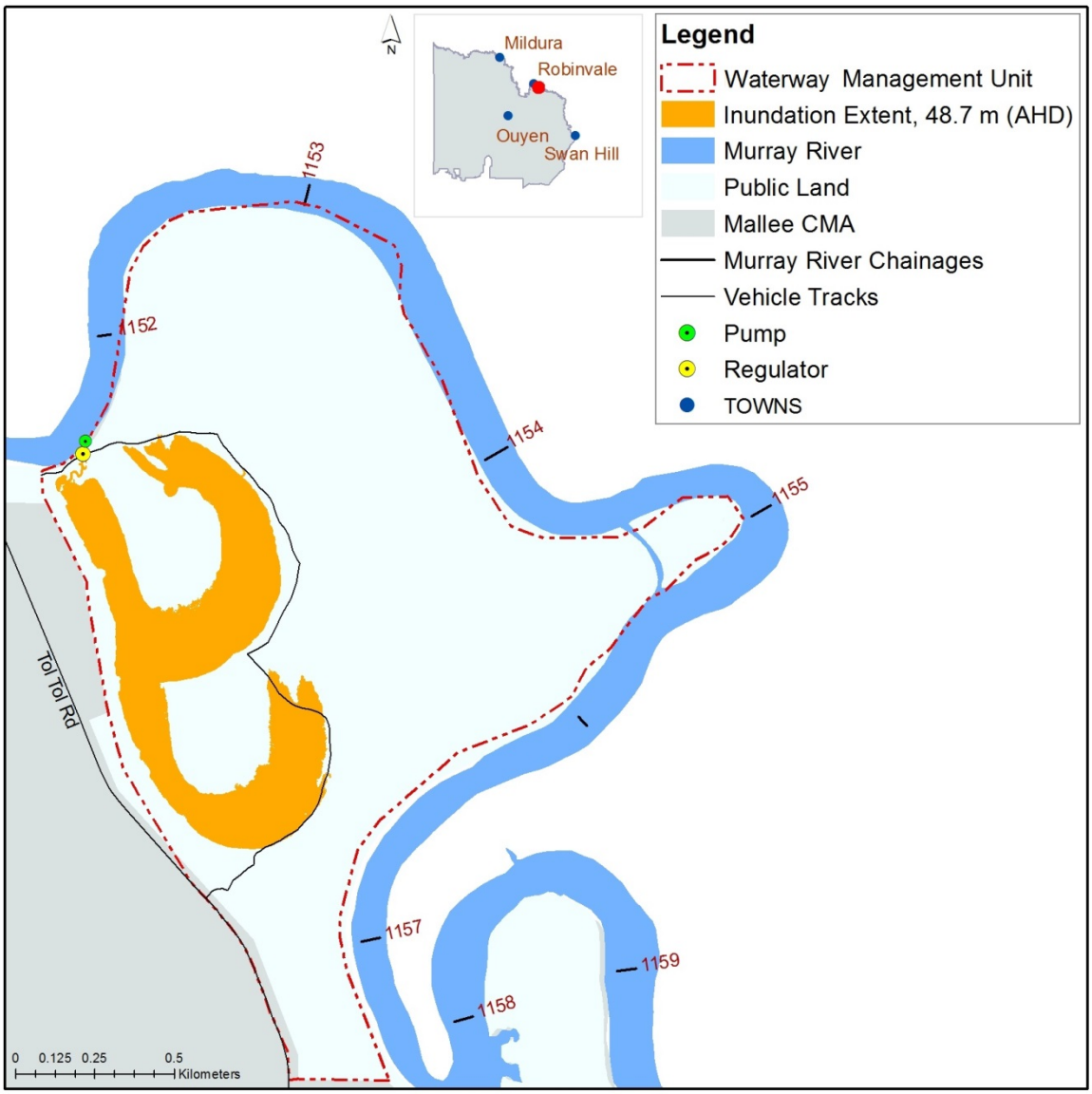

Figure 8 - Margooya Lagoon Inundation Extent

3.1.3 Environmental watering

The regulator which has been installed at the inlet to the lagoon enables disconnection from the Murray River. Operation of the regulator provides the ability to introduce a more natural wetting and drying cycle.

A drying cycle was implemented to remove large carp once the regulator was installed and commissioned. Environmental water was received and maintained in the lagoon in the spring and autumn 2009/10 allocations. In accordance with the Margooya Lagoon Operating Plan 2009/10, a maximum inundation event requiring 0.3 GL was carried out in Autumn 2010 (Table 6). This capitalised upon the spring 2009 watering by the continued provision of a drought refuge and prevention of critical loss of the River Red Gum, by extending the inundation to not only the red gum fringing the wetland but also up into the red gum that occupies the floodplain with a chenopod understorey.

Additional benefits included protection of many cultural heritage registered sites, mostly living scar trees and an improvement in the native fish population as outlined in Figure 9

Table 6 - Margooya Lagoon environmental Watering history

Water year	Time of inflow	Inflow source	Source volume (ML)	Total volume (ML)	Cost of delivery ($/ML)	Area (Ha) Inundated	Comments
2009/10	spring 2009	EWR	577.0	1053	$30 - 45**	44.42	Regulator installed in Winter 09
		RMOL*	476.0				
	autumn 2010	EWR	335.7	335.7		44.42	

*RMOL = River Murray Operating Losses

**the cost of delivery is dependent on factors such as fuel prices, river heights, site access, type of pump required, volume to be pumped etc.

Since 2009, the following has occurred with respect to wetting and drying of Margooya Lagoon:

- 2009/10 – Wetland filled via flooding due to high flows in the Murray River;
- 2010/11 – Wetland remained wet due to flooding;
- 2011/12 – Wetland went through drying phase;
- 2012/13 – Wetland inundated;
- 2013/14 – Partial dry;
- 2014/15 – Partial dry and complete dry by 2015;
- 2015/16 – Wetland inundated.

In general the operating regime is to open the regulator in June/July and close it from December to May.

4. Water Dependent Values

4.1 Environmental Values

Wetlands and waterways on the floodplain are a vital component of the landscape supporting a diversity of flora and fauna which may vary greatly with the type of wetland/waterway system. The habitat provided by vegetation communities around wetlands is essential for maintaining populations of water dependent fauna species. Other ecological functions provided by floodplain complexes include water filtration, slowing surface water flow to reduce soil erosion, flood mitigation and reducing nutrient input into waterways. Protecting the ecological functioning of wetlands ensures these vital services are maintained.

The Margooya Lagoon WMU covers approximately 320 hectares of floodplain flats, floodplain creeks and a 44 hectare wetland which contains significant flora and fauna communities listed in various legislation, agreements or conventions.

4.1.1 Listings and significance

Fauna

Margooya Lagoon consists of a series of wetlands and creeks that provide habitat for a large range of fauna. Native species recorded in the area are listed in Appendix 1. Few water dependent terrestrial species have been identified in surveys. A number of species that are commonly associated with water or riparian habitats have been previously documented to occur (MCMA 2010 – Appendix 3).

Of special interest and responsibility are the species listed in legislation previously recorded at Margooya Lagoon (MCMA 2010) (Table 7)[1]

Table 7 - Listed fauna recorded at site (MCMA 2010)

Scientific Name	Common Name	EPBC	FFG	DELWP
Polytelis anthopeplus monarchoides	Regent Parrot (eastern)*	VU	L	VU
Haliaeetus leucogaster	White-bellied Sea-eagle*		L	VU
Stagonopleura guttata	Diamond Firetail		L	NT

Legend
EPBC status: Vulnerable
FFG status: Listed as threatened
DELWP status Vulnerable, Near Threatened

*Species are included as they are dependent on habitats that are water dependent

These species are considered water dependent because they forage or nest in or over water, or require flooding to trigger breeding and fledging. The details of the relationship of these species and their water requirement are detailed below.

[1] NB records from databases have not been included.

Regent Parrot

The Regent Parrot is listed as nationally vulnerable under the EPBC Act. In Victoria the total population of the Regent Parrot is estimated at to be fewer than 350 breeding pairs (DotE 2015).The species is reliant on the habitat provided by River Red-gum communities which fringe Margooya Lagoon. The species is regularly observed at the wetland which is close to known breeding areas further up and downstream along the Murray River. DotE (2015a) describes the primarily habits as riparian or littoral River Red Gum (*Eucalyptus camaldulensis*) forests or woodlands and adjacent Black Box (*E. largiflorens*) woodlands. Nearby open mallee woodland or shrubland, usually with a ground cover of spinifex (*Triodia*) or other grasses, supporting various eucalypts, especially Christmas Mallee (*E. socialis*) and Yellow Mallee (*E. costata*) Mallee, as well as Belah (*Allocasuarina cristata*), Buloke (*A. leuhmannii*) or Slender Cypress Pine (*Callitris preissii*) also provide important habitat for this subspecies. They often occur in farmland, especially if the farmland supports remnant patches of woodland along roadsides or in paddocks.

Nests are most often located in River Red Gum (*Eucalyptus camaldulensis*), and occasionally in Black Box (*E. largiflorens*), usually within 16 m of permanent water, or sometimes actually standing in water. Nest sites may sometimes occur near temporary water sources, such as ephemeral streams or seasonal billabongs, but these are usually within about 60 to 100 m of permanent water sites (Beardsell 1985; Burbidge 1985; Webster 1993; Webster & Leslie 1998 as referenced within DotE 2015a). Nest trees are typically large (>150 cm diameter at breast height (DBH) and approximately 30 m tall) (Sluiter et al. 2007 as referenced within DotE 2015a). Generally, about one-third of nests are in dead trees, but there is much variation between sites and between years (Burbidge 1985 as referenced within DotE 2015a). In South Australia, this subspecies mainly nests in dead trees (Higgins 1999 as referenced within DotE 2015a) but is also known to have nested in holes in cliffs along the Murray River (Campbell 1900; Ross & Howe 1930 as referenced within DotE 2015a). Many breeding colonies, assumed to be traditional nesting sites, are in areas that have become drowned as a result lock and weir construction on the Murray River, although it is likely that birds have continued to nest at these sites in trees that are now dead (Higgins 1999; Smith 2001 as referenced within DotE 2015a).

The Regent Parrot was observed during surveys of the lagoon in 2008 (GHD 2008) and was documented to be locally common and considered likely to forage, nest and seek refuge at Margooya Lagoon utilising vegetation corridors in the area to access areas of mallee away from the floodplain (GHD 2008).

White-bellied Sea-Eagle

The White-bellied Sea-Eagle is distributed along the coastline (including offshore islands) of mainland Australia and Tasmania. It also extends inland along some of the larger waterways, especially in eastern Australia. The inland limits of the species are most restricted in south-central and south-western Australia, where it is confined to a narrow band along the coast (Barrett et al. 2003; Bilney & Emison 1983; Blakers et al. 1984; Marchant & Higgins 1993 as referenced within DotE 2015b). Recent analysis indicates that the distribution of the sea-eagle may shift in response to climatic conditions, with an apparent decreased occupancy of inland sites (and increased occupancy of coastal sites) during drought conditions (Shephard et al. 2005a as referenced within DotE 2015b).

The White-bellied Sea-eagle requires healthy River Red Gum for nesting as well as relying on the lagoon itself for feeding (fish). Wetting and drying is beneficial, with greater fish availability during the drying phase. Three individuals of this species (a pair and a sub adult) were recorded during surveys in 2008 (GHD 2008).

Breeding has been recorded from only a relatively small area of the total distribution. Breeding records are patchily distributed, mainly along the coastline, and especially the eastern coast, extending from Queensland to Victoria, and to Tasmania. Breeding has also been recorded at some sites further inland, e.g. around the Murray, Murrumbidgee and Lachlan Rivers in northern Victoria and south-west NSW, and at other large drainage systems and water storages (Marchant & Higgins 1993 as referenced within DotE 2015b). Although known breeding sites are widely dispersed, the species could potentially breed throughout much of its range (Birds Australia 2006c, pers. comm as referenced within DotE 2015b.).

Birds have been recorded at or in the vicinity of freshwater swamps, lakes, reservoirs, billabongs, saltmarsh and sewage ponds (Boekel 1976; Favaloro 1944; Gosper 1981; Marchant & Higgins 1993 as referenced within DotE 2015b). Terrestrial habitats include coastal dunes, tidal flats, grassland, heathland, woodland, forest (including rainforest) and even urban areas (Bell 1984a; Czechura 1984a; Harris 1980; Johnson & Hooper 1973; Longmore 1978; Quinn 1969; Roberts & Ingram 1976; Smith 1984 as referenced within DotE 2015b).

Breeding has been recorded on the coast, at inland sites, and on offshore islands (Marchant & Higgins 1993 as referenced within DotE 2015b). Breeding territories are located close to water, and mainly in tall open forest or woodland (Emison & Bilney 1982; Marchant & Higgins 1993 as referenced within DotE 2015b).

The White-bellied Sea-Eagle generally forages over large expanses of open water; this is particularly true of birds that occur in coastal environments close to the sea-shore, where they forage over in-shore waters (Marchant & Higgins 1993; Smith 1985 as referenced within DotE 2015b). However, the White-bellied Sea-Eagle will also forage over open terrestrial habitats (such as grasslands) (Marchant & Higgins 1993; Sedgwick 1978 as referenced within DotE 2015b). Birds may move to and congregate in favourable sites during drought or food shortage (del Hoyo et al. 1994; Ferguson-Lees & Christie 2001; Marchant & Higgins 1993; Shephard et al. 2005a as referenced within DotE 2015b).

Diamond Firetail

The Diamond Firetail is endemic to south-eastern Australia, ranging from Carnarvon Ranges in Queensland to the Eyre Peninsula and Kangaroo Island in South Australia. Diamond Firetails are found in open grassy woodland, heath and farmland or grassland with scattered trees (Birdlife Australia 2015). They are often found in riparian areas (OEH 2015). The species is reliant on the habitat provided by the River Red Gum communities which fringes Margooya Lagoon and on native grasses fringing the lagoon for foraging. Diamond Firetails feed on the ground and generally eat ripe or partially ripe seeds and can be seen hopping around on the ground. They occasionally eat insects and their larvae. The nest can be found in trees and shrubs with dense foliage and has sometimes been known to build in the base of a raptor's nest (Birdlife Australia 2015). This species is infrequently observed within the catchment but appears to be a regular visitor to Margooya Lagoon. This species was recorded at Margooya Lagoon (GHD 2008) and is considered likely to regularly visit the wetland.

Other

A number of other terrestrial fauna species are considered likely to occur at Margooya Lagoon but which were not recorded during the most recent terrestrial survey (GHD 2008). The following species of conservation significance are considered likely to make use of the site are provided in Table 8. Many of these species are strictly water dependent others may rely on flood events or other characters of the water ecosystem for foraging or to trigger biological events such as breeding. Some species are only expected to make occasional use of the site as a rare visitor occasionally making use of the available habitats or as a more regular visitor likely to make use of the site following inundation. The full list of species considered and further information on rationale is provided within GHD 2008. A full list of all fauna previously recorded within the WMU is provided in Appendix 1.

Table 8 - Fauna of conservation significance considered Possible or Likely to occur at Margooya Lagoon as detailed in GHD 2008

Scientific Name	Common Name	EPBC	FFG	DSE
MAMMAL				
Nyctophilus corbeni	South-eastern Long-eared Bat	VU	L	EN
BIRD				
Lathamus discolor	Swift Parrot	EN	L	EN
Ardea modesta	Eastern Great Egret	Mi	L	VU
Oxyura australis	Blue-billed Duck		L	EN
Stictonetta naevosa	Freckled Duck		L	EN
Falco hypoleucos	Grey Falcon		L	EN
Pomatostomus temporalis	Grey-crowned Babbler		L	EN
Ardea intermedia	Intermediate Egret		L	EN
Egretta garzetta	Little Egret		L	EN
Oreoica gutturalis	Crested Bellbird		L	NT
Geopelia cuneata	Diamond Dove		L	NT
Melanodryas cucullata	Hooded Robin		L	NT
Cacatua leadbeateri	Major Mitchell's Cockatoo		L	VU
Struthidea cinerea	Apostlebird		L	
Melithreptus gularis	Black-chinned Honeyeater			NT
Chrysococcyx osculans	Black-eared Cuckoo			NT
Nycticorax caledonicus	Nankeen Night Heron			NT
Phalacrocorax varius	Pied Cormorant			NT
Todiramphus pyrrhopygia	Red-backed Kingfisher			NT
Platalea regia	Royal Spoonbill			NT
Anas rhynchotis	Australasian Shoveler			VU
Falco subniger	Black Falcon			VU
Lichenostomus plumulus	Grey-fronted Honeyeater			VU

Aythya australis	Hardhead			VU
Biziura lobata	Musk Duck			VU
REPTILE				
Morelia spilota metcalfei	Carpet Python		L	EN
FROGS				
Litoria raniformis	Growling Grass Frog	VU	L	EN
Limnodynastes fletcheri	Barking Marsh Frog			
INVERTEBRATE				
Notopala sublineata	River Snail		L	CR

Legend
EPBC status: Endangered, Vulnerable, Migratory
FFG status: Listed as threatened
DELWP status Endangered, Vulnerable, Near Threatened

Fish

The natural fish community expected in an episodic floodplain wetland such as Margooya Lagoon has been altered by the inundation for the Euston weir pool. Pest species such as European Carp have invaded the wetland. Recent monitoring of Margooya Lagoon by the Murray Darling Freshwater Research Centre (MDFRC 2011) has indicated some improvement in native fish populations after the regulator with carp screen was installed enabling the introduction of a drying phase and some exclusion of carp (Figure 9). Further monitoring and investigation of fish populations is required under the new regime (MCMA 2010).

Common name	Scientific name	May 2004 prior to reg.	Dec 2009 Full	April 2010 draining (slow)	June 2010 filling (pumped)	October 2010 draining (moderate)	November 2010 filling (river flows)
Golden perch	*Macquaria ambigua*		6	3	2	12	1
Silver perch	*Bidyanus bidyanus*		9	10			
Bony herring	*Nematalosa erebi*	✓	1	9	4		
Goldfish*	*Cyprinus carpio*	✓	4				
Carp*	*Carassius auratus*		34			10	3
Unspecked hardyhead	*Craterocephalus stercusmuscarum fulvus*	✓		125	6	100	12
Carp gudgeon	*Hypseleotris spp.*	✓	54	535	61	938	292
Flathead gudgeon	*Philypnodon grandiceps*	✓					
Australian Smelt	*Retropinna semoni*		1	2			
Oriental Weatherloach*	*Misgurnus anguillicaudatus*		12	2			4
Gambusia*	*Gambusia holbrooki*	✓	1	637	7	57	400

Figure 9 - Standardised fyke net (catch per 20 net hours) catch for each fish community surveyed in Margooya Lagoon. * denotes exotic species.(MDFRC 2011 as presented in MCMA 2010)

A regional survey of aquatic vertebrates in 2004 found three native fish species at Margooya Lagoon. These were Carp Gudgeon (*Hypseleotris* spp.), Fly-specked Hardyhead (*Craterocephalus stercusmuscarum*) and Flathead Gudgeon (*Philypnodon grandiceps*) (Ho et al. 2004). These species prefer slow-flowing or still waters such as billabongs and floodplain wetlands. Aquatic macrophytes and woody debris are important to small fish to provide shelter, a food source and a substrate for attachment of eggs during spawning (Rogers & Ralph 2011). The presence of small fish in floodplain wetlands is also important for waterbird diversity as they make up a large portion of the diet of many waterbirds species (MDBC 2001).

The drying and re-wetting of wetlands is likely to support recruitment of native fish (DEWNR 2012), but their persistence may be temporary depending on the ongoing water regime. Occurrences of threatened native fish (Silver Perch) have declined since 2009. Silver Perch were recorded within the lagoon again in 2011 (Ecological objectives doc 2015).

Higher numbers of native fish are recorded in drainage cycles when compared to filling cycles within the lagoon. It appears that with the carp screen installed and regular wetting and drying that native fish diversity can be supported.

Assessment in 2008 by GHD (GHD 2008) determined that four fish species of conservation significance are expected to make use of Margooya Lagoon occasional especially after inundation (Table 9).

Table 9 - Fish of conservation significance expected to make use of Margooya Lagoon from GHD 2008

Scientific Name	Common Name	Conservation Status		
		EPBC	FFG	DELWP
Macquaria australasica	Macquarie Perch	EN	L	EN
Maccullochella peelii	Murray Cod	VU	L	VU
Bidyanus bidyanus	Silver Perch		L	VU
Macquaria ambigua	Golden Perch			NT

Legend
EPBC status: Endangered, Vulnerable
FFG status: Listed as threatened
DELWP status Endangered, Vulnerable, Near Threatened

Filling of Margooya Lagoon during August 2011 resulted in a different response of fish species than those demonstrated in previous surveys. Assessment of directional movement detected golden perch moving between the river and wetland. Carp were recorded predominantly from the wetland to the river. Carp Gudgeon were predominantly moving into the lagoon, probably involuntarily with high inflows. After the in-flow rate through the regulator decreased (Day 3) Bony Herring were entering the wetland and Australian Smelt were moving in both directions.

These movement patterns may indicate depletion of suitable habitat and resources within the wetland habitat during this even and similar conditions (availability of food and refuge habitat) across the river channel and wetland environments (MDFRC 2011).

Frogs

Six species of native frog have been recorded at Margooya Lagoon including the State and Commonwealth listed Growling Grass Frog, *Litoria raniformis*. The diversity of frog species and the presence of the Growling Grass Frog, which has suffered major declines throughout the Murray-Darling Basin (Rogers & Ralph 2011), is of significant ecological value. Like most flood dependent species frogs respond to the timing, duration and frequency of flooding, with the timing of inundation being the most significant factor. Close proximity to permanent waterbodies and drought refuges is also important for frogs. Aquatic vegetation complexity is important for many species, particularly at tadpole stage, and can drive occupancy patterns and recruitment success (Tarr & Babbitt 2002, cited in Rogers & Ralph 2011).

The EPBC Act listed Growling Grass Frog, is usually found in seasonally flooded wetlands with complex aquatic vegetation communities and relies on drought refuges to survive dry periods. The Growling Grass Frog is particularly sensitive to changes in wetland hydrology and prefers annual flooding and long periods of inundation (five to seven months) due to a long larval phase. This frog requires flooding in spring/summer for successful recruitment as this is when it is active and breeding takes place. It can be excluded from wetlands under reduced flood frequency (Rogers & Ralph 2011).

Frogs are considered to be good indicators of environmental health and may act as 'sentinel' species for secondary salinisation (DSE 2006). A study by the Arthur Rylah Institute (2006) found that salinity levels up to 3000 EC did not limit amphibian occupancy but amphibian diversity declined significantly between 3000 and 6000 EC.

During the 2008 survey (GHD 2008) habitats for amphibians was found to be generally limited compared to when Margooya Lagoon is inundated, however, during inundation events several species would be expected including Spotted Marsh Frog (*Limnodynastes tasmaniensis*), Plain's Froglet (*Crinia parinsignifera*), Peron's Tree Frog (*Litoria peronii*) and Southern Bullfrog (*Limnodynastes dumerilii dumerilii*). Each of these four species of frog are expected to respond favourably to managed flows. The dense vegetation along the wetland edge remains sufficiently damp to support several species such as the Plain's Froglet (*Crinia parinsignifera*).

Waterbirds

The absence of a drying cycle within the floodplain wetland can have a negative impact on flora and fauna (Kingsford 2000). Floodplain vegetation begins to die through prolonged inundation, productivity declines and although a few waterbirds may benefit (e.g. fish feeding species), most decline (GHD 2008).

Australia's waterbirds are often nomadic and take advantage of highly variable and often temporary aquatic resources. The distribution of temporary habitat patches throughout the landscape may facilitate movement and exploitation of available resources for waterbirds (Roshier et al. 2001). The provision of environmental water to wetlands is one method of creating such habitat patches for waterbirds, allowing them to move between suitable habitat to survive and reproduce (MDBA 2009). Taft et al. (2002, cited in MDBA 2009) states that wetland management which increases the diversity of available habitat types such as variable water depths, mud flats, inundated vegetation and deep water areas have the greatest abundance and diversity of waterbirds. For this reason drawdown patterns are important as they change habitat types and influence waterbird presence (MDBA 2009). Exposed mud flats and fringing vegetation provide ideal feeding grounds for wading birds upon drawdown (DEWNR 2012). Nine species of waterbird were observed in the most recent surveys (GHD 2008) including the EPBC migratory and FFG listed White-bellied Sea-eagle.

Margooya Lagoon has historically supported a diverse range of waterbirds with 24 species recorded in the species list for this site (Appendix 1).

Nankeen Night Herons utilise shallow water for foraging and breed in colonies building stick nests over water (Pizzey and Knight 2007). They are nomadic in response to rainfall and flooding of suitable habitat. Breeding usually occurs from September to February. Nankeen Night Herons have a minimum lag time to breeding of three months from flood, and breeding success is significantly enhanced by longer durations of inundation, up to 12 months (Rogers & Ralph, 2011).

Great Egrets breed on a stick platforms built over water, usually between November and February (Pizzey & Knight 2007). They have a preference for permanent water sites, and forage in water up to 30 cm deep (Rogers & Ralph 2011). Fish are a significant part of the diet (Rogers & Ralph 2011). Nests are built in the forks of trees over water, in colonies (which can be of mixed species). Long lag times for breeding have been recorded, though this may be variable depending on whether flooding occurs during the optimal breeding season of November to May or whether it occurs outside of the main breeding season (in which case the lag period is longer) (Rogers & Ralph 2011). Minimum flood duration needs to be six to seven months to support breeding (Rogers & Ralph 2011).

Vegetation communities

Ecological Vegetation Classes (EVCs) were developed by the state of Victoria in 1994 and have been utilised since for mapping floristic biodiversity. Vegetation communities are grouped based on structural, floristic and ecological features. DELWP has defined all of the EVCs within Victoria.

The status of ecological vegetation classes (EVCs) with the Margooya Lagoon WMU are mainly depleted within the Robinvale Plains bioregion. A map of the EVCs within the Margooya Lagoon target area is shown in Figure 10 and a summary of the water-dependent EVCs and their status can be found in Table 10. Refer to Appendix 2 for the full EVC description.

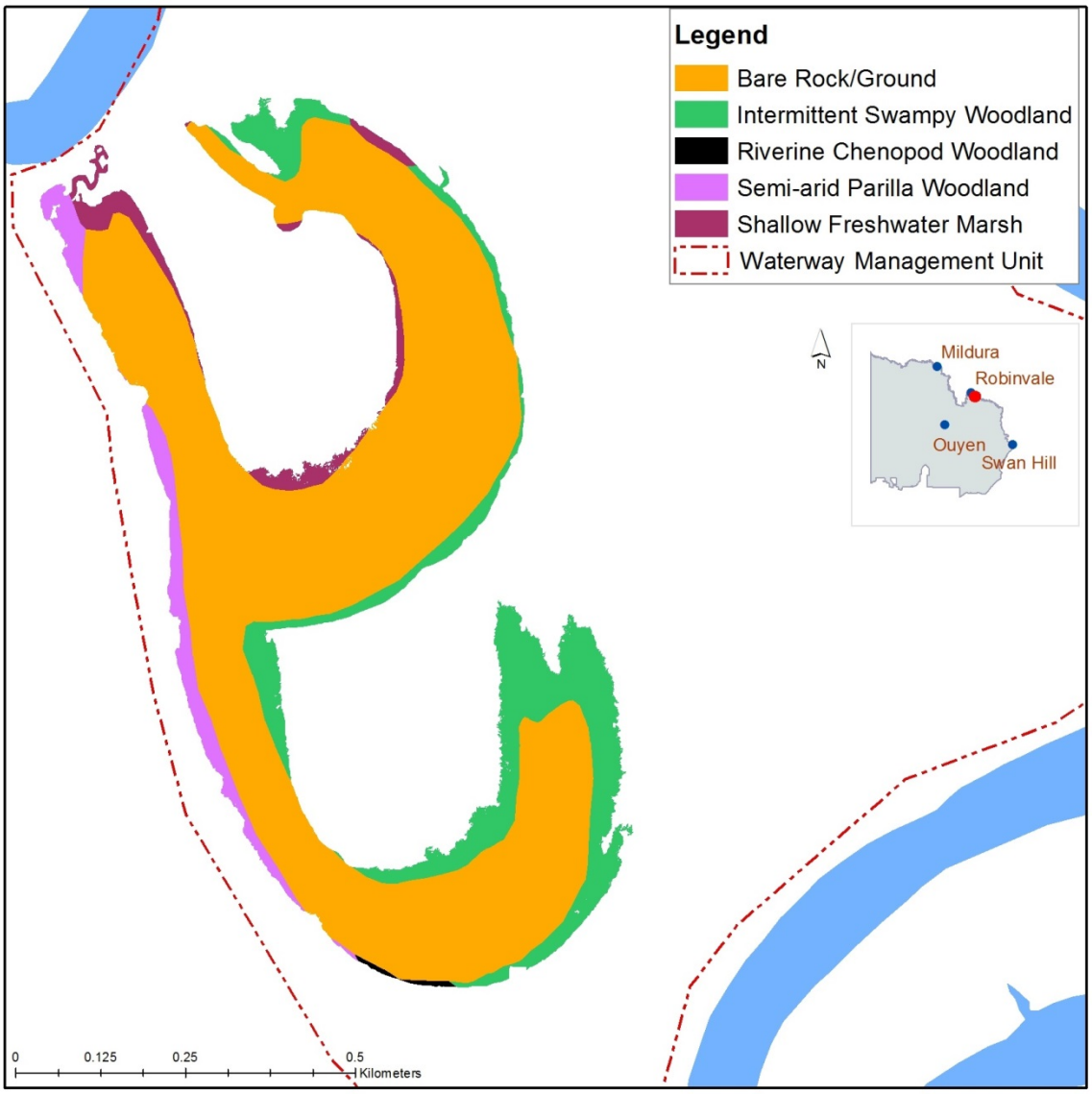

Figure 10 - Ecological Vegetation Classes (EVCs) present within Margooya Lagoon

Table 10 - Conservation status of EVCs in the target area (Robinvale Plains Bioregion)

EVC no.	EVC name	Water Dependent	Conservation Status
98	Semi-arid Chenopod Woodland	No	Vulnerable
200	Shallow Freshwater Marsh	Yes	Vulnerable
828	Semiarid Parilla Woodland	No	Vulnerable
103	Riverine Chenopod Woodland	Yes	Depleted
295	Riverine Grassy Woodland	Yes	Depleted
810	Floodway Pond Herbland	Yes	Depleted
811	Grassy Riverine Forest/Floodway Pond Herbland Complex	Yes	Depleted
813	Intermittent Swampy Woodland	Yes	Depleted
823	Lignum Swampy Woodland	Yes	Depleted
818	Shrubby Riverine Woodland	Yes	Least concern

Flora

A full list of flora recorded at Margooya Lagoon can be found in Appendix 1. The dominant flora species in the target area is *Eucalyptus camaldulensis* (River Red Gum). This species forms the basis for the water dependent EVCs and is the keystone species of the Murray River floodplain. Protecting and maintaining the health of River Red Gum forests in the region was the target for emergency watering events throughout the prolonged dry period during the 1990s and 2000s.

A variety of EVCs are present within the WMU, leading to a large number of flora species having been recorded at Margooya Lagoon. Four flora species listed under the DELWP Advisory List (DEPI 2014) have been recorded within the WMU (see Table 11). Refer to Appendix 1 for a complete species listing for the site.

The vegetation composition at Margooya Lagoon was described during detailed assessments undertaken in 2008 (GHD 2008).

Wetland Vegetation

The edges of the wetland bed are likely to be more appropriately mapped as Tall Marsh (EVC 821), as this area is currently dominated by large and medium graminoids such as *Typha orientalis* (Broadleaf Cumbungi), *Cyperus exaltatus* (Tall Flat-sedge) and medium herbs such as *Persicaria decipiens* (Slender Knotweed). The ground layer supports a thick carpet of *Glinus lotoides* (Hairy Carpetweed), *Cynodon dactylon* (Native couch) and introduced *Polygonum aviculare* (Wireweed).

Fringing Vegetation

The perimeter of the Margooya Lagoon is fringed by Intermittent Swampy Woodland (EVC 813).

Floodplain Vegetation

Riverine Chenopod Woodland (EVC 103) occurs at higher elevations on the floodplain on the eastern side of the Lagoon and Semi-arid Parilla Woodland (EVC 828) occurs on the Parilla sands to the west of the Lagoon on higher elevations.

Within the northern sections of the Lagoon, Intermittent swampy Woodland is a woodland to 15 m tall dominated by *Eucalyptus camaldulensis* (River Red Gum), over an understorey tree layer of *Acacia stenophylla* (Eumong) to 10 m tall. The ground layer supports medium tufted and non-tufted graminoids such as *Cyperus gymnocaulos* (Spring Flat-sedge) and *Cynodon dactylon* (Native Couch) and scattered small to medium herbs, including *Wahlenbergia fluminalis* (River Bluebell), Brachyscome basaltica (Swamp Daisy), *Vittadinia cuneata* (Fuzzy New Holland Daisy), *Vittadinia dissecta* (Dissected New Holland Daisy) and *Atriplex semibaccata* (Berry Saltbush).

In the southern sections of the Lagoon, Intermittent Swampy Woodland is a Woodland dominated by flora species typical of drier conditions, such as *Eucalyptus largiflorens* (Black Box) and chenopods such as *Rhagodia spinescens* (Hedge Saltbush), *Enchylaena tomentosa* var. *tomentosa* (Ruby Saltbush) and *Atriplex semibaccata* (Berry Saltbush), *Muehlenbeckia florulenta* (Tangled Lignum) is also present.

Table 11 - Listed water dependant flora species recorded at the site (GHD 2008)

Scientific name	Common name	EPBC status	FFG status	DEWLP status
Eremophila divaricata* subsp. *divaricata*	Spreading Emu-bush	NL	NL	R
Lepidium pseudohyssopifolium	Native Peppercress	NL	NL	PK
Teucrium albicaule*	Scurfy Germander	NL	NL	PK

EPBC status: EXtinct, CRitically endangered, ENdangered, VUlnerable, Conservation Dependent, Not Listed
FFG status: Listed as threatened, Nominated, Delisted, Never Listed, Ineligible for listing
DELWP status: presumed EXtinct, Regionally Extinct, Extinct in the Wild, CRitically endangered, ENdangered, Vulnerable, Rare, Near Threatened, Data Deficient, Poorly Known, Not Listed

*Water Dependent

4.1.2 Wetland depletion and rarity

Victoria's wetlands are currently mapped and are contained within a state wetland database, using an accepted statewide wetland classification system, developed by Andrew Corrick from the Arthur Rylah Institute. Mapping was undertaken from 1981 using 1:25,000 colour aerial photographs, along with field checking. This database is commonly known as the 1994 wetland layer and contains the following:

- Categories (primary) based on water regime; and
- Subcategories based on dominant vegetation.

Concurrently with the development of the 1994 wetland layer, an attempt was made to categorise and map wetland areas occupied prior to European settlement. This was largely interpretive work and uses only the primary category, based on water regime. This is known as the 1788 layer.

It has been possible to estimate the depletion of wetland types across the state using the primary category only, based on a comparison of wetland extent between the 1788 and 1994 wetland layers. Comparison between the wetland layers has demonstrated the impact of European settlement and development on Victoria's wetlands. This has been severe, with approximately one third of the states wetlands being lost since European settlement; many of those remaining are threatened by continuing degradation from salinity, drainage and agricultural practices (ANCA 1996).

The Margooya Lagoon WMU contains one registered wetland. This wetland has been classified using the Corrick-Norman wetland classification system as permanent open freshwater. This type of wetland has increased in area in Victoria but decreased slightly in the Mallee CMA region since 1788. (Mallee CMA, Mallee Wetland Strategy p12).

Table 12 - Changes in area of the wetlands by Corrick classification

Category	No of Wetlands in target area	Total area (ha)	Decrease in wetland area from 1788 to 1994		
Permanent Open Freshwater	1	35.77	-6	+5	-1

*Source: DELWP Biodiversity Interactive Maps (http://www.depi.vic.gov.au/environment-and-wildlife/biodiversity/biodiversity-interactive-map)

4.1.3 Ecosystem functions

Wetlands and waterways on the floodplain are a vital component of the landscape which support a vast array of flora and fauna which may vary greatly with the type of wetland/waterway system. The habitat provided by vegetation communities around wetlands is essential for maintaining populations of water dependent fauna species. Other ecological functions provided by floodplain complexes include water filtration, slowing surface water flow to reduce soil erosion, flood mitigation and reducing nutrient input into waterways. Protecting the ecological functioning of wetlands ensures these vital services are maintained.

Wetland ecosystems support distinctive communities of plants and animals and provide numerous ecosystem services to the community (DSE 2005). Floodplain wetlands perform important functions necessary to maintain the hydrological, physical and ecological health of river systems. These ecosystem functions include:

- Enhancing water quality through filtering sediments and re-using nutrients;
- Absorbing and releasing floodwaters;
- Providing organic material to rivers to maintain riverine food chains; and
- Providing feeding, breeding and drought refuge sites for an array of flora and fauna, especially waterbirds and fish.

Altered water regimes in the target area due to river regulation and dry conditions have seen a decrease in the frequency of inundation in these floodplain wetlands and therefore a subsequent decrease in the ability for these wetlands to perform these valuable ecosystem functions.

4.2 Social

4.2.1 Cultural Value

The Mallee has been occupied for thousands of generations by Indigenous people with human activity dated as far back as 23,400 years ago. The region's rich and diverse Indigenous heritage has been formed through the historical and spiritual significance of sites associated with this habitation; together with the strong connection traditional owners continue to have with the Mallee's natural landscapes.

Given the semi-arid climate of the region, ready access to more permanent water has been a major determinant of human habitation, and as such the highest density of identified Indigenous cultural heritage site are located around or close to areas of freshwater sources.

Within the Mallee CMA region, the Murray River and its associated waterways were important habitation areas for multiple Indigenous groups, containing many places of spiritual significance. The high number of Indigenous cultural heritage sites throughout the Murray floodplain is unique in Victoria, for both concentration and diversity. They include large numbers of burial, middens and hunting sites.

In the south of the region, waterways were focal points for the region's Traditional Owners, with many lakes being the site for large gatherings of several social clan groups that afforded trade and cultural exchanges.

Waterways also play a large role in the region's more recent non-Indigenous heritage due to the historical infrastructure (e.g. buildings, irrigation and river navigation structures) they often contain. These places provide links to early industries and settlements and play a key part in the region's identity.

4.2.2 Cultural Heritage

The floodplain of the Murray River has significant cultural heritage values for the local indigenous communities. It is well recognised as a traditional meeting place providing water, food and materials for medicines, shelter, clothing and tools. The area contains numerous scar trees, middens, mounds, burial sites, surface scatters and other artefacts.

Margooya Lagoon is a significant place for the local indigenous people, and they have been involved in the development of the adaptive management plan and monitoring.

Surveyed sites include middens, earth features, scarred trees, Aboriginal mounds and surface scatters. Surface scatters in this area may consist of chipped stone artefacts, animal bones, shell, charcoal, hearth stones, clay balls and ochre. A search of the DELWP GeoVic Database shows that most areas in the WMU around the Murray River and the wetlands are areas of Cultural Heritage Sensitivity.

Aboriginal people continue to have a connection to this country. There is no Registered Aboriginal Party (RAP) that covers this area, however Tati Tati Aboriginal Corp has applied previously. There are two Native Title claimants including the Robinvale Aboriginal Community and the Latje Latje Peoples. The land council, and other Aboriginal community members, continue to value this country through traditional laws and customs.

European heritage reflects the pioneering history of the area. These forests have had many uses since European settlement including grazing, rice growing, charcoal burning, forestry and local firewood collection. The area is popular for bird watching and water related activities such as camping, fishing and picnics.

4.2.3 Recreation

The region is popular for camping, fishing, boating, four wheel driving, trail bike riding, horse riding, bird watching and walking and these uses will continue in the park. Achieving the ecological goals outlined in this plan will enhance the scenic amenity of the area and so enhance the recreational values.

4.3 Economic

Margooya Lagoon has been managed as Begg's Bend State Forest and is a camping area which brings a small amount of economic benefits to Robinvale. There are olive groves and bee hives in the surrounding area and there is only one stock and domestic extractor at the northern end of the wetland who uses water from Margooya Lagoon. Consultation on the management of the water regime is required with this landholder.

4.4 Significance

The environmental, social and economic values of Margooya Lagoon outlined in preceding sections indicate that this site is significant to the local communities and is important in maintaining the functioning of the river system and the sustainability of the riparian and floodplain ecosystems.

While these values do not constitute Margooya Lagoon being a unique or pristine site, the riparian and floodplain communities of the Murray River are important to the functioning of the river system and its sustainability and as such should be protected.

Of particular importance are the River Red Gum communities that fringe the lagoon. It is these significant trees that form the basis of a functioning ecosystem and are a signal of the health of the surrounding floodplain. Also of significance is the lagoon's function as a healthy and productive nursery for the recruitment of native fish. It is these values that make the Margooya lagoon system a priority for protection and enhancement through the management of environmental water to this target site.

5. Ecological Condition and Threats

5.1 Past condition

Margooya Lagoon Monitoring Program: 2008

The condition of Margooya Lagoon was assessed in 2008, and a monitoring program was established with a range of flora quadrats, tree health assessments and photopoints set up to enable to assessment of the condition and trajectory of change of vegetation and habitat present at the site (GHD 2008). In general, the vegetation at Margooya Lagoon was in moderate to good condition, given the overall low abundance of weeds and the diversity of indigenous flora species observed in the understorey. The following three parameters related to vegetation condition were identified as requiring monitoring and were included in the monitoring program:

- Tree health;
- Weed abundance; and
- Other threatening processes e.g. RRG regeneration within the wetland bed.

Other observations on the condition of Margooya Lagoon are outlined below:

Tree health

In general, the River Red Gum trees surveyed at Margooya Lagoon were in fair to moderate condition. More than half of the trees sampled had a canopy cover of < 60%, but most trees had healthy leaves (green and not red-brown), intact bark and no mistletoe attack. Tree health was highly variable within each of the two transects. Some very large and large old trees had died or were showing signs of dieback (very large and large old trees were typically in poorer condition than medium and small trees). This could be the consequence of natural senescence but may be the result of other factors such as increased soil salinity and/or groundwater salinity (GHD 2008). It was identified that a rigorous monitoring program aimed at measuring these other factors as well as tree health is required to determine the causes of tree dieback at the lagoon.

Weeds

The understorey of the Intermittent Swampy Woodland was diverse in indigenous flora species and weeds were generally in low to moderate abundance (typically 525 % cover in quadrats). Weed species of concern include: *Polygonum aviculare* (Wireweed), *Cirsium vulgare* (Scotch Thistle), *Phyla canescens* (Fogfruit), *Bromus rubens* (Red Brome), Sonchus oleraceus (Sow Thistle), *Dittrichia*

graveolens (Stinkwort), *Olea europaeum* (Olive) and *Paspalum distichum* (Water Couch). Control of these weeds was recommended to prevent and minimise the spread of infestations to other areas of the Lagoon.

Regenerating River Red Gums (RRG) in the wetland bed

River Red Gums were prevalent along the edges of the wetland bed. The cover of regenerating RRG was typically 25-50 % within the 20 m X 20 m quadrats located on the edges of the wetland bed and trees are typically < 2m tall. Soil moisture in the wet-dry littoral zone favours the recruitment of RRGs within this zone. Whilst RRG play an important role within floodplain and wetland systems through their provision of carbon (leaf litter) and habitat for fauna, regeneration within the wet-dry littoral zone may be considered a threat to the biodiversity and character of the wetland (Scholz et al. 2005). Reducing the abundance of RRG regeneration within the wet/dry zone may be one of the aims of the proposed wetting and drying regime through providing a more appropriate watering regime.

Margooya Lagoon Index of Wetland Condition Assessment: 2009

The condition of Margooya Lagoon was assessed in December 2009 using a method developed by DELWP called the Index of Wetland Condition (IWC) method (see Appendix 3 for details on IWC method and the results of the assessment). The IWC defines wetland condition as the state of the biological, physical, and chemical components of the wetland ecosystem and their interactions. The overall IWC score for Margooya Lagoon was 5 out of 10, which is considered to be moderate. The hydrology and biota sub-indices were considered to be in very poor and poor condition respectively. Hydrology was considered to be very poor due to the significant disruption the permanent inundation due to Euston weir pool has had on the natural wetting and drying cycle of Margooya Lagoon. Water properties and physical form scored excellent.

Margooya Lagoon General Condition: 2010 EWMP

The permanent inundation of the lagoon due to river regulation and the resultant increased carp population had modified the wetland vegetation and negatively impacted on the native fish population. The EVCs that once dominated the study area had been under stress and the native fish population has decreased. These threats would be expected to continue without intervention. However, the temporary disconnection from the Murray River in 2009 with earth banks followed by the installation of a permanent regulator to reinstate a more natural wetting and drying cycle and decrease the carp population (using carp screens) aimed to increase the abundance, distribution and diversity of native wetland species in the study area with particular emphasis on the River Red Gum communities fringing the lagoon and the native fish population in the lagoon.

After the management intervention began, the initial monitoring and anecdotal evidence indicated an initial increase in River Red Gum forest health (Figure 11) and an improvement in the native fish population had begun.

Figure 11 - Increased River Red Gum health demonstrated in photopoint monitoring at Margooya Lagoon between 2008 and 2009.

5.2 Current condition and trajectory

The Margooya Lagoon is relatively intact, however its condition will continue to decline without regular and well planned watering regime. Whilst a range of surveys and assessments have been undertaken at the Margooya Lagoon, there has not been a standard ongoing monitoring program to allow the comparison of data to analyse trajectory of change in the condition of native vegetation and fauna habitat. No vegetation surveys have been undertaken at Margooya Lagoon since the preparation of the original EWMP for this site (Mallee CMA 2010). It is recommended that follow up monitoring is undertaken to enable an assessment of the trajectory of change of condition of native vegetation at the site. To allow a comparison with previous assessments it is recommended that monitoring is undertaken in line with the recommended procedure in the Margooya Lagoon Monitoring Program (GHD 2008).

5.3 Water related threats

The regulation of the Murray River has altered the water regime through the section of the river upstream of Euston weir including the Margooya Lagoon area. Flow events of the magnitude required to create flow into the floodplain creeks and wetlands are less frequent and of shorter duration (see section 3). This combined with dry conditions over the last decade affects the vigor of the vegetation and places trees under stress, affecting the productivity and functioning of the floodplain ecosystem.

Threats described in the AVIRA database which may have an impact on the Margooya Lagoon include:

- Changed water regime
- Introduction/increase of exotic flora and fauna

These threats are confirmed by monitoring and field investigations carried out by GHD (2008 p 65) as well as the additional documented threats of wetland loss and degradation due to change in water regime and localised tree death and stress in the vegetation adjacent to the lagoon which may be attributed to possible saline groundwater influences resulting from surrounding irrigation areas.

6. Management Objective

Ecological objectives were revised in 2015 by GHD as part of the review of this EWMP. The full documentation of the development of ecological objectives is in Appendix 4.

6.1 Management goal

The environmental water management goal for Margooya Lagoon over the next 5-10 years is outlined below.

'*To provide a water regime that improves River Red Gum health and maintains and enhances key habitats for native fish, frogs, waterbirds and threatened birds*'

6.2 Ecological Objectives

Ecological objectives represent the desired ecological outcomes of the site based on the key values outlined in the water dependent values section. In line with the Victorian Waterway Management Strategy (VWMS) the ecological objectives are expressed as the target condition or functionality for each key value. The water dependant values (outlined in section 4) associated with each ecological objective is detailed in Table 13.

Table 13 - Ecological objectives and water dependant values

Ecological Objectives	Justification (value based)
Maintain and enhance the condition of River Red Gum with chenopod understorey.	Habitat for threatened fauna species (e.g. Regent Parrot and White-bellied Sea-eagle) and threatened flora species (Spreading Emu Bush and Scurfy Germander). Also supports a range of other possible threatened species habitat (e.g. Lace Monitor, Carpet Python). Littoral zone supports habitats for frogs, waterbirds, fish.
Maintain and enhance the condition of River Red Gum with flood tolerant understorey (littoral RRG)	Habitat for threatened fauna species (e.g. Regent Parrot and White-bellied Sea-eagle). Other possible threatened species habitat (e.g. Lace Monitor, Carpet Python). Also supports habitat for a range of non-threatened fauna.
Provide nursery habitat for Silver and Golden Perch	The EPBC and FFG listed Silver Perch has been recorded at Margooya Lagoon in 2009 and 2010. This objective will support recruitment of these species. Enhance water quality due to native species composition rather than introduced carp.
Exclude large-bodied carp from the wetland and provide habitat for small-bodied fish	Enhancement of water quality due to reduced carp abundance and greater aquatic vegetation abundance. As well as the intrinsic ecological value of native fish presence, this group of fauna will also provide an important food source for waterbirds and freshwater turtles.

Ecological Objectives	Justification (value based)
Provide periodic frog habitat	Frogs provide food for wetland birds, snakes, and fish and themselves prey on insects.
Provide periodic habitat for Growling Grass Frog	It is possible that specifically managed flows could result in the threatened Growling Grass Frog utilising the wetland.
Provide periodic habitat for waterbirds – piscivores, deep water foragers	Waterbirds provide important ecological functions such as foraging on and consuming insects/aquatic vegetation/fish but they are also a prey source for larger predators such as Lace Monitor, Carpet Python and raptors. Threatened deep water preferring waterbirds include Hardhead and Musk Duck with each of these species being possible at Margooya.
Provide periodic habitat for waterbirds – dabbling ducks, grazing waterfowl, waders	Waterbirds provide important ecological functions such as foraging on and consuming insects/aquatic vegetation but they are also a prey source for larger predators such as Lace Monitor, Carpet Python and raptors. Provide opportunistic foraging habitat for migratory species Threatened species including Eastern Great Egret, Australasian Shoveler and EPBC-listed migratory species.
Provide conditions to enhance littoral vegetation zones – broad and diverse	Support habitat for small fish, threatened species, frog breeding, waterbird breeding.
Introduce a periodic drying phase to promote nutrient cycling	Drying phase maintains a productive ecosystem, drying wetland to consolidate sediments. Also maintain nutrient mineralisation, carbon cycling. Dry wetland to obtain nutrient cycling (oxidise nutrients and make carbon available – drive bacterial productivity, phytoplankton, waterbirds, fish etc. Rewetting releases nutrients.

As more is learnt about the area and the response to the watering events are monitored the principles of adaptive management along with availability of environmental water sources will guide future requirements and management actions at this and other environmental watering sites.

6.3 Hydrological Objectives

Hydrological objectives describe the components of the water regime required to achieve the ecological objectives at this site. The ecological objectives at this site aim to return a more natural wetting and drying regime to Margooya Lagoon and are centred on improving the health of the River Red Gum communities and improving habitat for native fish, frogs and birds in the lagoon. The lagoon would ideally be allowed a drying phase after each watering event.

The management of the fish population is a complex task in regards to hydrological targets with many knowledge gaps and a range of variables to be considered. For example Ellis and Pyke (2010) observed that *it is generally recognised that elevated flows and discharge induces spawning in golden perch and silver perch (King et al.2010; Mallen-Cooper and Stuart, 2003). The Murray River demonstrated elevated (but within bank) flows during late November and early December 2009. These elevated flows appear to have stimulated these species to spawn in the river channel, with larvae and/or juveniles subsequently transported into Margooya Lagoon*. This reliance on natural triggers leads to a requirement for Margooya Lagoon to be operated with an adaptive management approach to take advantage of conditions as they arise. The gates of the regulator will need to be managed to ensure the River Red Gum communities are given the best opportunity to thrive but at the same time monitoring the movement and life cycles of the native fish.

Table 14 - Hydrological objectives for Margooya Lagoon

Ecological Objective	Water management area	Hydrological Objectives										
		Mean frequency of events (Number per 10 years)			Tolerable interval between events (years)		Duration of Ponding (months)			Preferred timing of inflows	Target supply level (m) AHD	Volume to fill to TSL (ML)
		Min	Opt	Max	Min	Max	Min	Opt	Max			
Maintain and enhance the condition of River Red Gum with chenopod understorey.	Fringing vegetation	4	4-5	5	3	4	2	2-8	24	Winter-spring	48.7	430
Maintain and enhance the condition of River Red Gum with flood tolerant understorey (littoral RRG)	Floodplain vegetation	4	5-10	10	3	4	2	2-8	24	Winter-spring	47.64	350
Provide nursery habitat for Silver and Golden Perch	Margooya Lagoon	Opportunistic	-	-	-	-	<12	12	24	Late spring – early summer	≤47.64	350
Exclude carp from the wetland and provide habitat for small-bodied fish	Margooya Lagoon	At all times – utilise carp screen	-	-	-	-	-	-	-	All year	-	
Provide periodic frog habitat	Margooya Lagoon littoral and aquatic vegetation	Opportunistic	-	-	-	-	3-4	7	8	Spring/summer	≤47.64	350
Provide periodic habitat for waterbirds – piscivores, deep water foragers	Margooya Lagoon	Opportunistic	-	-	-	-	6 (breeding)	8 (breeding)	NA	Any time of year – spring for breeding	47.64	350
Provide periodic habitat for waterbirds – dabbling ducks, grazing waterfowl, waders	Margooya Lagoon shallows	Opportunistic	-	-	-	-	6 (breeding)	8 (breeding)	NA	Any time of year – spring for breeding (summer for migratory waders)	≤47.64	350
Provide conditions to enhance littoral vegetation zones – broad and diverse	Margooya Lagoon littoral vegetation	7	10	10	Varies from 2-10	-	2	2-12	12	Spring/summer	Water level variation	-
Introduce a periodic drying phase to promote nutrient cycling	Margooya Lagoon	5	10	10	2	2	-	-	-	late summer - winter	-	-

[1] Estimate based on filling from empty to the target supply level (TSL), assuming no inflows
[2] Estimate based on maintaining at target supply level (TSL) for optimum duration of ponding, assuming no inflows
[3] Sum of 1 and 2

6.4 Watering regime

The wetland watering regime has been derived from the ecological and hydrological objectives. To allow for adaptive and integrated management, the watering regime is framed using the seasonally adaptive approach. This means that a watering regime is identified for optimal conditions, as well as the maximum and minimum tolerable watering scenarios. The minimum watering regime is likely to be provided in drought or dry years, the optimum watering regime in average conditions and the maximum watering regime in wet or flood years.

The optimal, minimum and maximum watering regimes are described below. Due to the inter-annual variability of these estimates (particularly the climatic conditions), determination of the predicted volume requirements in any given year will need to be undertaken by the environmental water manager when watering is planned.

Minimum watering regime

Fill wetland to provide an open water assemblage an average of four years in every ten years. A drying phase will follow each watering event

Optimal watering regime

Fill wetland to capacity every second year with a drying phase between events. Allow to completely dry at least one in every ten years

Maximum watering regime

Wetland filled every year with no drying phase between.

7. Managing Risks to Achieve Objectives

Table 15 below identifies the risks to achieving the ecological objectives and watering requirements as well as to the ecological values of the target area by identifying threats. Risks are classified as high, medium, or low dependent on the likelihood and consequence of them occurring.

Prior to delivering environmental water in any given season, these risks will be further refined as part of the Seasonal Watering Proposal and Environmental Water Delivery Plan process. These documents will provide a greater level of risk analysis and mitigation measures according to conditions observes closer to the proposed delivery (i.e. operational risks). The documents will also include detailed consideration of the impact of proposed mitigation measures on the likelihood and consequence of the risk occurring (residual risk) as this may change according to catchment conditions and operations closer to the proposed delivery. They will clearly outline roles and responsibilities regarding risk management.

Table 15 - Assessment of Risks to achieving to achieving the objectives of the Margooya EWMP

Risk	Description	Likelihood	Consequence	Risk	Management Measure
Required watering regime not met	Flood duration too long or short	Possible	Moderate	L	Determine environmental water requirements based on seasonal conditions and to support potential bird breeding events Monitor flood duration to inform environmental water delivery Monitor the ecological response of the wetland to flooding Add or drawdown water where appropriate or practical
	Flood timing too late or early	Possible	Moderate	L	Liaise with Goulburn-Murray Water to seek optimum timing of water delivery Monitor flood timing to inform environmental water delivery Monitor the ecological response of the wetland to flooding
Poor water quality	Low dissolved oxygen High turbidity High water temperature Increased salinity levels Increased nutrient levels Increased organic matter	Possible	Moderate	L	Monitor water quality and the ecological response of the wetland to flooding Add or drawdown water where appropriate or practical
Pest aquatic plant and	Introduction of pest fish	Likely	Moderate	M	Monitor the ecological response of the wetland to flooding Install a carp screen Implement an appropriate drying regime

animal invasion	Growth and establishment of aquatic pest plants	Possible	Moderate	L	Monitor the abundance of native and pest aquatic plants Control pest plants in connected waterways Spray or mechanically remove pest plants Implement an appropriate drying regime

8. Environmental Water Delivery Infrastructure

8.1 Constraints

The regulator installed in 2009 for environmental watering is limited to filling the lagoon, inundating 44.42 Ha and holding the water at a height of 48.7m AHD. This does not allow for full inundation of the floodplain.

8.2 Infrastructure recommendations

No further infrastructure is recommended at this time.

9. Demonstrating Outcomes

The Margooya Lagoon has been identified as offering an excellent opportunity to monitor changes in flora and fauna over time (GHD 2008) because the lagoon is:

- Easily accessible;
- Currently in moderate to good condition;
- Floristically diverse; and
- Threatening processes are evident that require monitoring so that management action can be taken to reduce impact on biodiversity at the lagoon before threats become severe (e.g. weed invasion and River Red Gum (RRG) regeneration within the wetland bed).

Monitoring objectives to measure the success of environmental watering as well as risks associated with watering are outlined in Table 16. It should be noted that it may not be feasible to implement all monitoring activities.

Table 16 - Monitoring priorities for Margooya Lagoon

Objective	Method
Measuring success of achieving Ecological Objectives	
Maintain and enhance the condition of River Red Gum with chenopod understorey.	TLM tree health monitoring
Maintain and enhance the condition of River Red Gum with flood tolerant understorey (littoral RRG)	TLM tree health monitoring
Provide nursery habitat for Silver and Golden Perch	Fish surveys
Exclude carp from the wetland and provide habitat for small-bodied fish	Fish surveys
Provide periodic frog habitat	Song meters; Active search - nocturnal
Provide periodic habitat for waterbirds – piscivores, deep water foragers	Waterbird surveys – conducted pre, during and post inundation as water levels change GIS mapping to monitor water levels – i.e. waterbird habitat availability.
Provide periodic habitat for waterbirds – dabbling ducks, grazing waterfowl, waders	Waterbird surveys – conducted pre, during and post inundation as water levels change GIS mapping to monitor water levels – i.e. waterbird habitat availability.
Provide conditions to enhance littoral vegetation zones – broad and diverse	Employ methods including full floristic assessment of targeted quadrats (20m x 20m) to measure condition. Standard 20 min, 2 ha bird surveys to monitor threatened bird/bush bird abundance/diversity and presence/absence
Introduce a periodic drying phase to promote nutrient cycling	Water quality testing

10. Consultation

This Plan was developed in collaboration with key stakeholders namely Parks Victoria, the Department of Environment, Land, Water and Planning, Lower Murray Water and local interest groups. Parts of Margooya Lagoon are freehold and consultation with local landholders was required regarding the management of all wetlands and associated waterways.

Table 17 - Consultation Process for development of Margooya Lagoon Environmental Water Management Plan

Meeting date	Stakeholders	Details
May 2014	Parks Victoria	Initial discussion to introduce concept of plan and discuss the issue of feral pigs in the area.
May 2014	Lower Murray Water	Discussion on drainage disposal to the wetlands creating habitat for feral pigs and management actions going forward.
June 2016	Department of Environment, Land, Water and Planning	Plan presentation
June 2016	Lower Murray Water	Plan presentation
June 2016	Local residents and landholders	Plan presentation
June 2016	Murray Lower Darling Rivers Indigenous Nations	Plan presentation
June 2016	Mildura BirdLife	Plan presentation
June 2016	Department of Environment, Land, Water and Planning	Plan presentation

11. Knowledge Gaps and Recommendations

This plan is based on the best information at the time of writing. In some cases this information is scarce or outdated. Further investigation and information collection will continue and the results of this further work will continue to build a better picture of the site and add rigor to future planning. Some areas where further knowledge would be beneficial are outlined in Table 18.

Table 18 - Knowledge gaps and recommendations for the target area

Knowledge and data gaps	Action recommended
Role of wetland for fish breeding and population	Monitoring of fish population
Breeding activity of waterbirds	Periodic monitoring of waterbird breeding activity during watering events
Breeding activity and diversity of frogs (e.g. persistence of Growling Grass Frog)	Monitoring of frog response to watering - Songmeters

*This monitoring should be undertaken following guidelines set out in Margooya Lagoon Monitoring Report (GHD 2008) to enable a comparison of the current condition with baseline data

12. References

ANCA (1996) *A Directory of Important Wetlands in Australia Second Edition.* Australian Nature Conservation Agency , Canberra, ACT

Baldwin D.S. (2007) Assessment of sulfidic sediments in Margooya Lagoon. A report to the Mallee Catchment Management Authority

Birdlife Australia (2015). Accessed on 10/11/2015 from http://www.birdlife.org.au/bird-profile/diamond-firetail

Department of Environment and Primary Industries, Bioregions: Accessed November 2011 http://www.DEPI.vic.gov.au/conservation-and-environment/victorias-bioregions#bioregion

DEPI (2014) Advisory list of rare or threatened plants in Victoria – 2014. Department of Environment and Primary Industries

DSE (2005) *Index of Wetland Condition. Conceptual framework and selection of measures.* Department of Environment and Primary Industries, East Melbourne, Victoria

DSE, (2013). *Advisory List of Threatened Vertebrate Fauna in Victoria- 2013*. Department of Environment and Primary Industries, East Melbourne, Victoria

DotE (2015a). Biodiversity Species Profile and Threats Database *Polytelis anthopeplus monarchoides* – Regent Parrot (eastern). Department of the Environment accessed 10/11/2015 from http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=59612

DotE (2015b). Biodiversity Species Profile and Threats Database *Haliaeetus leucogaster* – White-bellied Sea-eagle. Department of the Environment accessed 10/11/2015 from http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=943

Ecological Associates (2007b) *Investigation of Water Management Options for the River Murray* – Robinvale to Wallpolla Island: *Final Report,* Ecological Associates for *Mallee Catchment Management Authority Mildura, Victoria*

Ellis, I and Pyke, L. (2010). Assessment of fish movement to and from Margooya Lagoon upon re-connection to the Murray River. Report to the Mallee Catchment Management Authority. The Murray-Darling Freshwater Research Centre. Mildura, Victoria

GHD (2008) *Report for Margooya Lagoon Monitoring Program* (Prepared for Mallee Catchment Management Authority, October 2008)

Green, D and Alexander, P (2006), *River Murray Wetland Database: NSW, Victoria. Wetland Commence to flow levels, June 2006* NSW Wetland Working Group Albury, NSW

Land Conservation Council (1989) *Mallee Area Review Final Recommendations* Land Conservation Council, Melbourne Victoria

MCMA (2003) *Murray River Frontage Action Plan – Nyah to Robinvale* Mallee Catchment Management Authority Mildura, Victoria

MCMA (2006) *Mallee River Health Strategy* Mallee Catchment Management Authority Mildura, Victoria

MCMA (2006A) *Mallee Wetland Strategy* Mallee Catchment Management Authority Mildura, Victoria

MCMA (2014) *Mallee Waterway Strategy 2014-22* Mallee Catchment Management Authority Mildura, Victoria

MDFRC (2011) *Assessment of fish movement to and from Margooya Lagoon upon re-connection to the Murray River during elevated flows: Spring 2010.* Mallee Catchment Management Authority, Mildura, Victoria

Mitsch, W. J. and Gosselink, J (1993) *Wetlands*, Second Edition. New York: Van Nostrand Reinhold

OEH (2015) Diamond Firetail profile. Accessed on 10/11/2015 from http://www.environment.nsw.gov.au/threatenedSpeciesApp/profile.aspx?id=10768

Peters, G. (2009_ *Aquatic Value Identification and Risk Assessment (AVIRA). Environmental, Social and Economic Values and Threats.* Riverness Protection & Restoration Services, Belmont, Victoria

Rogers, K. & Ralph, T. J. (2011) Floodplain wetland biota in the Murray Darling Basin. Edited by Rogers K and Ralph TJ. Pages 17-82. CSIRO Publishing. Collingwood

Roshier, D. A., Robertson, A. I., Kingsford, R. T., Green, D. G. (2001). Continental-scale interactions with temporary resources may explain the paradox of large populations of desert waterbirds in Australia. *Landscape Ecology*, *16*, 547-556

Scholz, O. Meredith, S. Suiter, L., Keating, R and Ho, S. 2005. *Living Murray icon site wetlands within the Mallee CMA region: monitoring program designs and 2004-05 monitoring results.* Report prepared for Mallee CMA by Murray Darling Freshwater Research Centre

Sunraysia Environmental (2014). *Regional Context Document for Environmental Water Management Plans: Mallee CMA Region,* Sunraysia Environmental for Mallee Catchment Management Authority Mildura, Victoria

VEAC (2008) *River Red Gum Investigation* Victorian Environmental Assessment Council East Melbourne, Victoria

13. Abbreviations and Acronyms

CAMBA	China-Australia Migratory Bird Agreement
CMA	Catchment Management Authority
DELWP	Department of Environment, Land, Water and Planning
DEPI	Department of Environment and Primary Industries (now DEWLP)
DSE	Department of Sustainability and Environment (now DELWP)
EVC	Ecological Vegetation Class
EPBC	Environment Protection and Biodiversity Conservation Act
EWA	Environmental Water Allocation
EWMP	Environmental Water Management Plan
EWH	Environmental Water Holder
EWR	Environmental Water Reserve
EWH	Environmental Water Holder
FFG	Flora and Fauna Guarantee Act
WMU	Floodplain Management Unit
G-MW	Goulburn-Murray Water
IWC	Index of Wetland Condition
JAMBA	Japan-Australia Migratory Bird Agreement
MCMA	Mallee Catchment Management Authority
MDBA	Murray-Darling Basin Authority (formally Murray-Darling Basin Commission, MDBC)
Ramsar	Global treaty adopted in the Iranian city of Ramsar in 1971 that focuses on the conservation of internationally important wetlands
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement
RRG	River Red Gum
TLM	The Living Murray Initiative
VEAC	Victorian Environmental Assessment Council
VEWH	Victorian Environmental Water Holder
VWMS	Victorian Waterway management Strategy
WMU	Waterway Management Unit

Appendix 1. Flora and Fauna Species List

Updated November 2015

Flora Species List

Scientific Name	Common Name	Classification	GHD 2008	2010 EWMP
Native Species				
Acacia oswaldii	Umbrella Wattle	P		Y
Acacia stenophylla	Eumong	P	Y	
Alternanthera denticulata s.l.	Lesser Joyweed		Y	
Amyema miquelii	Box Mistletoe			Y
Asperula gemella	Twin-leaf Bedstraw	r	Y	
Atriplex semibaccata	Berry Saltbush		Y	
Atriplex suberecta	Sprawling Saltbush		Y	
Austrostipa eremophila	Desert Spear-grass			Y
Austrostipa scabra subsp. *falcata*	Rough Spear-grass			Y
Austrostipa trichophylla	Spear-grass			Y
Brachyscome basaltica var. *gracilis*	Woodland Swamp-daisy	P	Y	
Chenopodium nitrariaceum	Nitre Goosefoot		Y	
Cynodon dactylon	Couch		Y	
Cyperus exaltatus	Tall Flat-sedge		Y	
Cyperus gymnocaulos	Spiny Flat-sedge		Y	
Dissocarpus paradoxus	Hard-head Saltbush			Y
Dodonaea viscosa subsp. *angustissima*	Slender Hopbush		Y	
Duma florulenta	Tangled Lignum		Y	
Eclipta platyglossa	Yellow Twin-heads		Y	
Einadia nutans subsp. *nutans*	Nodding Saltbush		Y	Y
Enchylaena tomentosa var. *tomentosa*	Ruby Saltbush		Y	Y
Enteropogon acicularis	Spider Grass			Y
Eragrostis spp.	Love Grass		Y	
Eremophila divaricata subsp. *divaricata*	Spreading Emu-bush	r	Y	Y
Eremophila longifolia	Berrigan			Y
Eucalyptus camaldulensis	River Red-gum		Y	
Eucalyptus largiflorens	Black Box		Y	Y
Euchiton sphaericus	Annual Cudweed	P	Y	
Euphorbia drummondii	Flat Spurge		Y	
Glinus lotoides	Hairy Carpetweed		Y	
Glycyrrhiza acanthocarpa	Southern Liquorice		Y	
Helichrysum luteoalbum	Jersey Cudweed	P	Y	
Juncus aridicola	Tussock Rush		Y	
Lachnagrostis filiformis	Common Blown-grass		Y	
Lepidium pseudohyssopifolium	Native Peppercress	k		Y

Scientific Name	Common Name	Classification	GHD 2008	2010 EWMP
Ludwigia peploides subsp. *montevidensis*	Clove-strip		Y	
Maireana brevifolia	Short-leaf Bluebush		Y	
Maireana trichoptera	Hairy-wing Bluebush			Y
Olearia pimeleoides	Pimelea Daisy-bush	P	Y	Y
Persicaria decipiens	Slender Knotweed		Y	
Rhagodia spinescens	Hedge Saltbush		Y	Y
Rumex brownii	Slender Dock		Y	
Rytidosperma caespitosa	Common Wallaby-grass			Y
Salsola tragus subsp. *tragus*	Prickly Saltwort			Y
Sclerochlamys brachyptera	Short-wing Saltbush		Y	
Sclerolaena diacantha	Grey Copperburr			Y
Senecio pinnatifolius	Variable Groundsel	P	Y	
Senecio quadridentatus	Cotton Fireweed	P	Y	
Senecio runcinifolius	Tall Fireweed	P	Y	
Senna form taxon 'zygophylla'	Narrow-leaf Desert Cassia		Y	
Sida corrugata	Variable Sida			Y
Solanum esuriale	Quena			Y
Sporobolus mitchellii	Rat-tail Couch		Y	
Teucrium albicaule	Scurfy Germander	k		Y
Teucrium racemosum s.l.	Grey Germander		Y	
Thysanotus baueri	Mallee Fringe-lily			Y
Typha orientalis	Broad-leaf Cumbungi		Y	
Vittadinia cervicularis var. *subcervicularis*	Annual New Holland Daisy	P	Y	Y
Vittadinia cuneata	Fuzzy New Holland Daisy	P	Y	
Vittadinia dissecta s.l.	Dissected New Holland Daisy	P	Y	
Vittadinia gracilis	Woolly New Holland Daisy	P		Y
Wahlenbergia fluminalis	River Bluebell		Y	
Whalleya proluta	Rigid Panic		Y	
Introduced species				
Alyssum linifolium	Flax-leaf Alyssum			Y
Aster subulatus	Aster-weed		Y	
Bromus rubens	Red Brome		Y	
Chondrilla juncea	Skeleton Weed		Y	
Cirsium vulgare	Spear Thistle	R	Y	
Conyza bonariensis	Flaxleaf Fleabane		Y	
Cyperus eragrostis	Drain Flat-sedge		Y	
Dittrichia graveolens	Stinkwort	R	Y	
Hedypnois cretica	Cretan Hedypnois		Y	
Lactuca serriola	Prickly Lettuce		Y	
Marrubium vulgare	Horehound	R	Y	
Medicago minima	Little Medic			Y
Medicago polymorpha	Burr Medic			Y

Scientific Name	Common Name	Classification	GHD 2008	2010 EWMP
Olea europaea	Olive		Y	
Opuntia spp.	Prickly pear	C, WoNS	Y	
Paspalum distichum	Water Couch		Y	
Phyla canescens	Fog-fruit		Y	
Polygonum aviculare s.l.	Prostrate Knotweed		Y	
Silene apetala var. *apetala*	Mallee Catchfly			Y
Sonchus oleraceus	Common Sow-thistle		Y	
Verbena supina	Trailing Verbena		Y	

Key:

r Listed as rare under VROTs list
k Listed as poorly known under VROTs list
P Listed as protected under FFG Act
C Listed as Regionally Controlled under CaLP Act within the Mallee CMA
R Listed as Restricted under the CaLP Act within the Mallee CMA
WoNS Weed of National Significance

Fauna Species List

Updated November 2015

Scientific Name	Common Name	Status	Type	Source of information		
				GHD 2008	2010 EWMP	2011 Fish report
NATIVE FAUNA						
Birds						
Acanthagenys rufogularis	Spiny-cheecked Honeyeater		B	Y		
Acanthiza uropygialis	Chestnut-rumped Thornbill		B		Y	
Anas gracilis	Grey Teal		B	Y		
Anas superciliosa	Pacific Black Duck		B	Y		
Aphelocephala leucopsis	Southern Whiteface		B		Y	
Artamus cyanopterus	Dusky Woodswallow		B	Y	Y	
Cacatua galerita	Sulphur-crested Cockatoo		B	Y	Y	
Cacatua sanguinea	Little Corella		B	Y	Y	
Cacomantis flabelliformis	Fan-tailed Cuckoo		B	Y		
Chenonetta jubata	Australian Wood Duck		B		Y	
Circus approximans	Swamp Harrier		B	Y		
Climacteris picumnus picumnus	Brown Treecreeper		B	Y	Y	
Colluricincla harmonica	Grey Shrike-thrush		B	Y	Y	
Coracina novaehollandiae	Black-faced Cuckoo-shrike		B	Y		
Corcorax melanorhamphos	White-winged Chough		B	Y	Y	
Corvus coronoides	Australian Raven		B	Y	Y	
Corvus mellori	Little Raven		B	Y		
Cracticus nigrogularis	Pied Butcherbird		B	Y	Y	
Cracticus torquatus	Grey Butcherbird		B	Y		
Cuculus pallidus	Pallid Cuckoo		B	Y		
Cygnus atratus	Black Swan		B	Y		
Dacelo novaeguineae	Laughing Kookaburra		B	Y	Y	
Egretta novaehollandiae	White-faced Heron		B		Y	
Elseyornis melanops	Black-fronted Dotterel		B	Y		
Eolophus roseicapilla	Galah		B	Y	Y	
Geopelia striata	Peaceful Dove		B	Y	Y	
Grallina cyanoleuca	Magpie-lark		B	Y	Y	
Gymnorhina tibicen	Australian Magpie		B	Y	Y	
Haliaeetus leucogaster	White-bellied Sea Eagle	L v	B	Y		
Haliastur sphenurus	Whistling Kite		B	Y		
Hirundo neoxena	Welcome Swallow		B	Y		
Hirundo nigricans	Tree Martin		B	Y	Y	
Lichenostomus penicillatus	White-plumed Honeyeater		B	Y	Y	
Lichenostomus virescens	Singing Honeyeater		B			
Malurus cyaneus	Superb Fairy-wren		B	Y		
Malurus lamberti	Variegated Fairy-wren		B		Y	

Scientific Name	Common Name	Status	Type	Source of information		
				GHD 2008	2010 EWMP	2011 Fish report
Manorina melanocephala	Noisy Miner		B	Y	Y	
Ocyphaps lophotes	Crested Pigeon		B	Y		
Oriolus sagittatus	Olive-backed Oriole		B	Y		
Pachycephala rufiventris	Rufous Whistler		B		Y	
Pardalotus striatus	Striated Pardalote		B	Y	Y	
Pelecanus conspicillatus	Australian Pelican		B	Y	Y	
Petroica goodenovii	Red-capped Robin		B		Y	
Phaps chalcoptera	Common Bronzewing		B	y		
Philemon citreogularis	Little Friarbird		B	Y	Y	
Platycercus elegans elegans	Crimson Rosella		B	Y	Y	
Platycercus elegans flaveolus	Yellow Rosella		B		Y	
Polytelis anthopeplus monarchoides	Regent Parrot	L VU v	B	Y	Y	
Psephotus haematonotus	Red-rumped Parrot		B	Y		
Rhipidura fuliginosa	Grey Fantail		B	Y		
Rhipidura leucophrys	Willie Wagtail		B	Y	Y	
Smicrornis brevirostris	Weebill		B	Y	Y	
Stagonopleura guttata	Diamond Firetail	L v	B		Y	
Tadorna tadornoides	Australian Shelduck		B	Y		
Threskiornis molucca	Australian White Ibis		B		Y	
Fish						
Bidyanus bidanyus	Silver perch		F			Y
Craterocephalus stercusmuscarum	Unspecked hardyhead		F			Y
Hypseleotris klunzingeri	Carp gudgeons		F			Y
Macquaria ambigua	Golden perch		F			Y
Nematalosa erebi	Bony herring		F			Y
Retropinna semoni	Australian Smelt		F			Y
Tandanus tandanus	Freshwater catfish		F			Y
Reptiles						
Chelodina expansa	Broadshelled turtle		R			Y
Chelodina longicollis	Eastern long-necked turtle		R			Y
Cryptoblepharus carnabyi	Carnaby's Wall Skink		R	Y		
Emydura macquarii	Murray river turtle		R			Y
Morethia boulengeri	Boulenger's Skink		R	Y		
Invertebrate						
Cherax destructor	Yabby		I			Y
Mammals						
Macropus fuliginosus	Western Grey Kangaroo		M	Y		
Tachyglossus aculeatus	Echidna		M	Y		
Amphibians						
Crinia parinsignifera	Plains Froglet		A	Y		
Crinia signifera	Common Froglet		A	Y		

Scientific Name	Common Name	Status	Type	Source of information		
				GHD 2008	2010 EWMP	2011 Fish report
Limnodynastes dumerilii	Southern Bullfrog		A	Y		
Limnodynastes tasmaniensis	Spotted Marsh Frog		A	Y		
INTRODUCED FAUNA						
Birds						
Passer domesticus	House Sparrow		B			
Sturnus vulgaris	Common Starling		B	Y	Y	
Mammals						
Canis vulpes	Red Fox		M	Y		
Oryctolagus cuniculus	European Rabbit		M	Y		
Sus scrofa	Pig		M	Y		
Fish						
Carassius auratus	Goldfish		F			Y
Cyprinus carpio	Carp		F	Y		Y
Gambusia spp	Gambusia		F			Y
Misgurnus anguillicaudatus	Oriental Weatherloach		F			Y
Perca fluviatilis	Redfin		F			Y

Legend:

Type: Invertebrate, Fish, Amphibian, Reptile, Bird, Mammal

Appendix 2. Ecological Vegetation Classes

Appendix 2 provides a description of each EVC within Margooya Lagoon (GHD 2008 and DELWP EVC benchmark descriptions)

Updated November 2015

EVC no.	EVC name	Bioregional Conservation Status Murray Fans	Description
813	Intermittent Swampy Woodland	Depleted	According to the EVC Benchmark for the RobP Bioregion, Intermittent Swampy Woodland (EVC 813; ISW) is a eucalypt woodland to 15m tall with a variously shrubby and rhizomatous sedgy – turf grass understorey, at best development dominated by flood stimulated species in association with flora tolerant of inundation. Flooding is unreliable but extensive when it happens. Occupies low elevation areas on river terraces (mostly at the rear of point bar deposits or adjacent to major floodways) and lacustrine verges (where sometimes localised to narrow transitional bands). Soils often have a shallow sand layer over heavy clay and are frequently brackish. Within the Margooya Lagoon, ISW is a Woodland to 15 m tall dominated by *Eucalyptus camaldulensis* (River Redgum), over an understorey tree layer of *Acacia stenophylla* (Eumong) to 10 m tall. The ground layer supports medium tufted and nontufted graminoids such as *Cyperus gymnocaulos* (Spring Flat-sedge) and *Cynodon dactylon* (Native Couch). Medium to large herbs are scattered including *Wahlenbergia fluminalis* (River Bluebell), *Brachyscome basaltica* (Swamp Daisy), *Vittadinia cuneata* (Fuzzy New Holland Daisy), *Vittadinia dissecta* (Dissected New Holland Daisy) and *Atriplex semibaccata* (Berry Saltbush).
821	Tall Marsh		According to the EVC benchmark for the RobP Bioregion, Tall Marsh (EVC 821) is a wetland dominated by tall emergent graminoids (rushes, sedges, reeds), typically in thick species poor swards. Occupies wetlands in usually associated with anabranches of creeks. Soils are almost permanently moist. Dominant species are tolerant of inundation, but not total immersion for extended periods. Large and medium graminoids such as *Typha orientalis* (Broadleaf Cumbungi), *Cyperus exaltatus* (Tall Flat-sedge) and medium herbs such as *Persicaria decipiens* (Slender Knotweed) dominate the wetland edges. The ground layer supports a thick carpet of *Glinus lotoides* (Hairy Carpetweed), *Cynodon dactylon* (Native couch) and introduced *Polygonum aviculare* (Wireweed). Regenerating River Red Gums (RRG) are prevalent along the edges of the wetland bed. The cover of regenerating RRG was typically 2550 % within the 20 m X 20 m quadrats located on the edges of the wetland bed. Regenerating RRG is considered a threat to the wetland and should be monitored.
103	Riverine Chenopod Woodland	Endangered	According to the EVC Benchmark for the RobP Bioregion, Riverine Chenopod Woodland is a eucalypt woodland to 15 m tall with a diverse shrubby and grassy understorey occurring on most elevated riverine terraces. Confined to heavy clay soils on higher level terraces within or on the margins of riverine floodplains (or former floodplains), naturally subject to

			only extremely infrequent incidental shallow flooding from major events if at all flooded.

Appendix 3. Index of Wetland Condition

Background

The condition of Margooya Lagoon was assessed in December 2009 using a method developed by DELWP called the Index of Wetland Condition (IWC) method. The IWC defines wetland condition as the state of the biological, physical, and chemical components of the wetland ecosystem and their interactions.

The IWC has five sub-indices based on the catchment of the wetland and its fundamental characteristics: physical form, hydrology, water properties, soils and biota. Each sub-index is given a score between 0 and 20 based on the assessment of a number of measures. The overall IWC score is not a simple summation of the sub-index scores. A formula is used that weights each sub-index according to the contribution it makes to the overall condition of the wetland. The wetland hydrology sub-index for example contributes more to the overall score than the soils sub-index.

Methods

Sub-indices

The table below shows what is measured for each of the six sub-indices and how each sub-index is scored. The sections below describe this in greater detail. Further information can be found on the IWC website (www.dse.vic.gov.au/iwc).

IWC sub-indices and measures

Sub-index	What is measured	How it is scored
Wetland catchment	The intensity of the land use within 250 metres of the wetland	The more intensive the landuse the lower the score
	The width of the native vegetation surrounding the wetland and whether it is a continuous zone or fragmented	The wider the zone and more continuous the zone, the higher the score
Physical form	Whether the size of the wetland has been reduced from its estimated pre-European settlement size	A reduction in area results in a lowering of the score
	The percentage of the wetland bed which has been excavated or filled	The greater the percentage of wetland bed modified, the lower the score
Hydrology	Whether the wetland's water regime (i.e. the timing, frequency of filling and duration of flooding) has been changed by human activities	The more severe the impacts on the water regime, the lower the score
Water properties	Whether activities and impacts such as grazing and fertilizer run-off that would lead to an input of nutrients to the wetland are present	The more activities present, the lower the score
	Whether the wetland has become more saline or in the case of a naturally salty wetland, whether it has become more fresh	An increase in salinity for a fresh wetland lowers the score or a decrease in salinity of a naturally salty wetland lowers the score
Soils	The percentage and severity of wetland soil disturbance from human, feral animals or stock activities	The more soil disturbance and the more severe it is, the lower the score

Biota	The diversity, health and weediness of the native wetland vegetation	The lower the diversity and poorer health of native wetland vegetation, the lower the score
		The increased degree of weediness in the native wetland vegetation, the lower the score

Scoring method

Each subindex is given a score between 0 and 20 based on the assessment of a number of measures as outline above. Weightings are then applied to the scores as tabulated below. The maximum possible total score for a wetland is 38.4. For ease of reporting, all scores are normalised to an integer score out of 10 (i.e. divide the total score by 38.4, multiply by 10 and round to the nearest whole number).

IWC sub-index	Weight
Biota	0.73
Wetland catchment	0.26
Water properties	0.47
Hydrology	0.31
Physical form	0.08
Soils	0.07

Five wetland condition categories have been assigned to the sub-index scores and total IWC scores as tabulated over page. The five category approach is consistent with the number of categories used in other condition indices such as the Index of Stream Condition. Biota sub-index score categories were determined by expert opinion and differ to those of the other sub-indices.

Non-biota sub-index score range	Biota sub-index score range	Total score range	Wetland condition category
0-4	0-8	0-2	Very poor
5-8	9-13	3-4	Poor
9-12	14-16	5-6	Moderate
13-16	17-18	7-8	Good
16-20	19-20	9-10	Excellent
N/A	N/A	N/A	Insufficient data

Results

The overall IWC score for Margooya Lagoon was 5 out of 10, which is considered to be moderate. The hydrology and biota sub-indices were considered to be in very poor and poor condition respectively. Hydrology was considered to be very poor due to the significant disruption the

permanent inundation due to Euston weir pool has had on the natural wetting and drying cycle of Margooya Lagoon.

Margooya Lagoon IWC sub-index and overall score

IWC sub-index	Score /20	Category
Wetland catchment	16	Good
Physical form	20	Excellent
Hydrology	0	Very poor
Water properties	17	Excellent
Soils	14.5	Good
Biota	8.52	Poor
Overall IWC score	**5 / 10**	**Moderate**

Appendix 4. Development of Ecological Objectives

Proposed Ecological Objectives for Margooya Lagoon

The ecological objectives for Margooya Lagoon were initially developed during the drafting of the 2010 Margooya Lagoon EWMP. As part of the update of the Margooya Lagoon EWMP the Mallee CMA has requested that the ecological objectives are reviewed. This document outlines the process to review, and where appropriate suggest revisions of the 2010 ecological objectives. These have been developed using a process of identifying water dependant values from databases and literature and drafting objectives for these values which are measurable, feasible and supported by evidence.

Water Dependant Ecological Values

Table 19 Ecological Values

Value	Importance (listings, alignment to strategies)	Habitat requirements	Current Condition or occurrence	Ecological objective required?
River Red Gum	*Habitat for threatened fauna species (e.g. Regent Parrot and White-bellied Sea Eagle) carbon cycling etc*	*Occasional wetting is important for promoting seed set of flood tolerant vegetation, subsequent dry phase provides suitable conditions for seed germination.*	*RRG health associated with the lagoon has been observed to be in decline, although some trees are still in good condition.*	*Objective to improve the health of RRG,* *This is an action, not an objective: including possible surcharge level (via Lock 15 weirpool raising) to push water into RRG communities.*

Value	Importance (listings, alignment to strategies)	Habitat requirements	Current Condition or occurrence	Ecological objective required?
Silver Perch and Golden Perch	*Habitat for threatened fish and native fish communities.* *Silver Perch (EPBC and FFG)*	The drying and re-wetting of wetlands is likely to support recruitment of native fish (DEWNR 2012), but their persistence may be temporary depending on the ongoing water regime, which will include a drying regime.	*Occurrences of threatened native fish (Silver Perch) have declined due to the proliferation and competition with large-bodied carp at Margooya Lagoon due to the previously relatively permanent inundation of the wetland.* *Silver Perch were recorded within the lagoon again in 2011.* *Higher numbers of native fish are recorded in drainage cycles when compared to filling cycles within the lagoon. It appears that with the carp screen installed and regular wetting and drying that native fish diversity can be supported.*	*Objective to maintain and enhance populations of native fish, including use of periodic drying to remove carp (i.e. carp fingerlings that pass through the carp screen and reach adult size in wetland)*

Value	Importance (listings, alignment to strategies)	Habitat requirements	Current Condition or occurrence	Ecological objective required?
Native frog species (including threatened species e.g. Growling Grass Frog)	Aquatic vegetation complexity is important for many species, particularly at tadpole stage, and provides food and habitat to shelter from predators, therefore allowing recruitment to occur (Tarr & Babbitt 2002, cited in Rogers & Ralph 2011).	Frogs respond to the timing, duration and frequency of flooding, with the timing of inundation being the most significant factor. Close proximity to permanent waterbodies and drought refuges is also important for frogs (Tarr & Babbitt 2002, cited in Rogers & Ralph 2011).	*Four species of frog observed during GHD 2008 survey. All four species likely to persist in the area and respond favourably to managed flows.*	*An objective to support diversity and abundance of frogs (foraging habitats with opportunistic breeding) – inundation of the wetland at suitable time of year with required duration to meet reproductive cycle.*
Regent Parrot (Polytelis anthopeplus)	*EPBC Listed (Vulnerable);* *FFG threatened;* *DSE Advisory Listed (Vulnerable)*	Species is reliant on the habitat provided by the River Red Gum communities which fringe Margooya Lagoon. Regent Parrots breed within the hollows supported by mature River Red Gums.	*Requires RRG associated with the lagoon for nesting/breeding habitat. Regularly observed at the wetland which is in close proximity to known breeding areas further up and downstream along the Murray River.*	*Supported by River Red Gum objectives – extend inundation into root zone of RRG for appropriate frequency and duration*

Value	Importance (listings, alignment to strategies)	Habitat requirements	Current Condition or occurrence	Ecological objective required?
Diamond Firetail (Stagonopleura guttata)	*FFG threatened;* *DSE Advisory Listed (Vulnerable)*	Species uses habitat provided by the River Red Gum/grassy communities (granivore) that fringe Margooya Lagoon. Dependency on water apart from for drinking is unknown, possibly a link with current grasses fringing Margooya and water regime.	*Feeds on seeds from grasses fringing the lagoon. This species is infrequently observed within the catchment but appears to be a regular visitor to Margooya Lagoon (recorded GHD 2008 and previous VBA records).*	*Possibly supported by River Red Gum and wetting and drying objectives*
White bellied Sea Eagle *(Haliaeetus leucogastera)*	*CAMBA Listed;* *FFG threatened;* *DSE Advisory Listed (Vulnerable)*	*Requires* River Red Gum for nesting*, feeds on fish. Wetting and drying will be beneficial* fish abundance will increase under a wetting and drying cycle that promotes wetland productivity.	*Requires the RRG associated with the lagoon for nesting, as well as relying on the lagoon itself for foraging opportunities.*	*Supported by River Red Gum and fish objectives*
Waterbirds	Wetland management which increases the diversity of available habitat types such as variable water depths, mud flats, inundated vegetation and deep water areas have the greatest abundance and diversity of waterbirds (Taft *et al.* 2002, cited in MDBA 2009).	The provision of environmental water to wetlands is one method of creating such habitat patches for waterbirds, allowing them to move between suitable habitat to survive and reproduce (MDBA 2009).	*Nine species of waterbird observed including the EPBC migratory/FFG listed White-bellied Sea-eagle. Additional species are likely to occur depending on the extent of wetting/drying*	*Objective to support a variety of waterbird habitat (foraging and potentially breeding) to promote diversity/abundance – a wetting a drying regime*
Native Vegetation including specific Ecological Vegetation	*A diverse range of native vegetation types (including terrestrial, emergent and aquatic vegetation) provides*	*A number of EVCs within the target area rely on seasonal inundation and or/ periods of flooding:* • *Intermittent Swampy Woodland (EVC 813)*	*Previous monitoring conducted by GHD in 2008 indicated that terrestrial vegetation was in variable condition (RRG tree*	*Improve condition of RRG EVCs and wetland/littoral vegetation*

Value	Importance (listings, alignment to strategies)	Habitat requirements	Current Condition or occurrence	Ecological objective required?
Classes (EVCs) and aquatic and emergent vegetation.	*habitat for a greater diversity of fauna species and improves ecosystem function.*	• *Shallow Freshwater Marsh (EVC 200)* • *Riverine Chenopod Woodland (EVC 103)* • *Lignum Swampy Woodland (EVC 823)* • *Floodway Pond Herbland (EVC 810)* • *Grassy Riverine Forest/Floodway Pond Herbland Complex (EVC 811)* • *Riverine Grassy Woodland (EVC 295)* • *Shrubby Riverine Woodland (EVC 818)* *Wetland vegetation including macrophytes and aquatic vegetation rely on inundation to survive and a suitable duration to contribute to the seed bank.*	*health ranging from good to poor).*	*communities and EVCs by introducing a wetting and drying regime to Margooya Lagoon.*
Threatened flora species	*Flora species listed under the DELWP maintained VROTS list has been recorded at the site.* *Spreading Emu-bush (rare)* *Scurfy Germander (poorly known)*	*At least two water dependent listed flora species have been recorded.* *Spreading Emu-bush (Eremophila divaricata subsp. divaricata) commonly occurs in woodlands on alluvial or sandy soils, and is often found along the Murray River and associated billabongs within EVCs including Intermittent Swampy Woodland (EVC 813), Riverine Chenopod Woodland (EVC 103), Lignum Swampy Woodland (EVC 823) and Riverine Grassy Woodland (EVC 295)*[2]*.*	*Current status of population of these species is unknown.*	*Supported by River Red Gum objectives*

[2] Flora Information System (FIS) Database (2015) Viridans Publishing, Victoria.

Value	Importance (listings, alignment to strategies)	Habitat requirements	Current Condition or occurrence	Ecological objective required?
		Scurfy Germander (Teucrium albicaule) is classified as poorly known within Victoria, and plants usually grow on clay soils in depressions which might at times be temporarily flooded[3]*. Likely EVCs for this species to be found in include Riverine Chenopod Woodland (EVC 103) and Lignum Swampy Woodland (EVC 823).*		

Management Goal

The management goal needs to reflect the ecological values of the site as described above in the EWMP. It needs to have been derived by a transparent and documented process, and have a sound rationale (especially if proposing a substantive change from recent management).

'*To provide a water regime that improves River Red Gum and littoral vegetation health and maintains and enhances key habitats for native fish, frogs, waterbirds and threatened birds*'

Ecological Values

Table 20 Ecological Objectives

Ecological objective	Ecological objective - comments	Justification (value based)	Site (if applicable)	Monitoring

[3] Toelken, H.R. (1985) Notes on Teucrium L. (Labiatae). *Journal of Adelaide Botanic Gardens*. 7(3) 295-300.

Maintain and enhance the condition of River Red Gum with chenopod understorey	Improve and maintain the health of River Red Gums fringing Margooya Lagoon by providing inundation of a suitable frequency, duration and extent (includes 100% fill and 'surcharged' event via Lock 15 weirpool raising)	*Habitat for threatened fauna species (e.g. Regent Parrot and White-bellied Sea-eagle) and threatened flora species (Spreading Emu Bush and Scurfy Germander). Also supports a range of other possible threatened species habitat (e.g. Lace Monitor, Carpet Python). Littoral zone supports habitats for frogs, waterbirds, fish.*	Fringing River Red Gum around Margooya Lagoon and associated EVCs.	TLM RRG Monitoring method
Maintain and enhance the condition of River Red Gum with flood tolerant understorey (littoral RRG)	Improve and maintain the health of River Red Gums fringing Margooya Lagoon (littoral RRG) by providing inundation of a suitable frequency, duration and extent (includes 100% fill)	*Habitat for threatened fauna species (e.g. Regent Parrot and White-bellied Sea-eagle). All supports a range of other possible threatened species habitat (e.g. Lace Monitor, Carpet Python). Also supports habitat for a range of non-threatened fauna.*	Fringing River Red Gum around Margooya Lagoon and associated EVCs.	TLM RRG Monitoring method
Exclude carp from the wetland and provide habitat for small-bodied fish	Provide a suitable water regime (to provide deep water and suitable conditions for littoral vegetation growth) to maintain (and if possible enhance) the diversity and abundance of native fish species. This involves the use of the carp screen installed on the regulator to exclude large-bodied carp.	Enhancement of water quality due to reduced carp abundance and greater aquatic vegetation abundance. As well as the intrinsic ecological value of native fish presence, this group of fauna will also provide an important food source for waterbirds and freshwater turtles.	Within Margooya Lagoon itself.	Fish surveys

Provide nursery habitat for Silver and Golden Perch	Provide a suitable water regime (to provide deep water and suitable conditions for littoral vegetation growth) to support nursery habitat for Golden and Silver Perch. This involves the use of the carp screen installed on the regulator to exclude large-bodied carp.	The EPBC and FFG listed Silver Perch has been recorded at Margooya Lagoon in 2009 and 2010. This objective will support recruitment of these species. Enhance water quality due to native species composition rather than introduced carp.	Within Margooya Lagoon itself.	Fish surveys
Provide periodic frog habitat	Provide periodic periods of inundation to maintain and enhance the diversity and abundance of frogs at Margooya Lagoon. Wetting regimes (likely to include 100% filling to inundate fringing/breeding habitat) may include sufficient inundation duration to allow reproductive cycle to complete timed preferably for spring/summer inundation. Inundation should extend to the fringe of the wetland where emergent macrophytes are present (calling/laying habitat for frogs).	Frogs provide food for wetland birds, snakes, fish and themselves prey on insects. It is possible that specifically managed flows could result in the threatened Growling Grass Frog utilising the wetland.	Within Margooya Lagoon itself.	Song meters; Active search - nocturnal

Provide periodic habitat for waterbirds – piscivores, deep water foragers	Provide periodic inundation levels that comprise of 100% full and 'surcharged' (100%+ due to Lock 15 weirpool raising) to promote habitat for species that prefer deep water for foraging (piscivores such as cormorants/pelicans, deep diving ducks such as Hardhead and Musk Duck).	Waterbirds provide important ecological functions such as foraging on and consuming insects/aquatic vegetation/fish but they are also a prey source for larger predators such as Lace Monitor, Carpet Python, raptors. Threatened deep water preferring waterbirds include Hardhead and Musk Duck with each of these species being possible at Margooya.	Predominantly Margooya Lagoon itself.	Waterbird surveys – conducted pre, during and post inundation as water levels change GIS mapping to monitor water levels – i.e. waterbird habitat availability.

Provide periodic habitat for waterbirds – dabbling ducks, grazing waterfowl, waders	Provide periodic inundation of varying levels (e.g. bankful to lower levels which promote areas of mud/shallow water) to provide habitat for waders, dabbling ducks, grazing waterfowl Various inundation levels could be introduced including a partial fill and a drying phase (waders, migratory shorebirds) from higher levels of inundation (e.g. 100%) during a summer drawdown when migratory species appear in southern Australia.	Waterbirds provide important ecological functions such as foraging on and consuming insects/aquatic vegetation but they are also a prey source for larger predators such as Lace Monitor, Carpet Python, raptors. Provide opportunistic foraging habitat for migratory species Threatened species including Eastern Great Egret, Australasian Shoveler and EPBC-listed migratory species.	Predominantly Margooya Lagoon itself.	Waterbird surveys – conducted pre, during and post inundation as water levels change GIS mapping to monitor water levels – i.e. waterbird habitat availability.
Provide conditions to enhance littoral vegetation zones – broad and diverse	Maintain appropriate water regime (flooding in winter-spring and exposure in summer-autumn) to promote a broad and diverse littoral vegetation zone – including emergent and aquatic macrophytes The regulator allows winter/spring flooding and summer drawdowns to promote diversity and littoral vegetation zone extent in subsequent re-wetting events. This promotes plant growth and fauna habitat.	Support habitat for small fish, threatened species, frog breeding, waterbird breeding.	Around the fringe of Margooya Lagoon	Employ methods including full floristic assessment of targeted quadrats (20m x 20m) to measure condition. Weedon and Nicol 2006/Zampatti *et al.* 2006 understorey vegetation approach.

Introduce a periodic drying phase to promote nutrient cycling	The regulator allows summer-autumn drawdowns to dry out soils and organic matter to be released on subsequent rewetting.	Drying phase maintains a productive ecosystem, drying wetland to consolidate sediments. Also maintain nutrient mineralisation, carbon cycling. Dry wetland to obtain nutrient cycling (oxidise nutrients and make carbon available – drive bacterial productivity, phytoplankton, waterbirds, fish etc. Rewetting releases nutrients.	Within Margooya Lagoon	Water quality testing.