Merbein Common Waterway Management Unit Environmental Water Management Plan

Mallee Catchment Management Authority

mallee catchment management authority

State Government Victoria

Department of Environment and Primary Industries

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EXECUTIVE SUMMARY

Environmental water management plans have been developed for key sites in the Mallee region by the Mallee Catchment Management Authority in partnership with the Victorian Department of Environment and Primary Industries. These plans are based on Waterway Management Units (WMUs) of the Murray River floodplain and have been developed to guide future environmental water events at these sites.

The Merbein Common WMU is 16 km north-west of Mildura and takes in the area covered by the Murray River Park as defined in the VEAC River Red Gum Investigation (VEAC 2008). This plan focuses on a target area within the WMU for environmental watering events and related infrastructure development to maximise inundation extent to an area of 198 ha.

Environmental values for the Merbein Common WMU include a diverse range of water dependent flora and fauna species including some listed under state, national and international treaties, conventions, Acts and initiatives such as the endangered Freckled and Blue-billed Ducks. The area also contains a number of water dependent ecological vegetation classes and wetlands listed as depleted, such as Intermittent Swampy Woodland and the vulnerable Alluvial Plains Semi-arid Grassland. The target area has significant social values for the local community and the local indigenous community has strong connections to the area. The value which is central to the management of the site is the semi-permanent wetland community.

Merbein Common Waterway Management Unit Management goal:

Cowanna Billabong:
To provide a watering regime to maintain and improve the health of River Red Gum communities and to improve aquatic vegetation diversity.

Brickworks Billabong:
To provide a watering regime to maintain and improve the health of aquatic vegetation, particularly Ruppia species, to maintain appropriate salinity levels for Murray Hardyhead and to improve the health of River Red Gum and Black Box communities.

Catfish Billabong:
To provide a watering regime to maintain and improve the health of River Red Gum and Lignum communities.

To achieve these objectives, a long-term watering regime has been developed.

Minimum watering regime
Inundate the wetlands in the target area five years in every ten with an maximum interval of two years between events. Allow ponding in the wetlands for four months. Every three years in ten extend the inundation area onto the floodplain with a maximum interval of three years between events. Allow ponding on the floodplain for two months.

Optimal watering regime
Inundate the wetlands in the target area nine years in every ten with an maximum interval of two years between events. Allow ponding in the wetlands for ten months. Every five years in ten extend the inundation area onto the floodplain with a maximum interval of three years between events. Allow ponding on the floodplain for five months.

Maximum watering regime
Inundate the wetlands in the target area ten years in every ten with an maximum interval of one year between events. Allow ponding in the wetlands for twelve months. Every seven years in ten extend the inundation area onto the floodplain with a maximum interval of two years between events. Allow ponding on the floodplain for five months.

The constraint on the current ability to water the Merbein Common WMU is the lack of ability to retain the environmental water to a high enough level on the floodplain to inundate the target area. Infrastructure is proposed to increase the extent of floodplain which could be watered. It is anticipated that with works such as levees, road raising and culverts in place an increase in area able to be inundated from 67 ha to 198 ha could be achieved. The volume of water required to inundate the current extent possible is 926 ML while the anticipated increased extent would require 2947 ML.

A full cultural heritage management plan and detailed designs for the proposed works are the top two knowledge gaps and recommendations for the site.

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The Mallee Catchment Management Authority acknowledges the Victorian State Government for funding the development of the environmental watering plans. They also acknowledge the contribution to the development of the plans by Parks Victoria, Jane Roberts, Terry Hillman, other agencies and community members.

ABBREVIATIONS AND ACRONYMS

ANCA	Australian Nature Conservation Agency
AVIRA	Aquatic Value Identification and Risk Assessment
CAMBA	China-Australia Migratory Bird Agreement
CMAs	Catchment Management Authorities
DEH	Department of Environment and Heritage
DEPI	Department of Environment and Primary Industries
DNRE	Department of Natural Resources and Environment
DSE	Department of Sustainability and Environment
EA	Ecological Associates
EPBC	Environment Protection and Biodiversity Conservation Act
EVC	Ecological Vegetation Class
EWaMP	Environmental Water Management Plan
EWH	Environmental Water Holder
EWR	Environmental Water Reserve
FFG	Flora Fauna Guarantee Act
FSL	Full Supply Level
G-MW	Goulburn-Murray Water
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
TSL	Targeted Supply Level
VEAC	Victorian Environmental Assessment Council
VEWH	Victorian Environmental Water Holder
VWMS	Victorian Waterway Management Strategy
WMU	Waterway Management Unit

1. INTRODUCTION

1.1. Background

Environmental water management in Victoria is entering a new phase as ongoing water recovery sees significant volumes of water being returned to the environment. The increasing environmental water availability is providing new opportunities to protect, restore and reinstate high value ecosystems throughout northern Victoria. The spatial coverage of environmental watering has expanded considerably in recent years and this trend will continue into the future.

Environmental watering in Victoria has historically been supported by management plans which document key information such as the watering requirements of a site, predicted ecological responses and water delivery arrangements. State and Commonwealth environmental watering programs now have the potential to extend beyond those sites which have been watered in the past. Therefore, new plans are required to provide a transparent and informed approach to environmental water delivery across new environmental watering sites.

1.2. Purpose

The Victorian Catchment Management Authorities (CMAs) and Department of Environment and Primary Industries (DEPI) are working together to develop new Environmental Water Management Plans for both current and future environmental watering sites throughout northern Victoria. The primary purpose of the plans is to provide a consistent set of documents that support the Seasonal Watering Proposals to be submitted by CMAs to the Victorian Environmental Water Holder (VEWH) each year. The supporting information includes:

- water dependent environmental, social and economic values;
- water dependent environmental condition, threats and objectives;
- long-term water regime requirements to meet environmental objectives, under a range of climatic conditions;
- environmental watering management responsibilities;
- recent records of water delivery;
- opportunities for improved efficiency or capacity through structural works or other measures; and
- scientific knowledge gaps and recommendations for future work.

1.3. Site location

The Mallee CMA is situated in the north-west of Victoria. The area of responsibility is close to 39,000km^2 (3.9 million ha), with a regional population estimated to be 65,000. Population centres include Mildura, Birchip, Sea Lake, Ouyen, Robinvale, Red Cliffs and Merbein.

The Mallee CMA region covers almost one fifth of Victoria, making it the largest area managed by a Catchment Management Authority in the state.

Approximately 40% of the land area within the Mallee CMA boundary is public land, consisting mainly of National Parks, reserves, wilderness areas and large tracts of riverine and dryland forests. The other 60% is predominantly dryland cropping by area, but there is also a significant investment in irrigation of grapes, citrus, almonds, olives, and vegetables along the Murray River corridor which contributes over 40% of the value of agricultural production for the region.

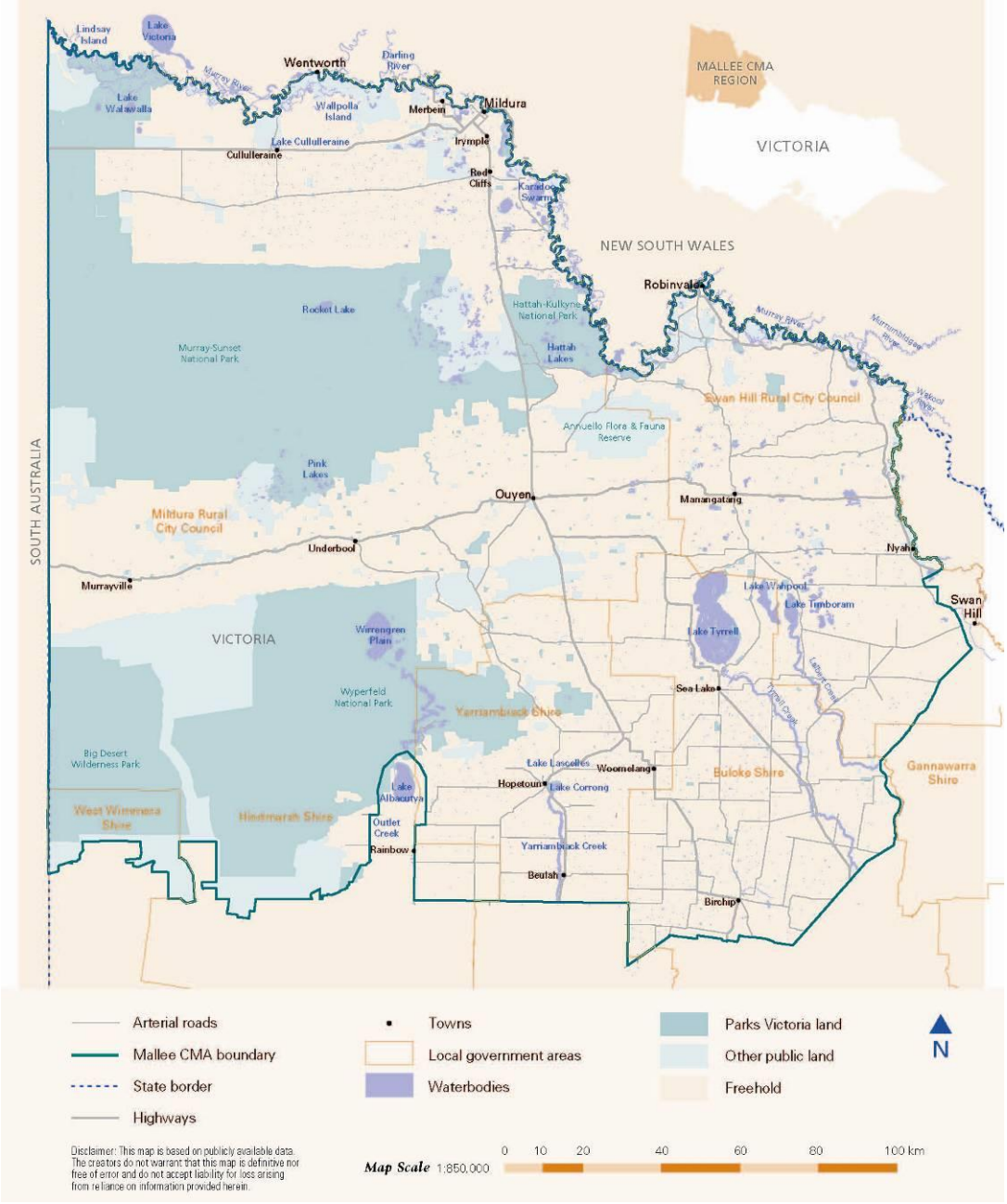


Figure 1 Map of the CMA region

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 (EA, 2007) was the development of a system of Waterway Management Units (WMUs). These divide the floodplain into management units which are areas in which water regimes can be managed independently of another WMU but which are relatively consistent in their ecological values and land uses. The Mallee CMA has based its environmental water management plans on these WMUs to achieve more effective management of hydrologically connected systems. The site for this plan is the Merbein Common WMU situated 16km north-west of Mildura on the Murray River floodplain (see Figure 2, p8).

1.4. Consultation

This Plan was developed in collaboration with key stakeholders namely Parks Victoria, the Department of Environment and Primary Industries and local interest groups. Three meetings were held during the development phase to seek input and gather information from experts and stakeholders as well as meetings with the DEPI and other CMAs.

Table 1 Consultation Process for development of Merbein Common WMU Environmental Water Management Plan

Meeting date	Stakeholders	Details
4 Sept 2012	Parks Victoria	Discussion of draft plan and request for input.
12 Sept 2012	Friends Of Merbein Common (FOMC) meeting including representatives from Parks Victoria, Merbein Rotary Club, Merbein Historical Society, Yelta Landcare Group, Merbein Lions, Merbein Development Association	Presentation of draft plan and request for input/feedback
10 October 2012	Yelta Landcare Group	

Those involved in the consultation phase were very interested in seeing the health of the floodplain improved through environmental watering events. FOMC suggested that where possible some of the environmental flow be used to move salt, as much as possible, off the floodplain to alleviate salinity impacts on vegetation and reduce the risk of acid sulphate soils developing. FOMC also suggested the area the CMA are looking at be increased to include the low-lying ground behind the Merbein sandbar. Mallee CMA will endeavour to consider suggestions from all stakeholders and make management decisions based on the best available scientific data.

1.5. Information sources

Information used in the development of this Plan was compiled from various sources (References, Section 10) including river health and catchment strategies, consultant reports and wetland and park management plans. A number of state-wide data sets and digital mapping layers were used including the:

- Flora Information System of Victoria;
- Atlas of Victorian Wildlife;
- Bioregional Conservation Status of Ecological Vegetation Classes;
- Wetland Environments and Extent up to 1994; and
- Aerial photography
- Digital Elevation and LiDAR modelling
- Local knowledge

This information was supplemented by discussions with people with an intimate knowledge of the study area, its environmental values and the management and operation of the Merbein Common Waterway Management Unit.

1.6. Limitations

The information sources used in the development of this report have a number of limitations. These limitations include that the data contained in the Flora Information System and the Atlas of Victorian Wildlife comes from a combination of incidental records and systematic surveys. The data varies in accuracy and reliability due to the distribution and intensity of survey efforts. In addition, the lack of knowledge about the distribution and characteristics of invertebrates and non-vascular plant species means the data is weighted towards the less cryptic elements of flora and fauna, i.e. vascular flora and vertebrates. This report also draws on material collated from management plans, research documents and published literature. These sources vary in their age and hence the degree to which they reflect the current situation. However, the Plan is intended to be a live document and will be amended as new information becomes available.

2. SITE OVERVIEW

2.1 Catchment setting

The Merbein Common Waterway Management Unit is located 16km north west of Mildura on the Victorian floodplain of the Murray River. The WMU is in the Murray Scroll Belt bioregion within the Mallee CMA region. The bioregion is characterised by an entrenched river valley and associated floodplain and lake complexes of numerous oxbow lakes, billabongs, ephemeral lakes, swamps and active meander belts. Alluvium deposits from the Cainozoic period gave rise to the red brown earths, cracking clays and texture contrast soils (Dermosols, Vertosols, Chromosols and Sodosols) supports Alluvial-Plain Shrubland, Riverine Grassy Chenopod Woodland and Riverine Grassy Forest ecosystems (DEPI website bioregions description). The Merbein Common WMU consists of floodplain containing two large lagoon systems and an extensive area of higher elevation area of Black Box woodland and chenopod shrubland (EA 2007b).

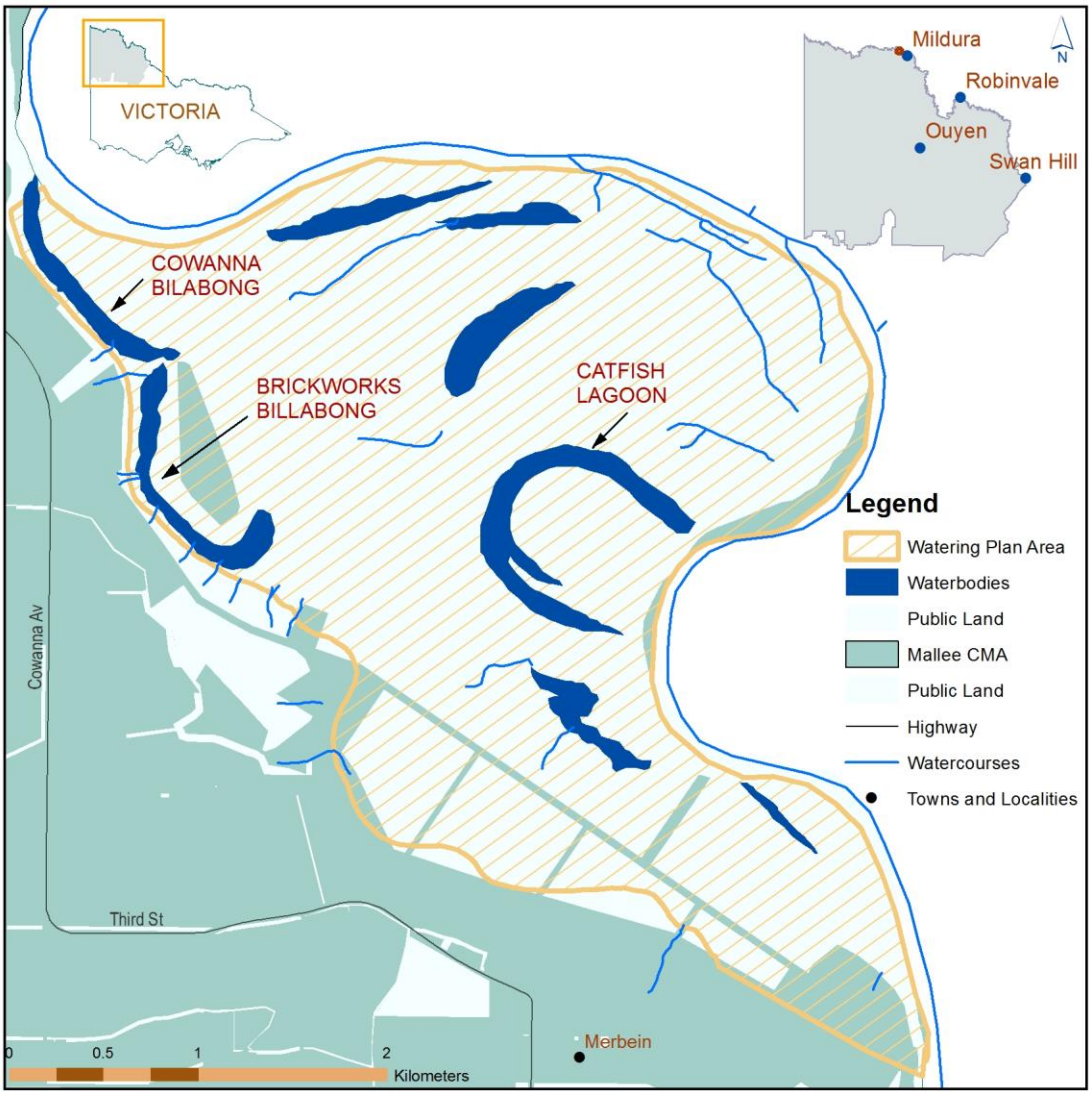


Figure 2 Map of Merbein Common Waterway Management Unit

The Waterway Management Unit boundary indicates the area for which water regimes can be managed largely independently of each other. The whole WMU has a water requirement as a floodplain complex but the focus for this plan is restricted to a target area within the WMU of 198 ha, as shown in Figure 3. This target area is the extent to which environmental water is able to be managed with proposed infrastructure in place. Constraints and proposed infrastructure are discussed fully in Sections 4 and 8.

Expansion of the target area is possible only with significant alterations to River Murray operations such as large releases from storage which is beyond the scope of this plan and would need to be addressed at a Basin scale.

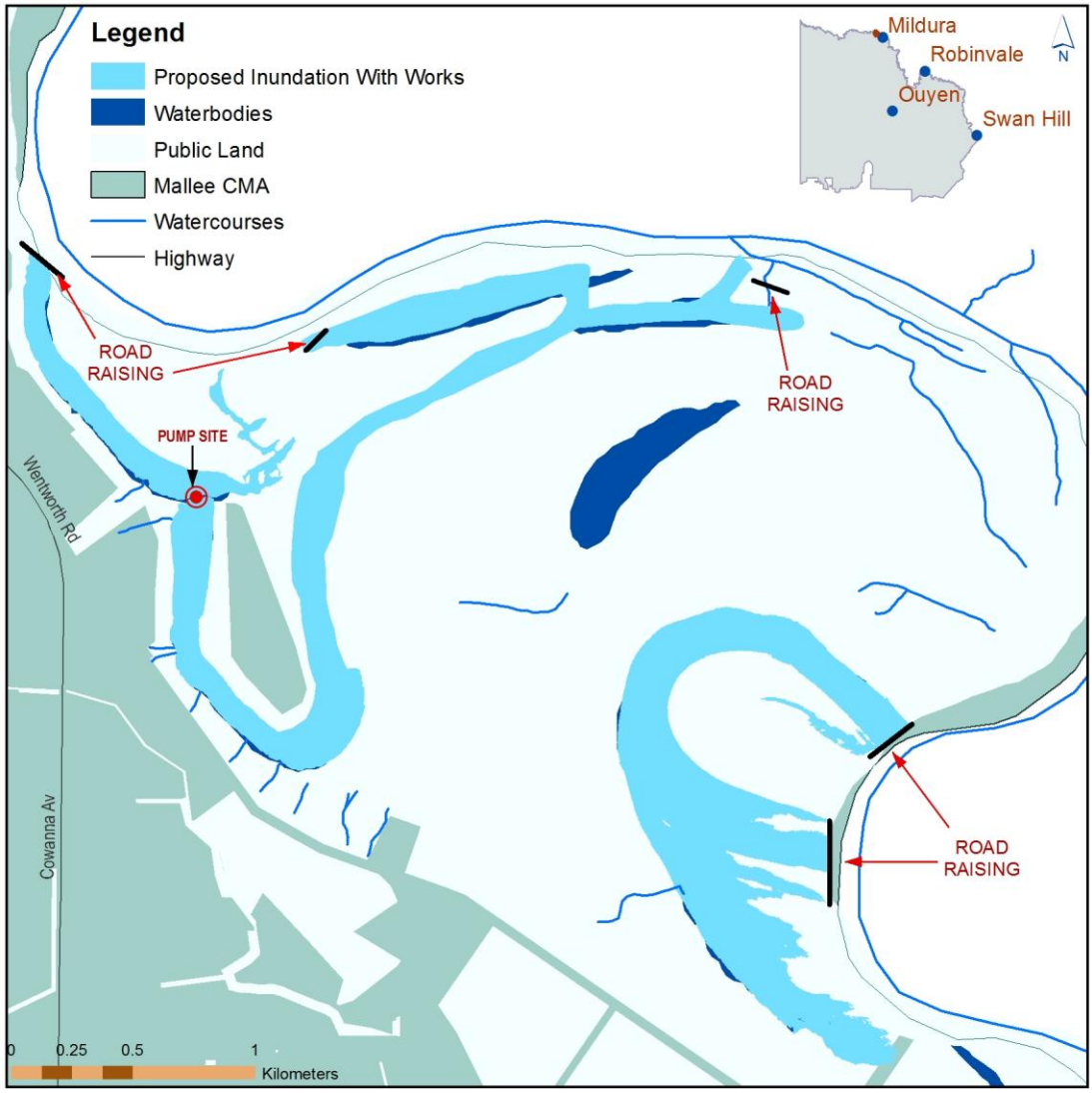


Figure 3 Target area showing achievable inundation extent of Merbein Common WMU

2.2 Land status and management

The Merbein WMU area is managed as a part of the proposed Murray River Park (VEAC 2008, p 63) in conjunction with the River Red Gum Forests Investigation (VEAC 2008). Until November 2009 the Merbein Common was managed by the Department of Environment and Primary Industries but is now managed by Parks Victoria as recommended by the Victorian Environmental Assessment Council.

The surrounding land is largely used for grapevines for wine and dried fruit as well as small areas of citrus and other fruit trees, nut trees and vegetables. There are also many vacant

areas that have previously been used for permanent and seasonal planting (MCMA 2010). Brickworks Billabong is used as an irrigation disposal basin resulting in salinity and nutrient issues. The area also houses a community use area and Merbein Sewage Treatment ponds (MCMA 2012a).

Table 2 Stakeholders for the Merbein Common WMU:

Group	Role
Parks Victoria	Land Manager
Mallee CMA	Regional environmental management
Department of Environment and Primary Industries	State level environmental water management planning, land manager, threatened species manager
Goulburn Murray Water	River Murray operations
Mildura Rural City Council	Local Government
Nyeri Nyeri and Latji Latji Community	Indigenous Representation
Friends of Merbein Common	Assistance in planning and implementation of programs

2.3 Wetland characteristics

A brief overview of the main characteristics of the target area is given in Table 3. .

Table 3 Summary of target area characteristics

Characteristics	Description
Name	Merbein Common Waterway Management Unit target area
Wetland mapping ID within area (DEPI wetland layer 1994)	Includes 6 registered wetlands: #7329954215 (Brickworks Billabong), #7329951224 (Cowanna Billabong), #7329973215 (Catfish Lagoon), #7329977204, #7329968230, #7329974230
Target Area	198 ha
Bioregion	Murray Scroll Belt
Conservation status	Regionally important
Land status	Murray River Park
Land manager	Parks Victoria
Surrounding land use	Regional Park, irrigated horticulture, rural township
Water supply	Natural inflows from Murray River. Cowanna Billabong is permanently inundated by Murray River operational flows with a commence to flow (ctf) of 2,000ML. Brickworks Billabong ctf is 20,000ML. Catfish Billabong ctf is 5,000. Others ctf at flows ranging up to 66,660ML/day measured at river gauge downstream of Mildura weir (# 425010.) Environmental water previously pumped from the river. Currently minimal irrigation system outfalls from irrigated horticulture properties.
1788 wetland category	Permanent open freshwater, Freshwater meadow, Deep freshwater marsh
1994 wetland category and sub-category	Open water- shallow (<5m), Meadow- Herb, Meadow- Black Box, Deep Marsh- Open water
Wetland Water Regime Class	Semi-permanent wetland
Wetland depth at capacity	2-5m

2.4 Environmental water

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 and Climate Change has appointed Commissioners to Victoria's first independent body for holding and managing environmental water – the Victorian Environmental Water Holder (VEWH) to be responsible for holding and managing Victoria's environmental water entitlements, and making decisions on their use.

Environmental Water for the study site may be sourced from the water entitlements and their agencies listed in Table 4 and further explained in Appendix 1. Recent environmental watering which has occurred at the Nyah Vinifera site is outlined in section 4.1.3.

Table 4 Summary of environmental water sources available to Merbein Common WMU

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	Mallee CMA

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

2.5 Legislative Policy Framework

There is 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 the site and the management of its environmental values are listed in Table 5. For the functions and major elements of each refer to Appendix 2.

Table 5 Legislation, agreements, convention and listings relevant to the target area

Legislation, Agreement or Convention	Jurisdiction
CAMBA	International
JAMBA	International
EPBC	National
FFG	State
DEPI advisory lists	State

2.6 Related Plans and Activities

The Merbein Common WMU is situated on the Victorian floodplain of the Murray River which is the subject of many investigations. These include Salinity Management Plans, Flow studies and Land Conservation Council Reviews. An investigation into River Red Gum Health by the Victorian Environmental assessment Council (VEAC) in 2008 resulted in this section of the Murray being included in the proposed Murray River Park.

There have also been local investigations. In 2006, Mallee CMA engaged consultants Ecological Associates to investigate water management options for the floodplain of the Murray River from Robinvale to Wallpolla Island. This investigation proposed infrastructure to enable greater inundation of the target area in the Merbein Common WMU.

The Merbein Common is within the area covered by the Merbein to the South Australian Border Frontage Action Plan (FAP) (MCMA 2003) and has seen projects including on ground works such as track rationalisations, rabbit control, plant and animal pest control and introduced facilities (Parks 2012). The main track rationalisation, The Merbein Link Trail has become a fundamental addition to the Merbein community. There is the potential to attract future funding and works through the FAP project.

The Department of Environment and Primary Industries, TAFE, SENSIS, Parks Victoria and the Mallee CMA have invested significant resources into the area specifically in the past ten years in environmental watering including the delivery of 450 ML under the environmental watering program undertaken by the Mallee CMA in 2010.

The Friends of Merbein Common is an active community group, helping sustain the health of the Merbein Common through small on ground works projects, and assisting in the planning and implementation of programs. These programs specifically include track rationalisations and aim to raise awareness of the natural values of the Common within Merbein and wider community.

3. WATER DEPENDENT VALUES

3.1 Environmental

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.

3.1.1 Wetland depletion and rarity

Victoria's wetlands are currently mapped and are contained within a state wetland database, using an accepted state-wide 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 information:

- categories (primary) based on water regime and
- subcategories based on dominant vegetation

None of the post-1994 wetland mapping is contained within this State wetland database.

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.

It has been possible to determine 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 Victorian wetlands. This has been severe, with approximately one-third of the state's wetlands being lost since European settlement; many of those remaining are threatened by continuing degradation from salinity, drainage and agricultural practices (ANCA 1996).

Across the state, the greatest decreases in original wetland area have been in the freshwater meadow (43 per cent decrease), shallow freshwater marsh (60 per cent decrease) and deep freshwater marsh (70 per cent decrease) categories (DNRE 1997).

The Merbein Common WMU contains eight wetlands (excluding sewerage treatment ponds), three of which are in the target inundation area. They have been classified using the Corrick-Norman wetland classification system as Permanent Open Freshwater (3), Deep Freshwater Marsh (2) and Freshwater meadow (3) (Figure 5 and Table 8). There has been very little decrease in these wetland types in the Murray Scroll Belt Bioregion, however freshwater meadow and Deep freshwater marsh are the first and second most depleted categories respectively in the Mallee CMA Region (MCMA, 2006A, p13). This makes them significant in terms of representativeness.

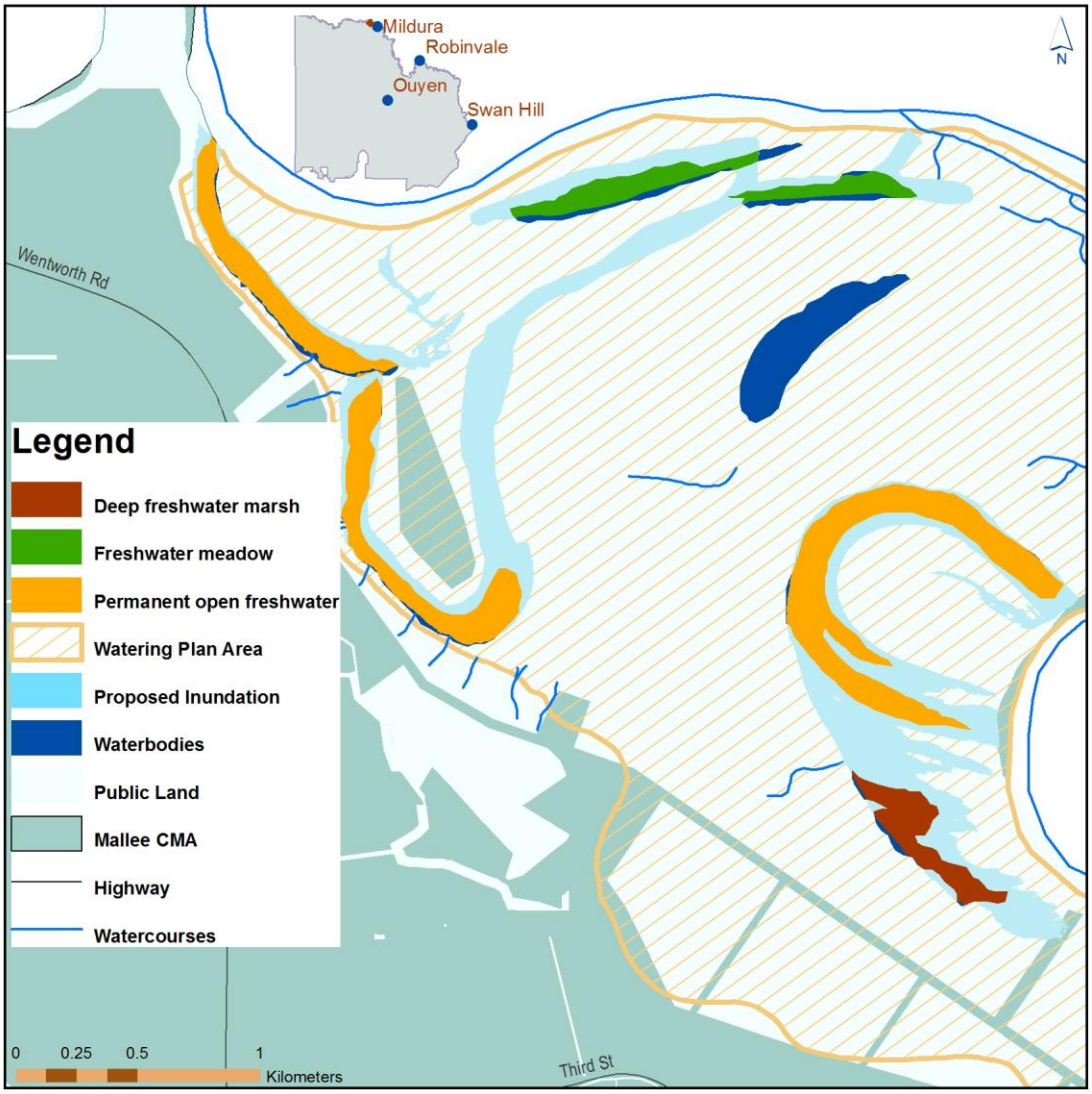


Figure 4 Map of wetland types within Merbein Common WMU

Table 6 Changes in area of the wetlands in the target area by Corrick classification

Category	No of Wetlands in target area	Total area (ha)	% Change in wetland area from 1788 to 1994		
			Victoria	Mallee CMA	Murray Scroll Belt
Freshwater meadow	3	28.4	-43	-80	0
Deep Freshwater Marsh	2	10.83	-70	-45	-6
Permanent Open Freshwater	3	55.28	-6	+5	0

Source: DSE Biodiversity interactive maps, Mallee Wetland Strategy

Several wetland classification systems exist and some of these are more relevant to the Mallee region (MCMA 2012a). Ecological Associates (2007a) proposed four categories, or Wetland Water Regime Classes, based on the residency time of water in the wetlands under natural conditions. These include:

- Semi-permanent Wetlands
- Persistent Temporary Wetlands
- Temporary Wetlands
- Episodic Wetlands

Immense detail and hydrological modeling was involved in the development of these Water Regime Classes. Although that level of detail and information is beyond the scope of this report, existing knowledge such as commence to flow rates for these wetlands, flow data for this reach of the Murray River (natural and current) and local knowledge has been used to classify the wetlands within the target area as Semi-permanent Wetlands.

The target area in Merbein Common WMU consists of two large lagoon systems, with Cowanna Billabong and Brickworks Billabong located in one system to the north-western end of the WMU. Cowanna Billabong is a Permanent Open Freshwater wetland under the 1994 wetland layer, which is connected to the River Murray by a small inlet pipe. However, it is likely that under natural flow conditions, Cowanna Billabong would have been classified as a semi-permanent wetland (MCMA 2012a).

Brickworks Billabong is just south of Cowanna Billabong. The two are separated by a block bank. Brickworks is managed as an irrigation drainage basin which has resulted in open water or bare mud with samphire vegetation and increased salinity (MCMA 2012a).

Catfish Lagoon is part of a second system and is located on the eastern side of Merbein Common.

Semi-permanent wetlands very rarely dry out and should ideally be full or close to full. Drying may occur under drought conditions and this can lead to colonisation of the wetland bed by terrestrial species. Water levels usually fall in summer and autumn and fill in winter. Drops in water level during summer and autumn allow exposure of fringing macrophytes which can be excluded by persistent flooding. Flooding should overtop the wetland level and reach the understorey of Red Gum woodlands encouraging growth of emergent macrophyte species. These wetlands provide semi-permanent habitat for a diverse range of waterbirds and are the primary habitat for Egrets and the Blue-billed Duck (EA 2007a).

3.1.2 Listings and significance

Fauna

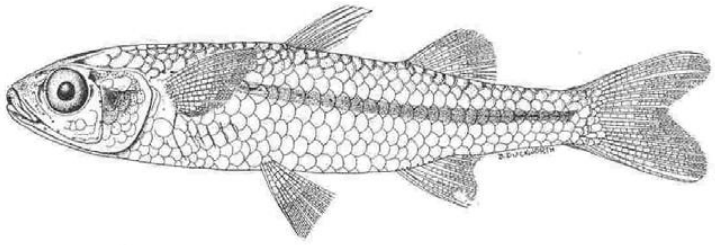
The wetland systems of the Merbein Common WMU provide habitat for a large range of native fauna species. Open water wetlands have the potential to support native fish populations (EA 2007b) and number of native species have been recorded within the target area. Ho *et al.* (2004) found the native Carp Gudgeon and Fly-Specked Hardyhead to be present at Catfish Billabong during fish sampling at this site.

Management actions, such as drying, can be used to remove carp and increase the potential for native fish populations in open water wetlands. When wetlands dry out nutrient transformation and sediment consolidation occur, this allows terrestrial plants to establish on the wetland floor. Once water re-enters the wetland these plants provide habitat and nutrients for aquatic fauna. Primary productivity of the wetland increases under re-inundation, aquatic macrophyte growth rises, providing increased food and habitat for fish. At Margooya Lagoon a managed dry phase was initiated after the wetland had been permanently inundated for nearly 50 years. Re-inundation of this wetland through environmental watering was timed to coincide with spawning of native fish species in the Murray River close to the Lagoon inlet. This resulted in eggs and larvae of Golden perch and Silver perch being transported into the wetland through the pumps (Ellis & Pike 2011a). Ellis (2010, cited in Ellis & Pyke 2011, p.14) found that both species displayed rapid growth which was attributed to the productive nursery habitat provided by flooding the wetland after a dry phase. It is hoped that using such techniques will improve fish habitat and increase native fish diversity in the wetlands of Merbein Common. Cowanna Billabong, which is permanently connected to the river, is to undergo a managed drying regime to facilitate this.

Murray hardyhead

Monitoring has been conducted at Brickworks Billabong to establish suitability for translocation of State and Commonwealth listed Murray Hardyhead (*Craterocephalus fluviatis)*. This wetland has been deemed suitable, due to its appropriate salinity levels and connection to the Murray River. This increases the conservation significance of this wetland and salinity levels should be managed for persistence of Murray Hardyhead at this site.

Murray hardyhead, *Craterocephalus fluviatilis,* are considered to be critically endangered in Victoria. This species, which was once abundant throughout its range, has suffered a dramatic decline. This is largely due to altered flow regimes and drought which has led to reduced connection between the Murray River and floodplain wetlands and drying of some lakes (Lintermans 2007). Altered flow regimes due to human processes and drought have impacted on water quality in waterways that historically supported Murray hardyhead (Ellis 2013), increasing salinity and degrading habitat (Lintermans 2007). Introduced species such as Eastern gambusia and Redfin perch have also impacted on Murray hardyhead through competition and predation (Ellis 2013).



Murray hardyhead
Craterocephalus fluviatilis

Description
Murray hardyhead are small but highly mobile, reaching approximately 72mm in length. The colour is silver to golden on the back, with a paler underside and a silvery-black mid-lateral stripe.

Habitat & Diet
Murray hardyhead are found around the margins of wetlands and billabongs and prefer open water, shallow, slow-flowing or still habitats. They can also be found in deeper habitats with dense aquatic vegetation. This species can survive in highly saline environments. Murray hardyhead feed mainly on zooplankton, dipteran larvae/pupae and algae.

Life Cycle
Spawning takes place over an extended breeding season (Sept – Apr) but peaks in Oct – Nov. Murray hardyhead are batch spawners and lay eggs amongst submerged aquatic vegetation, such as Ruppia sp. They are considered an annual species with few individuals surviving into their second year, consequently successful annual recruitment is critical.

Threats
Increased salinity, habitat degradation, altered flow regimes which decrease connectivity between rivers and wetlands. Pest species such as Eastern gambusia and Redfin Perch which compete with and prey on Murray hardyhead and potentially habitat destruction by Carp.

Species Trajectory
The distribution of Murray hardyhead has been significantly reduced. It is now considered extinct in NSW and is a nationally threatened species. Only eight known populations remain in Australia.

Source: Lintermans 2007, Ellis 2005, Ellis 2006, Ellis 2013

Murray hardyhead generally persist in waters with elevated salinity (ranging from approximately 1,000 to 110,000 $\mu S.cm^{-1}$) and submerged vegetation. Backhouse et al. (2008) states that it is not clear if this indicates a preference for saline habitats or if it is due to the exclusion of less salt tolerant species which compete or prey on Murray hardyhead. Salt tolerant Ruppia is often a key aquatic macrophyte in saline wetlands where Murray hardyhead are found. Zooplankton are the main source of food for Murray hardyhead and some of these micro-crustaceans also rely on Ruppia for habitat. The biggest threat to Murray hardyhead is reduced inflows to wetlands as a result of river regulation. A reduction in inflows also has a detrimental effect on macrophyte communities reducing feeding and breeding habitat for Hardyhead. As an annual species, Murray hardyhead relies heavily on successful recruitment each year. Ellis (2006, cited in Ellis 2010) states that this means even short-term changes which have a negative ecological impact on fish could have a significant effect on the long-term viability of Murray hardyhead populations. Environmental watering on an annual basis is listed as a key management action for the long-term preservation of Murray hardyhead populations

(Backhouse *et al*. 2008).

The Intermediate Egret is listed as Critically Endangered in Victoria and is one of three listed Egret species recorded in the Merbein Common WMU. Egrets mainly utilise shallow and deep freshwater wetlands with emergent vegetation and trees present for nesting and feeding, with River Red Gum being their preferred tree. Egrets require shallow water with dense aquatic vegetation for foraging and feed mainly on fish but also consume shrimp, crayfish, frogs and insects (Rogers & Ralph 2011). Draining of wetlands is the main cause of habitat loss for Egrets in Victoria. The manipulation of water regimes, modification and clearing of waterways, pollution and increased salinity resulting in death of nest trees also threaten egret habitat. Briggs (1997, cited in DSE 2001, p.4) states that Egrets do not breed in dead River Red Gums. These factors have led to fragmentation and decline of feeding and breeding habitat. The reduction of frequency, size and duration of flooding, as well as changed seasonality, due to water regulation has severely impacted breeding. The absence of major flood events in suitable wetlands for the required durations can lead to abandonment of breeding sites. For breeding to occur Egrets require high water levels for at least 3-5 months with suitable food and healthy trees for nesting. Rogers and Ralph (2011) estimate that these species require slow draw down of water so nest sites are flooded for a minimum of 6-7 months. Large flooding every 3-4 years, supplemented by smaller floods every 1-2 years are estimated to maintain Egret habitat (Rogers & Ralph 2011). Briggs *et al.* (1997, cited in DSE 2001 p.4) state that rising or stable water levels are noted as a trigger for breeding in waterbirds, making management of wetlands a key issue for egret conservation.

The Blue-billed Duck is found upon fresh wetlands with abundant aquatic vegetation and cover, but are also found on saline waters and artificial sites such as sewage ponds. Purdey & Loyn (2008) found that mean counts of Blue-billed Ducks were higher in semi-saline or permanent saline wetlands. Lignum and emergent vegetation such as cumbungi and spike-rush are used by this species especially for breeding and nests are usually positioned over water after flooding has commenced (Rogers & Ralph 2011). Marchant & Higgins (1990, cited in DSE 2003, p. 2) states that breeding probably varies in response to water levels. This species prefers deep water with dense aquatic vegetation for foraging. The Blue-bill Duck has a life expectancy of 3-4 years in the Murray-Darling Basin so it is recommended that flooding occurs every 1-2 years to maintain population numbers and waters should recede slowly (Rogers & Ralph 2011). The restoration of drained wetlands will help reverse the decline in wetlands habitats preferred by this species and in particular, maintaining open water of >1m depth (Purdy & Loyn 2008).

The Freckled Duck has mainly been recorded in Victoria on wetlands in the west of the state, it may be one of the world's rarest ducks. In Victoria Freckled Ducks have been most recorded on open freshwater, deep freshwater marshes and saline wetlands. Frith (1982, cited in DSE 2004, p. 2) states that this species favours densely vegetated Lignum Swamp habitat, with permanent swamps or freshly flooded creeks containing emergent vegetation and tangled Lignum used for breeding. It forages primarily in shallow waters on the edges of deeper waters, but can filter feed from the surface when food is available. Large floods every 1-2 years, with a duration of 5-6 months have been estimated as requirements for breeding and foraging by this species (Rogers & Ralph 2011).

The Commonwealth listed Growling Grass Frog, *Litoria raniformis,* is recorded on the species list for the Merbein Common WMU. This species 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 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).

Native fauna species recorded in the WMU are listed in Appendix 3. This list includes a range of water dependent species which will benefit from the wetlands in the target area receiving water on a more regular basis. As well species mentioned above, of special interest and responsibility are the water dependent species listed in legislation, agreements or conventions these are summarised in Table 6.

Table 7 Listed water dependent fauna recorded at the site

Common name	Scientific name	Type	FFG status	DEPI status	EPBC status	International
Australasian Shoveler	*Anas rhynchotis*	B	NL	V	NL	
Australian Shelduck	*Tadorna tadornoides*	B	NL	NL	M	
Australian White Ibis	*Threskiornis molucca*	B	NL	NL	M	
Australian Wood Duck	*Chenonetta jubata*	B	NL	NL	M	
Banded Lapwing	*Vanellus tricolor*	B	NL	NL	M	
Black Swan	*Cygnus atratus*	B	NL	NL	M	
Black-winged Stilt	*Himantopus himantopus*	B	NL	NL	M	
Blue-billed Duck	*Oxyura australis*	B	L	EN	M	
Carpet Python*	*Morelia spilota metcalfei*	R	L	EN	NL	
Caspian Tern	*Hydroprogne caspia*	B	L	NT	M	CAMBA JAMBA
Chestnut Teal	*Anas castanea*	B	NL	NL	M	
Clamorous Reed Warbler	*Acrocephalus stentoreus*	B	NL	NL	M	
Common Greenshank	*Tringa nebularia*	B	NL	V	M	CAMBA JAMBA
Common Sandpiper	*Actitis hypoleucos*	B	NL	V	M	CAMBA
Curlew Sandpiper	*Calidris ferruginea*	B	NL	E	M	
Eastern Great Egret	*Ardea modesta*	B	L	V	M	CAMBA JAMBA
Freckled Duck	*Stictonetta naevosa*	B	L	EN	M	
Glossy Ibis	*Plegadis falcinellus*	B	NL	NT	M	CAMBA
Grey Teal	*Anas gracilis*	B	NL	NL	M	
Growling Grass Frog	*Litoria raniformis*	A	L	EN	V	
Hardhead	*Aythya australis*	B	NL	V	NL	
Intermediate Egret	*Ardea intermedia*	B	L	CR	NL	
Lace Goanna*	*Varanus varius*	R	L	V	NL	
Little Egret	*Egretta garzetta nigripes*	B	L	EN	M	
Marsh Sandpiper	*Tringa stagnatilis*	B	NL	V	M	CAMBA JAMBA
Musk Dusk	*Biziura lobata*	B	L	V	M	
Nankeen Night Heron	*Nycticorax caledonicus*	B	NL	NT	NL	
Pacific Black Duck	*Anas superciliosa*	B	NL	NL	M	
Painted Snipe	*Rostratula benghalensis*	B	L	T	NL	
Pied Cormorant	*Phalacrocorax varius*	B	NL	NT	NL	
Pink-eared Duck	*Malacorhynchus*	B	NL	NL	M	
Red-naped Snake*	*Furina diadema*	R	L	V	NL	
Red-necked Avocet	*Recurvirostra*	B	NL	NL	M	
Red-necked Stint	*Calidris ruficollis*	B	NL	NL	M	
Royal Spoonbill	*Platalea regia*	B	NL	NT	M	
Silver Gull	*Chroicocephalus*	B	NL	NL	M	
Straw-necked Ibis	*Threskiornis spinicollis*	B	NL	NL	M	
Swamp Harrier	*Circus approximans*	B	NL	NL	M	

Legend
Type: Invertebrate, Fish, Amphibian, Reptile, Bird, Mammal
EPBC status: EXtinct, CRitically endangered, ENdangered, VUlnerable, Conservation Dependent, Migratory Not Listed
FFG status: Listed as threatened, Nominated, Delisted, Never Listed, Ineligible for listing
DEPI status: presumed EXtinct, Regionally Extinct, Extinct in the Wild, CRitically endangered, ENdangered, Vulnerable, Rare, Near Threatened, Data Deficient, Poorly Known, Not Listed

*Species are included as water dependent due to habitat requirements.

The species listed in Table 6 are water-dependent and migratory species (EPBC Act) that forage or nest in or on water or require flooding to trigger breeding and fledging. The list also includes three reptile species, Lace Goanna, Carpet Python and the Red-naped Snake that are indirectly dependent floodplain inundation as they require riparian trees, vigorous ground cover and fallen timber for habitat. In order to provide breeding opportunities, habitat elements within the target area of the WMU such as semi-permanent wetlands and River Red Gum communities must be maintained in good condition.

Vegetation communities

Within the target area of the Merbein Common WMU is a range of water dependent ecological Vegetation classes (EVCs) as shown in Figure 4. The conservation status of each of the represented EVCs is shown in Table 7. Two of the most extensive EVCs are Alluvial Plains Semi-arid Grassland (#806) and Lignum Shrubland (#808) which are both listed as vulnerable within the Murray Scroll Belt bioregion. Three others are listed as depleted.

Alluvial Plains Semi-arid Grassland dominates the proposed inundation area at Brickworks Billabong and a significant area of Catfish Lagoon. This EVC contains flood-promoted flora but a dry phase is important for this EVC. As Brickworks will be managed with consideration of Murray Hardyhead, permanent ponding will occur at this site. However, this will be low level ponding with the majority of the wetland still being exposed to drying. This will help maintain the integrity of this vulnerable EVC and the flora species within it.

Both lagoon systems at Merbein Common support varied woodland EVC's (Table 7), some of declining health. Where wetlands and woodlands are combined in close proximity, conservation significance is high. Woodlands provide habitat and grazing opportunities for fish through snags and debris deposited in the water. They also provide important refuges for birds, reptiles and mammals, such as perches and nesting hollows. When flooded, the woodland floor becomes an extension of the wetland habitat, thereby extending food and shelter opportunities for aquatic fauna (EA 2007b).

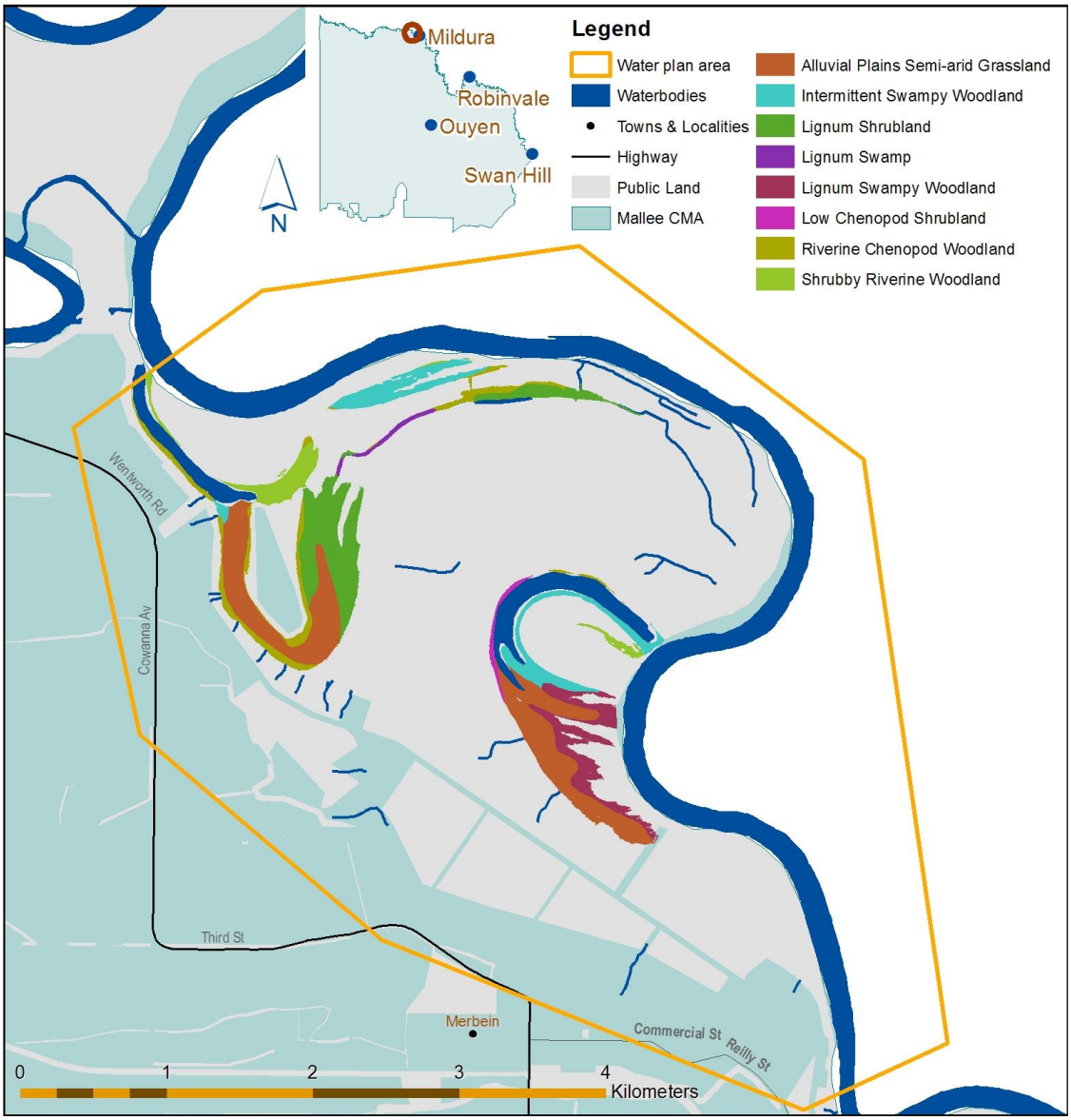


Figure 5 EVCs within the target area of the Merbein Common WMU

Table 8 Conservation status of water dependent EVCs in the target area

EVC no.	EVC name	Bioregional Conservation Status
		Murray Scroll Belt Bioregion
818	Shrubby Riverine Woodland	Least Concern
102	Low Chenopod Shrubland	Depleted
103	Riverine Chenopod Woodland	Depleted
806	Alluvial Plains Semi-arid Grassland	Vulnerable
808	Lignum Shrubland	Least Concern
104	Lignum Swamp	Vulnerable
813	Intermittent Swampy Woodland	Depleted
823	Lignum Swampy Woodland	Depleted

For a full list of EVCs within the entire WMU and details on each see Appendix 4.

Flora species

The EVCs within the target area of the Merbein Common WMU include a wide range of flora species. The communities are centred on the dominant River Red Gums (*Eucalyptus camaldulensis*) in the riparian areas, Lignum (*Muehlenbeckia florulenta*) shrublands and Black Box (*Eucalyptus largiflorens*) higher up on the flood plain.

Lignum is considered to be the most significant floodplain shrub in mainland Australia due to its extensive distribution, local dominance and value as habitat (Roberts & Marston 2011). It has particular ecological value as waterbird breeding habitat (Rogers & Ralph 2011) making it especially significant at this site. Lignum Shrublands are found in the Cowanna and Brickworks system and these areas generally retain water for several months after flooding. Wetland birds that breed over water, such as Egrets, use flooded Lignum shrublands for resting and Blue-billed and Freckled Ducks nest on Lignum.

Similarly, River Red Gums are the most widespread eucalypt tree in Australia, occupying riparian habitats along water courses and wetlands (Roberts & Marston 2011). They provide extensive habitat for a range of fauna, and waterbirds such as the listed Intermediate Egret which use these trees for nesting. However, trees in poor condition have little contribution to the function and productivity of the ecosystem and the quality of woodland habitat is greatly reduced (Roberts & Marston 2011). Briggs (1997, cited in DSE 2001, p.4) states that Egrets do not breed in dead River Red Gums. River Red Gums also deposit organic woody debris to wetlands which provide structural habitat features for wetland fauna such as perching sites for waterbirds and snags for fish (EA 2007b).

Black Box Woodlands occur in the less frequently flooded areas of the floodplain. They provide essential habitat and foraging opportunities for a range of species including mammals and reptiles and support a high proportion of ground foraging and hollow-nesting birds. Black Box Woodlands are particularly important to the endangered Carpet Python which utilise hollows, fallen logs and leaf litter for shelter and to find prey. These woodlands are also an important connection to surrounding Mallee landscape, allowing movement of fauna between these landscapes (EA 2007a). Black Box can tolerate a range of conditions from wet to dry and saline to fresh (Roberts & Marston 2011). However, under extended periods of dry conditions trees will suffer a decline in health and, eventually, death (EA 2007a).

Although no wetland species are recorded in the flora list for Merbein Common WMU, a range of these species are known to occur there (Kelly, P 2013 *pers. comm*). This is a key knowledge gap and could be addressed with a flora survey. Aquatic and emergent macrophytes are particularly important as they support many of the listed fauna species previously mentioned. Inappropriate water regimes resulting in prolonged inundation of Cowanna Billabong and prolonged drying of Brickworks and Catfish Billabongs have contributed to decreased diversity of aquatic species (Searle, L 2013, *pers.comm*).

Aquatic macrophytes are rooted to the wetland floor with their canopies floating near the water surface. They rise and fall with water levels and provide a physical structure to the aquatic environment as well as providing a food source for waterbirds and habitat for fish and macro invertebrates (EA 2007b). Aquatic macrophytes are highly productive wetland habitats providing shelter for macro-invertebrates and dabbling ducks such as the Freckled Duck that graze on this vegetation and the macro-invertebrates within it (EA 2007b). Aquatic macrophytes are dependent on water for growth and reproduction, and under sudden draw down these plants lose support and collapse and die quickly. The ideal flood requirement is 9-12 months (Rogers & Ralph 2011). They may persist in wetlands that are frequently flooded but if summer drying occurs they will die off and be replaced by lake bed herbs (EA 2007b).

Ruppia species are of particular importance at Brickworks Billabong as this is a proposed site for Murray Hardyhead translocation. This genus is mostly found in saline wetlands (Sainty & Jacobs 1981). Murray Hardyhead were mainly found in waters that supported Ruppia beds in the Kerang area. As well as providing protection from predation, Hardyhead also use Ruppia for attachment of eggs during breeding. They are also likely to feed on zooplankton fauna found in Ruppia (DSE 2010). Ruppia is the only aquatic macrophyte that dominates saline wetlands. Without Ruppia the potential for fauna diversity within these wetlands is significantly reduced (DSE 2004). This makes maintaining and improving Ruppia species at Brickworks Billabong particularly relevant as this saline wetland is a translocation site for the Murray Hardyhead.

Emergent macrophytes such as Cumbungi and Spike-rush are found on the perimeter of wetlands and fair best on frequently flooded sites. Under flooding they provide important breeding and nesting habitat for waterbirds such as the Freckled and Blue-billed Ducks. They also provide essential habitat for frogs such as the Growling Grass Frog and foraging opportunities for Egrets. Native fish will also utilise reed beds and semi-emergent vegetation where they feed on macro-invertebrates and shelter from predators (EA 2007b). Emergent macrophytes require annual flooding of approximately 6-12 months depending on species.

One water dependent flora species, Spiny Lignum (*Muehlenbeckia horrida)* which is listed as rare by DEPI has been recorded in the Merbein Common WMU. This species occurs in the Alluvial Plains Semi-arid Grassland EVC. This is classified as a vulnerable EVC for the Murray Scroll Belt Bioregion which falls within the inundation extent of the target area in the WMU.

A full list of flora recorded at the Merbein Common site can be found in Appendix 3.

3.1.3 Ecosystem functions

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.

The Merbein Common WMU contains a floodplain wetland complex of eight wetlands, (six of which are in the target area) which are categorised as freshwater meadow, deep freshwater marsh and permanent open freshwater. Altered water regimes due to river regulation and dry conditions have seen a decrease in the frequency of inundation of the wetlands and floodplain within this WMU. This has reduced the ability of the wetlands to carry out essential ecosystem functions, although individual wetlands within the system have been affected to varying degrees.

3.2 Social

3.2.1 Cultural heritage

Merbein Common is an important cultural site for the local indigenous people and there are numerous burial sites, middens, and scarred trees throughout the area. The area was traditionally occupied by the Nyeri Nyeri and Latji Latji people neighboured by the Barkindji tribe. Earthen ovens (*hearths)*, and middens are listed and some cultural sites have been documented and records are held by Aboriginal Affairs Victoria. The Merbein Common WMU holds one of the oldest freshwater midden sites in the area which adds to the significance of this particular site (Parks 2012). As is the case for most of the Murray River floodplain and beyond, it is recognised that waterways and floodplains are highly significant for the indigenous culture but the true extent of the number and types of sites present is still unknown. A contingency plan (Appendix 6) is in place should any evidence of cultural heritage sites be discovered during site visits or works.

The Nyeri Nyeri and Latji Latji people, neighboured by the Barkindji tribe traditionally have a strong connection to the area and made use of the natural resources within the woodlands for bush medicine, basket weaving and other cultural activities. The opportunity of co-management of the park by Parks Victoria and the Indigenous community opens up the possibility for the younger members of the community to gain valuable knowledge, skills, training and employment.

3.2.2 European Heritage

In the early days of European settlement the Common was initially used for the grazing of livestock, collection of firewood and recreational activities. In 1910 the Merbein Turf Club was founded, holding two race meetings a year. The Merbein Central Golf Club established a nine-hole course on the Common in 1926. The Merbein Gun Club was operational next to the race course during the 1920's and 1930's. During the Great Depression a collection of temporary homes were erected in the Common along the banks of the Murray River by families and itinerant workers who had fallen on hard times. This settlement became known as 'Bag Town', due to the construction of the homes being mostly from hessian materials (Wells 2007). Historically, the WMU hosts the site of the original pump which serviced the Merbein Irrigation area and other evidence of early European settlement.

3.2.3 Recreation

The region is popular for swimming, camping, fishing, boating, four wheel driving, picnicking, barbequing, trail bike riding, horse riding and walking and these uses will continue in the park. The target area is also popular for bird watching and water related activities.

3.3 Economic

The Merbein Common WMU has been used for grazing, irrigation, forestry, firewood collection and livestock in the past but is now valued for its natural assets and preserved for recreational use. Surrounding land is still used for irrigated horticulture and a water treatment plant.

3.4 Significance

The environmental, social and economic values outlined indicate the significance of this site. While these values do not constitute Merbein Common 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. The area is rich in biodiversity, essential as habitat to native species and a refuge for listed flora and fauna species. Of particular significance are the River Red Gum and Lignum communities which line the semi-permanent wetlands and creeks throughout the target area. The translocation of critically endangered Murray Hardyhead to Brickworks will further increase the ecological significance of the site.

The Merbein Common is considered very culturally significant as it has evidence of early indigenous occupation including one of the oldest freshwater midden sites as well as significant European historical sites such as original irrigation pumps. These social and cultural values are important to local communities of the area.

The values contained within the Merbein Common WMU and specifically the target area for this plan makes this area a priority for protection and enhancement through environmental water management.

4. 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 (DSE 2005). A wetland's hydrology is determined by surface and groundwater inflows and outflows in addition to precipitation and evapotranspiration (Mitsch and Gosselink, 2000 in DSE 2005). Duration, frequency and seasonality (timing) are the main components of the hydrological regime for wetlands and rivers.

The target area within the Merbein Common Waterway Management Unit is located on the Victorian floodplain of the Murray River (chainage 870.5km to 860.0km). River gauge Mildura (#425010) is located upstream of the WMU.

4.1 Water management and delivery

4.1.1 Pre-regulation

Prior to river regulation and bank construction, Cowanna Billabong, Brickworks Billabong and Catfish Lagoon would have filled with rising river levels and retained water for a period of time after river levels fell, before drying out. Natural flows were strongly seasonal with daily discharges highest in spring and lowest in autumn (EA 2007b). The semi-permanent wetlands of the floodplain experienced inundation during high flow periods punctuated with drying phases on a regular basis. The inundation allowed for recruitment and preservation of the floodplain species.

4.1.2 Post-regulation

In this part of the Murray River, the frequency, duration and magnitude of all but the largest floods have been reduced due to effects of major storages in the Murray and tributaries (Thoms et al, 2000, p 106). Regulation of the Murray River has decreased the volume of water flowing through Euston Weir. Flow events of 20,000ML/d and greater, which are required to inundate wetlands and floodplains, have decreased by 50% to 70% (EA 2007b). Extreme low flows have also been reduced. These conditions have altered the frequency and duration of wetting and drying events within wetlands.

An embankment which forms a vehicle track separates Cowanna Billabong from the River. The current commence to flow for Cowanna Billabong is approximately 2,000ML/day (Kelly, P. 2013 *pers. comm*). A single 600mm pipe culvert through the bank connects the river with Cowanna Billabong just below river level at low river flows and provides a permanent hydraulic connection (EA 2007b). Although Cowanna Billabong is classified as a permanent wetland under the Corrick-Norman system, it is noted that under natural flow regimes, prior to regulation it would likely have been classified as a semi-permanent wetland. The water level in this wetland changes with the river level, which is influenced by the weir at Wentworth (MCMA 2012a).

Post river regulation conditions have seen Brickworks Billabong isolated to provide an irrigation drainage disposal basin. Currently Brickworks Billabong would commence to flow at river levels of approximately 20,000ML/day (Kelly, P. 2013 *pers. comm*). A bank and regulator have been installed between Brickworks Billabong and Cowanna Billabong, with a single 450mm pipe connection through the bank allowing control of flow between these two sites. These Billabongs would have been connected by small flows before construction of the bank (EA 2007b). In order to isolate Brickworks Billabong as an irrigation drainage disposal basin, a second bank at the far end contains saline drainage water within the wetland. Salinities of 45,000 EC have been reported (Bluml 1992). This has led to degradation of the floodplain and vegetation, with a decline in tree health and an increase in

weed species (EA 2007b). Lower Murray Water are currently discussing options to end all irrigation drainage water disposal to Merbein Common (EA 2007b). Mallee CMA are also investigating options to reduce irrigation impacts on the Merbein Common WMU through on farm incentives.

Catfish Billabong located in Merbein Common east has a channel that provides intermittent connection to the river during low river flows (EA 2007b). In 2001 a drop in river level disconnected Catfish Billabong from the river and River Red Gum saplings grew in the inlet channel, causing siltation and raising of the channel level. Prior to 2001 the weirpool at Wentworth provided water levels high enough to flow into this wetland (MCMA 2012a). It is likely that the commence to flow would have been approximately 2,000ML/day (Kelly, P 2013 *pers. comm*). The channel currently acts as a connection that passes water to the billabong during lower levels, effectively lower that 8000ML/day in river flow. The channel is unregulated and water returns to the river as flow decreases (EA 2007b). Regular inflows through this channel create permanent inundation of around 0.5metres for the first 800m of the wetland.

Minor scroll swale systems allow water to first enter channels between 864 and 867 river km where upstream effluents are overtopped and through-flow occurs. A second scroll swale system is located between 868 and 870 river km. At higher river flows, water becomes overtopped and through-flow occurs. Due to this through-flow system, the central part of the floodplain becomes inundated only when river flows are very high (EA 2007b).

The seasonal distribution of flows in this section of the Murray River shows that, despite a reduction in discharge, the river retains the same annual pattern of higher flows in Winter and Spring with lower flows in Summer and Autumn (Figure 6).

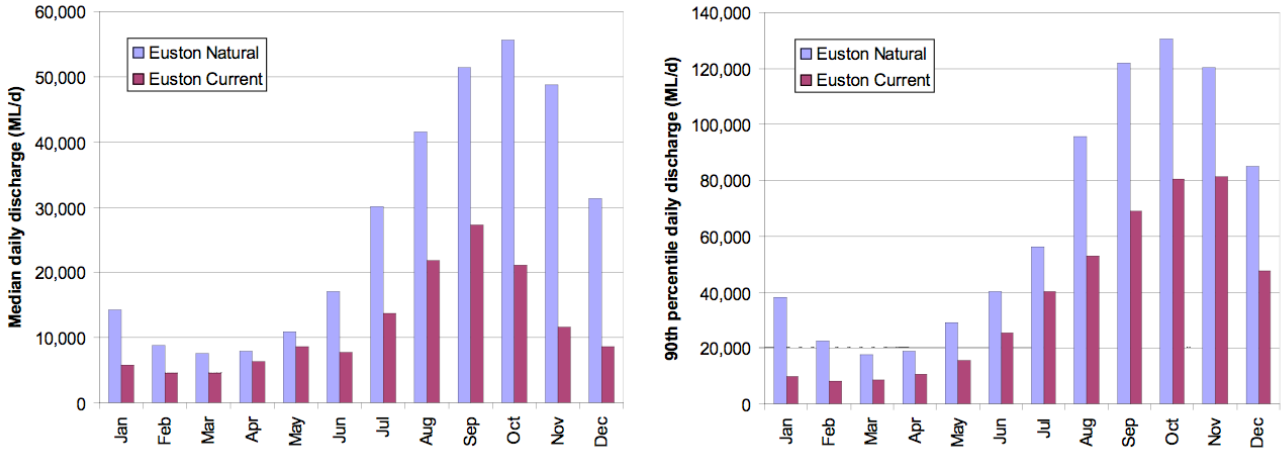


Figure 4 Distribution of median flows and 90th percentile flows for each month in the River Murray through Euston Weir for natural and current (benchmark) conditions.
Source: derived from MDBC MSM-Bigmod 109-year data (EA 2007b)

Although Euston Weir may not exactly reflect the current seasonal flow pattern for the River Murray closer to Merbein, this is the best scientific data available. 'Investigations into Water Management Options for the River Murray from Robinvale to Wallpolla Island' (EA 2007b) states that as there are no major tributaries or losses from the River Murray in the study area (which incorporates Merbein Common) and the hydrology for this reach of the Murray River can be broadly described in terms of the flow passing Euston Weir.

4.1.3 Environmental watering

Environmental watering began in the Merbein Common section of the WMU in Spring 2005 as emergency River Red Gum watering, River Red Gum stands were in poor health in various sections of the WMU. River Red Gum communities are found in three of the EVC's within the target area, Intermediate Swampy Woodland, Shrubby Riverine Woodland and Lignum Swampy Woodland. River Red Gum along the bank of Cowanna Billabong were in good health but tree health deteriorated further from the bank. Trees were dead or absent at the edge of Brickworks Billabong, with River Red Gum found further from the bank. At Catfish Lagoon tree health was generally poor at sites away from the river bank (EA 2007b). The water for these events was from various sources as outlined in Table 9.

Table 9 A summary of recent environmental watering events in Merbein Common WMU

Water year	Time of inflow	Inflow source	Source volume (ML)	Total volume (ML)	Cost of delivery ($)	Area (ha) Inundated
2005	Spring	EWR	249	249	30-$45ML *	46
2006	Autumn	EWR	274	274		46
2010	Autumn	EWR	445.7	445.7		41.52
2010	Spring	EWR	99.96	99.96		67.42

*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

The initial purpose of the emergency watering program was that the prolonged dry conditions had resulted in a decline in River Red Gum health on the Murray River floodplain. The watering took place in four events and filled three wetlands, Cowanna and Brickworks Billabongs and Catfish Lagoon, and flooded the adjacent riparian zone. This watering was effective in improving the health of trees lining the creeks and wetlands in the target area. This also had the added benefit of providing some drought refuge for waterbirds such as Egrets. The extent of emergency watering was limited by infrastructure. Photopoint monitoring (Figure 8) and anecdotal evidence indicated a positive response by the River Red Gums to the watering through increased foliage vigour.

Once the trees began to respond positively to the environmental watering and dry conditions abated, the purpose of the environmental watering changed from emergency response to long term sustainability of the system. A natural inundation event also occurred in 2010/2011, flooding the wetlands beyond the target area and beyond levels achievable with environmental watering. Brickworks Billabong was also watered in 2012/2013 for the purpose of the proposed translocation of State and Commonwealth listed Murray Hardyhead (*Craterocephalus fluviatis) (*Searle, L 2013, *pers. comm.).*

Currently environmental water can be pumped into the Merbein Common WMU from the Murray River into the wetlands and held on the floodplain, covering an area of 67 ha (Figure 7). This requires the use of diesel pumps and temporary earth blockbanks to maintain the water on the floodplain and prevent the water flowing back into the river at low points. The extent of inundation can be increased by the installation of permanent regulators, road raising and culverts. These opportunities for future works are discussed in section 8.

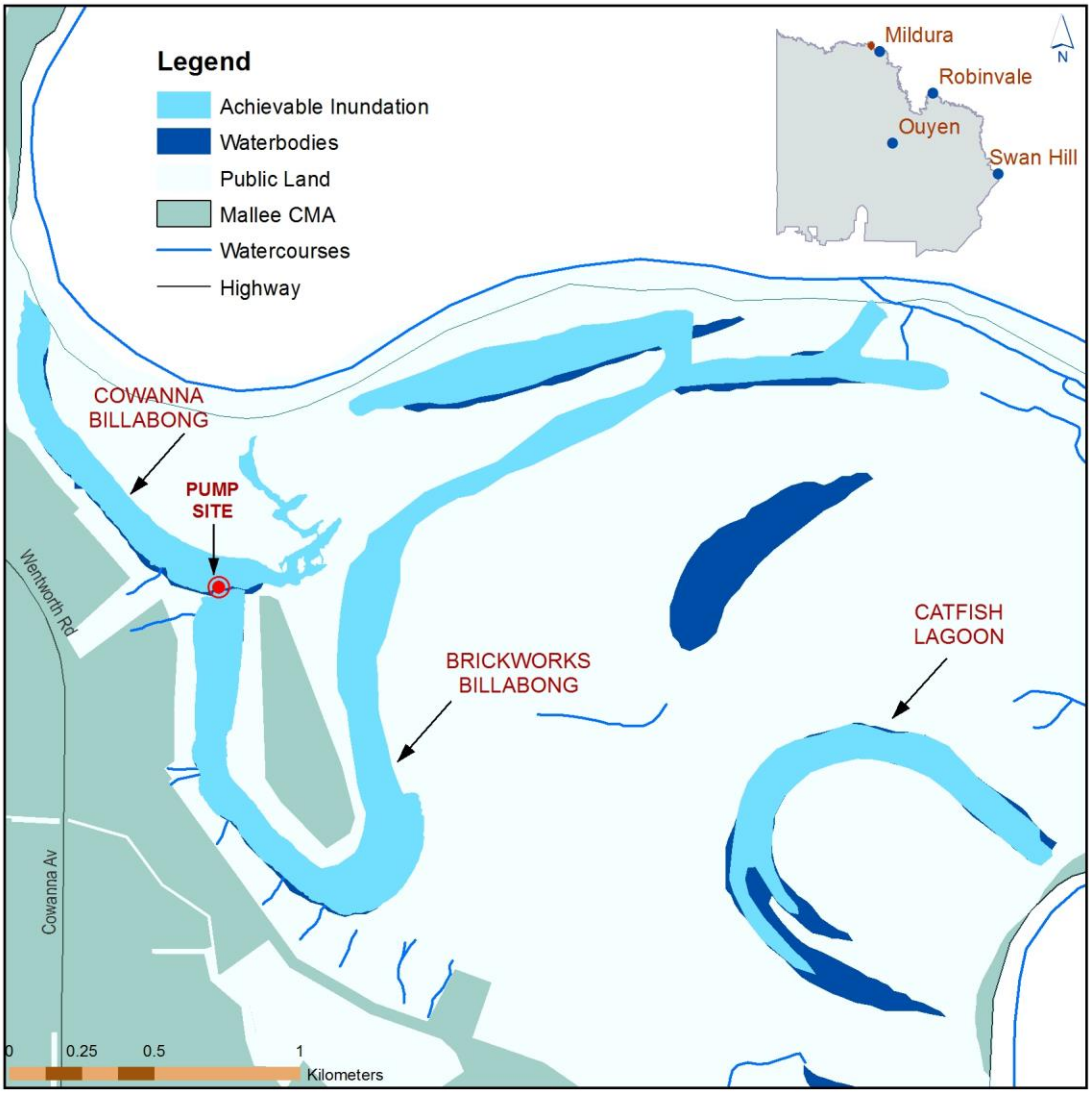


Figure 5 Current inundation extent of Merbein Common section of the WMU

5. THREATS AND CONDITION

5.1 Water dependent threats

The values for the target area of the Merbein Common WMU are described in section 3. Threats to these values are the result of such factors as human intervention and climate variability. Some of the threats which may have an impact on the Merbein Common WMU include:

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

The regulation of the Murray River has seen the water regime through the Merbein Common section altered. Flow events of the magnitude required allowing flows into the creeks and wetlands of the floodplain are less frequent and of shorter duration (see section 4.1). This combined with dry conditions over the last decade affects the vigour of the vegetation and places trees under stress, affecting the productivity and functioning of the floodplain ecosystem.

Historically irrigation, stormwater and other drainage water have been a consideration for water quality issues. Drains from adjoining freehold land enter along the western boundary of the Merbein Common WMU. Salinity impacts attributed to irrigation drainage and groundwater are evident in sections of the wetlands within the WMU.

The use of Brickworks Billabong as an irrigation drainage basin has led to issues with salinity and resulted in degradation of the floodplain and its vegetation. Tree health has diminished and succession of species such as Spiny Rush and Cumbungi and an increase in weed species has resulted (EA 2007b). Although increased salinity can be detrimental to surrounding vegetation, levels in Brickworks Billabong need to be maintained appropriately for translocation of Murray Hardyhead to this site. Murray Hardyhead tolerate moderately saline conditions, although lower levels may be required to facilitate breeding and recruitment (Backhouse *et al*. 2008). Brickworks Billabong is surrounded by woodlands and shrublands dominated by Black Box and Lignum and both of these species are also tolerant of moderately saline conditions. Environmental watering can help prevent salinity levels increasing beyond the tolerance of Hardyhead and provide freshwater inflows to benefit surrounding vegetation. Fresh water inflows, which are less dense, tend to flow over the top of the more saline, higher density water which sit lower in the vertical water profile (RPS Aquaterra 2013). It is expected that this freshwater sitting on top of the water profile will move laterally through the soil to benefit surrounding vegetation (Kelly, P 2013 *pers. comm*).

Stormwater from the Merbein township enters through the Foster St drain. Stormwater run-off has the potential to transfer pollutants such as sediments, nutrients and chemicals from surrounding farmland into wetlands and waterways, which can result in algal blooms. Stormwater can also cause erosion and reduce local and downstream water quality (MCMA 2006).

Permanent inundation of wetlands can alter natural hydrology regimes and reduce water circulation. This can lead to changes in water temperatures and dissolved oxygen levels and changes to salinity and pH which, in turn, can lead to acid sulphate soils over time. Nutrient outflow can be reduced resulting in a build-up of salinity and/or agricultural chemicals. Sedimentation within the wetland can increase as soils are no longer exposed to periods of drying (Mitsch & Gosselink 1993). Biodiversity can decline as breeding cues and recruitment of flora and fauna are lost. Invasive species which favour permanent inundation, such as carp, may thrive contributing further to the decline of native biodiversity

(MCMA 2012b). In summary, the overall productivity and ability of the wetland to perform essential ecosystem functions is reduced.

Acid sulphate soils can develop when saline or sulfidic soils are subjected to long term inundation (Baldwin *et al.* 2007). Wetlands used as drainage or disposal basins, such as Brickworks Billabong, can be exposed to sulfates through saline irrigation discharge and groundwater salinity. Evaporation and lack of flushing in these basins can result in further elevations in salinity (CSIRO 2004). Waterlogged and anaerobic conditions can encourage sulfidic sediment formation. When exposed to oxygen during a drying phase sulfuric acid can form and be released into surrounding waters with subsequent flooding with dire environmental consequences (MCMA 2012a). An assessment of acid sulfate soil materials at Brickworks Billabong found metal/metalloid concentrations in the soil represented a low hazard. Water sampling at Brickworks Billabong showed no evidence that acidification of sulfidic sediments occurred during the re-flooding event of 2011/12 (Ellis *et al* 2011).

Agricultural and other weeds are an ongoing threat and management issue along the Murray River floodplain. These may pose a threat when water is applied as increased water availability can cause weeds to thrive and displace native vegetation. A list of exotic flora species identified in the Merbein Common WMU are listed in Appendix 3.

Introduced fauna such as Common Carp pose a serious threat to the ecology of Merbein Common wetlands. Carp have been found to contribute to the loss of aquatic vegetation and increased turbidity, resulting in loss of habitat for waterfowl (Purdey & Loyn 2008). This species also competes with the native fish for habitat and food as well as having a detrimental effect on water quality (MCMA 2003). This is of particular concern given that Brickworks Billabong is a proposed site for translocation of Murray Hardyhead. However, managing salinity levels for Hardyhead through controlled wetland drying can also help control carp which are less salt tolerant. Spencer and Wassen (2009, cited in Rogers & Ralph 2011, p.264) suggest that Common Carp also significantly reduce recruitment success of the Growling Grass Frog.

5.2 Current condition

One method for assessing the current condition of a wetland is the Index of Wetland Condition (IWC) developed by DEPI. The IWC defines wetland condition as the state of the biological, physical, and chemical components of the wetland ecosystem and their interactions. The condition of the eight wetlands in this WMU has not been assessed. This is listed as a knowledge gap for this WMU.

Vegetation condition varies across the site. Woodland vegetation at Catfish Billabong near the river connection is in good health. Tree health is very poor in the southern half of the wetland and understory vegetation is largely absent (EA 2007b). Possible contributors to this variation in vegetation health are saline groundwater interactions, altered water regime, irrigation impacts and the recent prolonged dry conditions. River Red Gums of good health are found on the bank at Cowanna Billabong, but the health of trees deteriorates moving away from the wetlands edge (EA 2007b). Brickworks is managed as an irrigation drainage basin which has resulted in open water or bare mud with samphire vegetation and increased salinity (MCMA 2012a). Trees are dead or absent at the edge of the wetland, where salt-tolerant chenopods are present. Stands of River Red Gums and Black Box with a Lignum understorey are found further from the bank (EA 2007b). Although the woodland vegetation in Catfish Lagoon close to the river connection is in good health, tree health in the southern half of the wetland is very poor with a largely absent understorey, as this area receives less frequent inundation.

The wetlands within the Merbein Common WMU have had their water regime altered through river regulation which has impacted on the diversity and health of the vegetation in and surrounding the wetlands.

The fish population in the wetlands is dominated by Common Carp which compete with the native fish for habitat and food as well as having a detrimental effect on submerged water plants. Drying out of Cowanna Billabong for the removal of carp is a planned activity.

Salinisation of the floodplain through irrigation impacts from surrounding irrigated horticulture also contributes to the current poor health of areas of vegetation within the WMU. This appears to be an issue at Catfish Lagoon as the wetland appears to intercept the groundwater table.

5.3 Condition trajectory

Without management intervention in the form of environmental watering, water dependent condition within the target area is expected to worsen. Dry conditions and salinity will continue to impact already stressed vegetation, including key species like River Red Gum, Lignum and aquatic and emergent macrophytes. This will result in loss of valuable habitat for listed wetland birds, frogs and fish and wetland productivity and biodiversity which is directly dependent on water will continue to decline. Ward *et al* (2010) recommends that incorporating a more natural flow regime and maintaining the freshwater lens between saline groundwater and the aquatic ecosystems can minimize the formation of acid sulphate soils in inland wetlands. As Brickworks Billabong and Catfish Lagoon have previously been susceptible to sulfate accumulation, environmental watering is integral to minimizing further risk of acid sulphate soils in the target area.

Management intervention has already begun in the Merbein Common WMU with environmental watering events between 2005 and 2010 as outlined in section 4.1.3. Photographic (Figure 8) and anecdotal evidence indicates an increase in River Red Gum canopy health following these watering events. If this intervention is not continued the benefits from these watering events such as River Red Gum recovery may not be sustained and the floodplain will continue to become drier, resulting in reduced productivity, less carbon flux, and reduced functioning. Due to river regulation, natural flooding events may not be enough to sustain these communities and this plan proposes a watering regime to supplement these events in order to maintain and improve the condition of each wetland and their associated values.

Figure 6 River Red Gum communities at Merbein Common site (Cowanna Billabong) before (April 2010) and after (April 2012) watering events

6. MANAGEMENT OBJECTIVES

6.1 Seasonally adaptive approach

Victoria has adopted an adaptive and integrated management approach to environmental management. A key component of this approach for environmental watering is the 'seasonally adaptive' approach, developed through the Northern Region Sustainable Water Strategy and incorporated into the Victorian Waterway Management Strategy.

The seasonally adaptive approach identifies the priorities for environmental watering, works and complementary measures, depending on the amount of water available in a given year. It is a flexible way to deal with short-term climatic variability and helps to guide annual priorities and manage droughts. The approach is outlined in Table 10.

The seasonally adaptive approach has been used to guide the watering regime under various climatic scenarios. In drier periods, restricted water resource availability will potentially limit the number of ecological objectives which can realistically be provided through environmental water management. However, these ecological objectives can be achieved in wetter periods as water resource availability increases.

Table 10 The seasonally adaptive approach to river and wetland management (DSE, 2009)

	Drought	Dry	Average	Wet to very wet
Long-term ecological objectives	Long-term objectives to move towards ecologically healthy rivers - set through regional river health strategies and sustainable water strategies and reviewed through the 15-year resource review			
Short-term ecological objectives	• Priority sites have avoided irreversible losses and have capacity for recovery	• Priority river reaches and wetlands have maintained their basic functions	• The ecological health of priority river reaches and wetlands has been maintained or improved	• The health and resilience of priority river reaches and wetlands has been improved
Annual management objectives	• Avoid critical loss • Maintain key refuges • Avoid catastrophic events	• Maintain river functioning with reduced reproductive capacity • Maintain key functions of high priority wetlands • Manage within dry-spell tolerances	• Improve ecological health and resilience	• Maximise recruitment opportunities for key river and wetland species • Minimise impacts of flooding on human communities • Restore key floodplain linkages
Environmental water reserve	• Water critical refuges • Undertake emergency watering to avoid catastrophic events • Provide carryover (for critical environmental needs the following year) • If necessary, use the market to sell or purchase water	• In priority river reaches provide summer and winter baseflows • Water high priority wetlands • Provide river flushes where required to break critical dry spells • Provide carryover (for critical environmental needs the following year) • If necessary, use the market to sell or purchase water	• Provide all aspects of the flow regime • Provide sufficient flows to promote breeding and recovery • Provide carryover to accrue water for large watering events • If necessary, use the market to sell or purchase water	• Provide overbank flows • Provide flows needed to promote breeding and recovery • If necessary, use the market to sell or purchase water
River and wetland catchment activities	• Protect refuges (including stock exclusion) • Increase awareness of the importance of refuges • Enhanced monitoring of high risk areas and contingency plans in place • Investigate feasibility of translocations • Environmental emergency management plans in place • Protect high priority river reaches and wetlands through fencing; pest, plant and animal management; and water quality improvement works • Implement post-bushfire river recovery plans	• Protect refuges • Protect high priority river reaches and wetlands through fencing, revegetation, pest plant and animal management, water quality improvement and in-stream habitat works • Environmental emergency management plans in place • Improve connectivity • Implement post-bushfire river recovery plans	• Protect and restore high priority river reaches and wetlands through fencing, revegetation, pest plant and animal management, water quality improvement and in-stream habitat works • Monitor and survey river and wetland condition • Improve connectivity between rivers and floodplain wetlands	• Protect and restore high priority river reaches and wetlands through fencing, revegetation, pest plant and animal management, water quality improvement and in-stream habitat works • Monitor and survey river and wetland condition • Improve connectivity between rivers and floodplain wetlands • Emergency flood management plans in place • Implementation of post-flood river restoration programs

6.2 Management goal

The overall goal proposed for Merbein Common Waterway Management Unit target area has been developed through consultation with various experts and stakeholders including Parks Victoria, the Latji Latji and Nyeri Nyeri Community, Dr Marcus Cooling (Ecological Associates) and local residents. The goal considers the values the target area supports and the potential threats that need to be managed. This includes consideration of the values the target area has historically supported and the likely values it could support into the future.

Merbein Common Waterway Management Unit management goal

Cowanna Billabong:
To provide a watering regime to maintain and improve the health of River Red Gum communities and to improve aquatic vegetation diversity.

Brickworks Billabong:
To provide a watering regime to maintain and improve the health of aquatic vegetation, particularly Ruppia species, to maintain appropriate salinity levels for Murray Hardyhead and to improve the health of River Red Gum and Black Box communities.

Catfish Billabong:
To provide a watering regime to maintain and improve the health of River Red Gum and Lignum communities.

Maintaining and improving hydrological regimes of wetlands through environmental flows have been listed as key management actions for the listed Murray Hardyhead, Blue-billed Duck and Egret species found within this WMU.

6.3 Ecological and hydrological objectives

6.3.1 Ecological objectives

Ecological objectives represent the desired ecological outcomes of the site based on the key values outlined in section 3. 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 ecological objectives involve establishing one of the following trajectories of each key value, which is related to the present condition or functionality of the value:

- maintain
- improve
- protect
- reinstate

The primary aim for the target area in the Merbein Common WMU is to reinstate and maintain the character of the semi-permanent wetlands. However, underlying objectives have been determined for each wetland within the target area due to their individual values and related water requirements and these are as follows:

Cowanna Billabong

- Maintain health of River Red Gum communities
- Improve health of River Red Gum communities
- Improve diversity of aquatic vegetation

Maintaining and improving River Red Gum health at Cowanna Billabong will increase habitat opportunities for a range of species including Egrets and other waterbirds. An improvement in the diversity of aquatic plant communities will provide habitat and feeding opportunities for ducks and other waterbirds, as well as native fish and frogs. This is of particular significance to listed species.

Brickworks Billabong

- Maintain health of aquatic vegetation, particularly Ruppia species
- Improve health of aquatic vegetation, particularly Ruppia species
- Maintain appropriate salinity levels for Murray Hardyhead
- Improve health of River Red Gum and Black Box communities

Maintaining and improving the health of aquatic vegetation at Brickworks Billabong is of particular significance for Murray Hardyhead but will also benefit frogs and waterbirds through increased habitat and foraging opportunities. Similarly, maintaining appropriate salinity levels is directly targeted at Murray Hardyhead but will also benefit Ruppia species and the listed Freckled and Blue-billed Ducks that utilise saline waters. Improving the health of River Red Gum and Black Box communities will increase habitat for waterbirds and the listed Carpet Python.

In order for Brickworks Billabong to support Murray hardyhead annual environmental water inflows to the wetland will be required to maintain adequate levels to allow Murray hardyhead to complete their life cycle and increase in abundance. Environmental watering should commence from August to October to coincide with Hardyhead breeding season (October – November). Water levels should be high enough to inundate exposed sediments to promote a rise in zooplankton as a food source for breeding Murray hardyhead. Water levels should be allowed to decrease through summer to expose wetland sediments and fringing vegetation whilst also maintaining aquatic macrophyte beds within the wetland.

The frequency of environmental water delivery to any wetland to be used as a Murray hardyhead refuge may need to be determined by salinity levels within the wetland. Salinity levels should be maintained within a range which allows Murray hardyhead to complete their life cycle. Ellis (pers comm. 2014) suggests that salinity levels for Murray hardyhead in the Mallee region should be kept between 5,000 EC and 30,000 EC.

Although Brickworks Billabong will be managed as a semi-permanent wetland, ponding will be maintained permanently for Murray Hardyhead. The margins of the wetland will still be exposed to seasonal drying and surrounding trees will not suffer prolonged inundation. Flooding cannot reach the elevation of River Red Gum and Black Box communities as this would overtop the levee, but it is expected that lateral movement of freshwater top-ups across the landscape will benefit these communities (Kelly, P 2013 *pers. comm*).

Catfish Billabong

- Maintain health of River Red Gum communities
- Improve health of River Red Gum communities
- Maintain health of Lignum communities
- Improve health of Lignum communities

Maintaining and improving River Red Gum communities at Catfish Billabong will have

similar habitat benefits as at Cowanna and Brickworks. Targeting Lignum communities at this site will also help with provision of habitat for fauna species, in particular waterbirds which use Lignum for nesting.

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

The vulnerable water dependent EVC, Alluvial Plains Semi-arid Grassland, in which the listed Spiny Lignum has been recorded is found within the target area at Brickworks and Catfish Billabongs. This adds to the importance of maintaining and improving the target area through an environmental water program. The implementation of such a program will help to protect this listed species as well as the wide range of water dependent flora and fauna within the area.

6.3.2 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 are centred on reinstating and maintaining the character of the semi-permanent wetlands.

Semi-permanent wetlands should only dry out very rarely and should only be dry for 5% of the time. Water level should be above 50% of the wetland capacity 80% of the time. The wetland should reach retention level in 50% of years with a minimum duration of four weeks, with the ideal duration being twelve weeks. Breeding in frogs, fish and waterbirds requires events of twelve week duration in 50% of years, although a frequency of 30% of years may be sufficient for less productivity in these species. In order to replicate natural inflows, water levels should peak in August providing winter flooding and gradual retreat of water level over spring (EA 2007a).

The following hydrological objectives address the underlying ecological objectives for each site:

River Red Gum stands are found in Woodland EVC's within the target area. River Red Gum Woodlands require flooding every two to four years with durations of two to four months. Flood events may differ and a variance in ponding duration around the mean requirement for this species is encouraged. Although the timing of flooding is not vital for River Red Gum, spring-summer flooding encourages greater growth. Timing is important for understorey plant communities however. The critical interval for Red Gum Woodlands is five to seven years to prevent deterioration of tree condition (Roberts & Marston 2011).

Black Box stands occur in all the Woodland EVC's within the target area. They require flooding to occur every three to seven years with durations of two to six months. This species can tolerate shorter flood durations but plant vigour will suffer. Although timing of flood events is not crucial for Black Box it will effect understorey and other woodland biota. Black Box trees may survive prolonged periods of 12 to 16 years with no flooding but tree health will suffer and woodlands will become dysfunctional (Roberts & Marston 2011).

Lignum can tolerate a wide range of wet and dry conditions as well as moderate salinity levels. Flood requirements vary with frequencies of one to three years needed to maintain large shrubs with vigorous canopy and flooding every three to five years for maintenance of healthy shrubs. Intervals of seven to ten years can be tolerated by small shrubs but growth will decline and these plants do not accommodate nesting by birds. Durations of three to seven months sustain vigorous canopy, but continuous flooding is detrimental. Although timing of flooding is not crucial for Lignum, following natural seasonality is encouraged to provide for understorey and wetland plants (Roberts & Marston 2011).

Although continuous flooding may seem appropriate for aquatic macrophytes this type of regime can promote a monoculture of one dominant species (Roberts & Marston 2011). These aquatic species may persist in wetlands that are frequently flooded but if summer drying occurs they will die off and be replaced by lake bed herbs (EA 2007b). The ideal flood duration for aquatic macrophytes is 9-12 months, with flooding occurring annually during spring-summer (Rogers & Ralph 2011). A slow drawdown of water level is required to prevent collapse of plants (Roberts & Marston 2011). Emergent macrophytes require annual flooding of approximately 6-12 months depending on species. It is expected that implementing a semi-permanent water regime will also cater for emergent macrophytes.

In order to manage Brickworks Billabong for Murray Hardyhead ponding will need to occur on a permanent basis. This could be facilitated by implementing a regime based on the annual water requirements of aquatic and emergent macrophytes mentioned above. These water requirements have been used as a guide to develop the hydrological objectives for the Merbein Common WMU target area.

Table 11 Hydrological objectives for Merbein Common Waterway Management Unit target area

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)	Volume to fill to TSL (ML)	Volume to maintain at TSL (ML)	Total volume per event (ML)
		Min	Opt	Max	Min	Max	Min	Opt	Max					
Maintain Lignum Health	Wetland / Floodplain	**1**	**3**	**5**	**5**	**10**	**1**	**3**	**5**	**Winter/Spring**	**33**	**927**	**185**	**1112**
Improve Lignum Health		**3**	**5**	**10**	**1**	**7**	**3**	**5**	**7**	**Winter/Spring**	**34**	**1373**	**275**	**1648**
Maintain River Red Gum Health		**3**	**4**	**5**	**1**	**3**	**3**	**5**	**6**	**Winter/Spring**	**33**	**927**	**185**	**1112**
Improve River Red Gum Health		4	8	10	0	2	3	5	6	**Winter/Spring**	**34**	**1373**	**275**	**1648**
Improve Black Box Health		**2**	**3**	**5**	**1**	**7**	**2**	**4**	**6**	**Winter/Spring**	**34**	**1373**	**275**	**1648**
Reinstate semi-permanent water regime	Wetland	**5**	**9**	**10**	**0**	**2**	4	10	12	**Winter**	**33**	**927**	**185**	**1112**

[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

6.3.2 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

Inundate the wetlands in the target area five years in every ten with an maximum interval of two years between events. Allow ponding in the wetlands for four months. Every three years in ten extend the inundation area onto the floodplain with a maximum interval of three years between events. Allow ponding on the floodplain for two months.

Optimal watering regime

Inundate the wetlands in the target area nine years in every ten with an maximum interval of two years between events. Allow ponding in the wetlands for ten months. Every five years in ten extend the inundation area onto the floodplain with a maximum interval of three years between events. Allow ponding on the floodplain for five months.

Maximum watering regime

Inundate the wetlands in the target area ten years in every ten with an maximum interval of one year between events. Allow ponding in the wetlands for twelve months. Every seven years in ten extend the inundation area onto the floodplain with a maximum interval of two years between events. Allow ponding on the floodplain for five months.

7. POTENTIAL RISKS OF AND MITIGATION MEASURES FOR ENVIRONMENTAL WATERING

A table of potential risks and means for mitigating these is used as the basis for assessing the risk of environmental water delivery at this site. The terms for values that may be impacted come from the Aquatic Value Identification and Risk Assessment (AVIRA) Report (Peters, 2009).

The table identifies potential risks, events that could cause such risks, the outcomes of such risks, and the actual values that could subsequently be impacted by each risk. Mitigation strategies for each event are also identified.

Table 12 Potential risks associated with environmental water delivery

#	Risk	Description	Potential Impacts								Mitigation
			Environmental					Social		Economic	
			Fish *Water regime does not support breeding and feeding requirements*	**Birds** *Water regime does not support breeding and feeding requirements*	**Amphibians** *Water regime does not support breeding and feeding requirements*	**Invertebrate** *Water regime does not support breeding and feeding requirements*	**Native aquatic flora** *Watering requirement does not support establishment and growth.*	Reduced public access and use	Degradation of cultural heritage sites	Flooding of adjacent land	
1	Required watering regime not met	Flood duration too long or short	✓	✓	✓		✓	✓			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	✓	✓	✓		✓	✓			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
		Flooding depth too shallow or deep	✓	✓			✓	✓	✓	✓	Determine environmental water requirements based on seasonal conditions and to support potential bird breeding events Monitor flood depth to inform environmental water delivery Liaise with adjoining landowners prior to and during the delivery of environmental water to discuss and resolve potential or current flooding issues Add or drawdown water where appropriate or practical
		Flood frequency too long or short	✓	✓	✓	✓	✓	✓			Prioritise water requirements of wetlands in seasonal watering proposals according to their required water regimes and inundation history Monitor the condition of the wetland Monitor the ecological response of the wetland to flooding

2	Poor water quality	Low dissolved oxygen	✓	✓			✓				Monitor dissolved oxygen levels and the ecological response of the wetland to flooding Add or drawdown water where appropriate or practical
		High turbidity	✓				✓				Monitor turbidity levels and the ecological response of the wetland to flooding Add or drawdown water where appropriate or practical
		High water temperature	✓				✓				Monitor water temperature and the ecological response of the wetland to flooding Add or drawdown water where appropriate or practical
		Increased salinity levels	✓		✓	✓	✓				Monitor salinity levels and the ecological response of the wetland to flooding Add or drawdown water where appropriate or practical
		Increased nutrient levels									Monitor nutrient and Blue Green Algae levels, and the ecological response of the wetland to flooding Place public warning signs at the wetland if BGA levels are a public health risk Add or drawdown water where appropriate or practical
		Increased organic matter	✓				✓				Implement the required water regime
3	Pest aquatic plant and animal invasion	Introduction of pest fish	✓		✓	✓	✓				Monitor the ecological response of the wetland to flooding Install a carp screen Implement an appropriate drying regime
		Growth and establishment of aquatic pest plants	✓	✓	✓	✓	✓				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 existing arrangements (Section 4.1) limit the extent of area of floodplain which can be inundated by environmental watering in the Merbein Common WMU to 68ha (Figure 7). Currently at this extent water begins to break out through low points and return to the Murray River rather than being held on the floodplain at higher levels. Infrastructure such as permanent levees and regulators would increase the extent of inundation to the whole target area and prevent this breakout. The proposed infrastructure would be operated for ecological benefits including lateral connectivity with the Murray River.

The dependence of Sunraysia irrigators on the regulated river levels as well as the possibility of inundation of infrastructure and private land negates the possibility of manipulating weir pool levels to facilitate inundation of the target area. This restricts control of environmental watering events to pumping from the river onto the floodplain and controlling water height on the floodplain with small levees, regulators and culverts.

8.2 Infrastructure recommendations

"Investigations on Water Management Options for the Murray River" conducted by Ecological Associates (2007) concluded that the best environmental value for money spent at the Merbein Common WMU would be achieved by regulating Cowanna Billabong and Brickworks Billabong. Also proposed was the regulation of Catfish Billabong.

Works to enable management of the billabongs in Merbein Common WMU include:

- Road raising and box culverts installed to allow for high flows or pumped water to move across the floodplain and provide lateral connection to the river.
- Regulators installed to allow for manipulation of water levels.
- Rehabilitation of levees and weirs to assist with water management.

The proposed works would significantly increase the volume of water able to be delivered and area of floodplain able to be inundated (Table 12). Lateral connection to the river also allows movement of fish and water.

Table 13 Estimates of watering possibilities in Merbein Common WMU target area

	Area (ha)	Volume (ML)
Current arrangements	67.4	926.9
With investment	198	2947.8

Figure 9 indicates the location of the proposed works. Funding for detailed designs for these infrastructure upgrades is currently being sought.

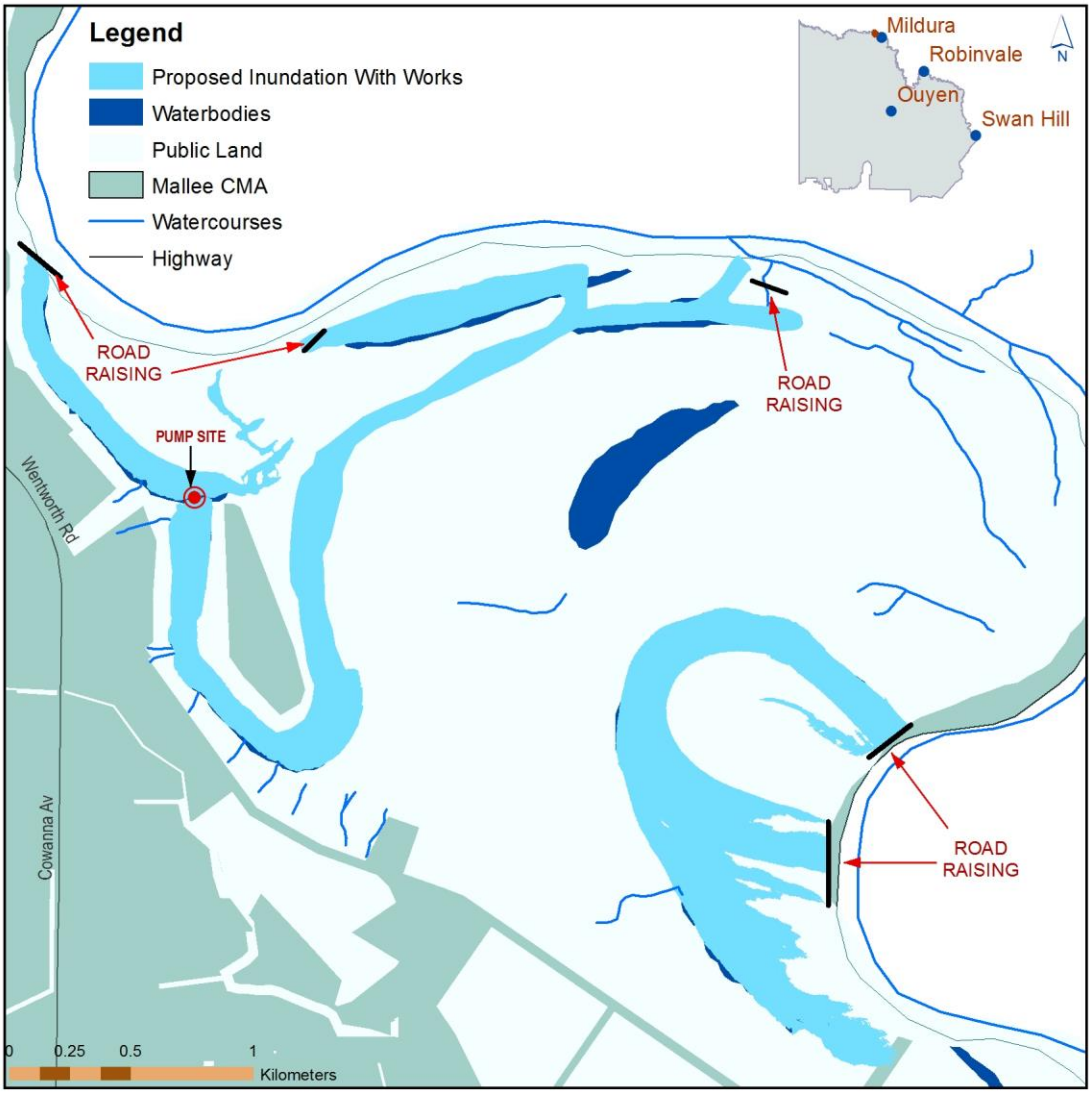


Figure 7 Anticipated inundation extent of Merbein WMU with proposed infrastructure in place

The proposed infrastructure would give greater control of the water levels on the floodplain, and would provide opportunity to return flows to the river as well as ecological connection to the river. Currently water is retained on the floodplain until it either permeates or evaporates. Returning water to the river would be dependent on accounting and water quality constraints.

9. KNOWLEDGE GAPS AND RECOMMENDATIONS

This plan is based on 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 17. A cultural heritage survey and management plan would be essential before any on ground works could be undertaken.

Table 14 Knowledge gaps and recommendations for the target area

Knowledge and data gaps	Action recommended	Responsibility
Full extent of cultural Heritage values	Cultural heritage management plan of WMU	Implementation of any of these recommendations would be dependent on investment from Victorian and Australian Government funding sources as projects managed through the Mallee CMA
Conceptual and detail designs for the management works	Engage consultants to carry out investigations and designs	
Condition of Wetlands	Assess using Index of Wetland condition method	
Role of wetland on fish breeding and population	Monitoring of fish population	
Accurate depth and volumes for the wetland	Install depth gauges and bathymetric survey	
Nesting habits of birds at the site	Data collection and monitoring	
Impacts of climate variability	Data collection and monitoring	
Understanding of causes of poor condition	Data collection and monitoring	
Understanding of causes of salinisation	Data collection and monitoring	
Fauna presence for each wetland – especially fish	Survey, data collection and monitoring	
Flora presence for each wetland – especially aquatic flora	Survey, data collection and monitoring	
Flow data for Lock 10	Modelling	
Understanding of natural flows prior to regulation	Modelling	

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APPENDIX 1: ENVIRONMENTAL WATER SOURCES

Sources of environmental water potentially available for this site under current arrangements and in the future.

Commonwealth Environmental Water Holder (CEWH)

Under *Water for the Future* the Commonwealth Government committed $3.1 billion to purchase water in the Murray-Darling Basin over 10 years. The Commonwealth Environmental Water Holder will manage their environmental water.

The Commonwealth Water Act 2007 identified that "the Commonwealth Environmental Water Holder must perform its functions for the purpose of protecting or restoring environmental assets so as to give effect to relevant international agreements". Wetlands listed as of International Importance (Ramsar) are considered priority environmental assets for use of the commonwealth environmental water (DEWHA 2008).

Victorian Environmental Water Holder (VEWH)

The VEWH (when established in June 2011) will be responsible for holding and managing Victorian environmental water entitlements and allocations and deciding upon their best use throughout the State. The environmental entitlements held by the VEHW that could potentially be made available to this site include:

- the Victorian River Murray Flora and Fauna Bulk Entitlement; and
- future Northern Victoria Irrigation Renewal Project Environmental Entitlement.

In 1987 an annual allocation of 27600 ML of high security water was committed to flora and fauna conservation in Victorian Murray wetlands. In 1999, this became a defined entitlement for the environment called the Victorian River Murray Flora and Fauna Bulk Entitlement.

The Northern Victoria Irrigation Renewal Project (NVIRP) water savings are predicted to provide up to 75 GL as a statutory environmental entitlement, which will be used to help improve the health of priority stressed rivers and wetlands in northern Victoria (DSE, 2008). The entitlement will have properties which enable the water to be used at multiple locations as the water travels downstream (provided losses and water quality issues are accounted for); meaning that the water can be called out of storage at desired times to meet specific environmental needs.

Donations

People who hold water entitlements sometimes donate water to their local catchment management authority for environmental use. Additionally, people have donated money to non-governmental organisations to buy temporary water allocation for environmental use. While the scale of donated water is generally small relative to other water sources, it can provide a valuable contribution, especially in times of critical needs.

River Murray Unregulated Flow (RMUF)

Unregulated flows in the River Murray system are defined as water that cannot be captured in Lake Victoria and is, or will be, in excess of the required flow to South Australia. If there is a likelihood of unregulated flow event in the River Murray system, the Authority provides this advice to jurisdictions The Upper States then advise the Authority on altered diversion rates and environmental releases within their existing rights to unregulated flows.

Based on the information received from Jurisdictions, the Authority reassesses the event and, if necessary, limits Upper States' access to ensure that the unregulated flow event is not over committed. The Authority then issues formal unregulated flow advice to jurisdictions including any limits to States access.

Depending on the volume of water remaining, the Authority advises EWG and the Water Liaison Working Group (WLWG) on the availability and volume of RMUF. Whilst there is a range of measures that can be undertaken by Upper States as part of their 'prior rights' during unregulated flows, RMUF events are prioritised solely for the environment.

APPENDIX 2: LEGISLATIVE FRAMEWORK

International agreements and conventions

Ramsar Convention on Wetlands (Ramsar)

The Australian Government is a Contracting Party to the convention, which is an inter-governmental treaty whose mission is "the conservation and wise use of all wetlands through local, regional and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world".

Bilateral migratory bird agreements

Australia is a signatory to the following international bilateral migratory bird agreements:

- Japan-Australia Migratory Bird Agreement (JAMBA);
- China-Australia Migratory Bird Agreement (CAMBA); and
- Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).

These agreements require that the parties protect migratory birds by:

- limiting the circumstances under which migratory birds are taken or traded;
- protecting and conserving important habitats;
- exchanging information; and
- building cooperative relationships.

Convention on the Conservation of Migratory Species of Wild Animals (Bonn)

This convention (known as the Bonn Convention or CMS) aims to conserve terrestrial, marine and avian migratory species throughout their range. It is an intergovernmental treaty, concluded under the aegis of the United Nations Environment Programme, concerned with the conservation of wildlife and habitats on a global scale. The Convention was signed in 1979 in Bonn, Germany, and entered into force in 1983.

Commonwealth legislation

Environment Protection and Biodiversity Conservation Act 1999 (EPBC)

This is the key piece of legislation pertaining to biodiversity conservation within Australia. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places – defined in the EPBC Act as matters of national environmental significance.

Water Act 2007 (Commonwealth Water Act)

This establishes the Murray-Darling Basin Authority (MDBA) with the functions and powers, including enforcement powers, needed to ensure that Basin water resources are managed in an integrated and sustainable way.

Aboriginal and Torres Strait Islander Heritage Protection Act 1984

This aims to preserve and protect areas and objects in Australia and Australian waters that are of particular significance to indigenous people from injury or desecration.

State legislation and listings

Flora and Fauna Guarantee Act 1988 (FFG)

This is the key piece of Victorian legislation for the conservation of threatened species and communities and for the management of potentially threatening processes.

Advisory lists of rare or threatened species in Victoria (DEPI)

Three advisory lists are maintained by DEPI for use in a range of planning process and in setting priorities for actions to conserve biodiversity. Unlike other threatened species lists, there are no legal requirements or consequences that flow from inclusion of a species on an advisory list. The advisory lists comprise:

- Advisory List of Rare or Threatened Plants In Victoria – 2005
- Advisory List of Threatened Vertebrate Fauna in Victoria – 2007
- Advisory List of Threatened Invertebrate Fauna in Victoria – 2009

Environmental Effects Act 1978

Potential environmental impacts of a proposed development are subject to assessment and approval under this Act. A structural works program and any associated environmental impacts would be subject to assessment and approval under the Act.

Planning and Environment Act 1987

This controls the removal or disturbance to native vegetation within Victoria by implementation of a three-step process of avoidance, minimisation and offsetting.

Water Act 1989 (Victorian Water Act)

This is the key piece of legislation that governs the way water entitlements are issued and allocated in Victoria. The Act also identifies water that is to be kept for the environment under the Environmental Water Reserve. The Act provides a framework for defining and managing Victoria's water resources.

Aboriginal Heritage Act 2006

All Aboriginal places, objects and human remains in Victoria are protected under this Act.

Other relevant legislation

The preceding legislation operates in conjunction with the following other Victorian legislation to influence the management and conservation of Victoria's natural resources as well as outline obligations with respect to obtaining approvals for structural works:

- Environment Protection Act 1970
- Catchment and Land Protection Act 1994
- Heritage Act 1995
- Conservation, Forests and Lands Act 1987
- Land Act 1958
- Heritage Rivers Act 1992
- Wildlife Act 1975
- Murray Darling Basin Act 1993
- National Parks Act 1975
- Parks Victoria Act 1998
- Forests Act 1958

APPENDIX 3: FLORA AND FAUNA SPECIES LIST

The tables below list the species recorded within the Merbein Common WMU.

Flora – Native

Common Name	*Scientific Name*	Records
Belah	*Casuarina pauper*	2
Black Box	*Eucalyptus largiflorens*	
Cattle Bush	*Alectryon oleifolius subsp. canescens*	2
Common Emu-bush	*Eremophila glabra*	1
Cottony Saltbush	*Chenopodium curvispicatum*	1
Cut-leaf Goodenia	*Goodenia pinnatifida*	1
Desert Cassia	*Senna artemisioides spp. agg.*	3
Desert Glasswort	*Pachycornia triandra*	2
Desert Lantern	*Abutilon otocarpum*	7
Doubah	*Marsdenia australis*	1
Dumosa Mallee	*Eucalyptus dumosa*	2
Dwarf Lantern-flower	*Abutilon fraseri*	4
Eucalypt	*Eucalyptus spp.*	1
Fine-leaf Desert Cassia	*Senna form taxon 'filifolia'*	1
Grey Mallee	*Eucalyptus socialis subsp. socialis*	2
Hard-head Saltbush	*Dissocarpus paradoxus*	2
Inland Pigface	*Carpobrotus modestus*	1
Leafless Ballart	*Exocarpos aphyllus*	2
Tangled Lignum	*Muehlenbeckia florulenta*	
Nealie	*Acacia loderi*	2
Pearl Bluebush	*Maireana sedifolia*	1
River Red Gum	*Eucalyptus camaldulensis*	
Sago Bush	*Maireana pyramidata*	2
Silver Needlewood	*Hakea leucoptera subsp. leucoptera*	2
Slender Cypress-pine	*Callitris gracilis subsp. murrayensis*	2
Spine Bush	*Acacia nyssophylla*	1
Spiny Lignum	*Muehlenbeckia horrida* subsp*. horrida*	
Sugarwood	*Myoporum platycarpum*	2
Weeping Pittosporum	*Pittosporum angustifolium*	1
Yarran	*Acacia melvillei*	1
Yorrell	*Eucalyptus gracilis*	1

Flora – Exotic

Common Name	*Scientific Name*	Records
Camel Thorn	*Alhagi maurorum*	9
Devil's Rope	*Cylindropuntia imbricata var. imbricata*	1
Lesser Jack	*Emex spinosa*	1
Hoary Cress	*Lepidium draba*	2
African Box-thorn	*Lycium ferocissimum*	6

Riverina Pear	*Opuntia cardiosperma*	1
Pepper Tree	*Schinus molle*	1

Fauna – Native

Common Name	***Scientific Name***	**Type**	**Records**
Apostlebird	*Struthidea cinerea*	B	2
Australasian Grebe	*Tachybaptus novaehollandiae*	B	20
Australasian Shoveler	*Anas rhynchotis*	B	9
Australian Hobby	*Falco longipennis*	B	1
Australian Magpie	*Gymnorhina tibicen*	B	16
Australian Pelican	*Pelecanus conspicillatus*	B	25
Australian Raven	*Corvus coronoides*	B	6
Australian Shelduck	*Tadorna tadornoides*	B	32
Australian White Ibis	*Threskiornis molucca*	B	17
Australian Wood Duck	*Chenonetta jubata*	B	25
Banded Lapwing	*Vanellus tricolor*	B	1
Barking Marsh Frog	*Limnodynastes fletcheri*	A	2
Black Kite	*Milvus migrans*	B	6
Black Swan	*Cygnus atratus*	B	10
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	B	12
Black-fronted Dotterel	*Elseyornis melanops*	B	4
Black-tailed Godwit	*Limosa limosa*	B	6
Black-winged Stilt	*Himantopus himantopus*	B	8
Blue-billed Duck	*Oxyura australis*	B	2
Blue-faced Honeyeater	*Entomyzon cyanotis*	B	2
Blue-winged Parrot	*Neophema chrysostoma*	B	2
Brolga	*Grus rubicunda*	B	3
Brown Treecreeper (south-eastern ssp.)	*Climacteris picumnus victoriae*	B	1
Brown-headed Honeyeater	*Melithreptus brevirostris*	B	2
Carpet Python	*Morelia spilota metcalfei*	R	5
Caspian Tern	*Hydroprogne caspia*	B	9
Chestnut Teal	*Anas castanea*	B	6
Chestnut-rumped Thornbill	*Acanthiza uropygialis*	B	4
Clamorous Reed Warbler	*Acrocephalus stentoreus*	B	4
Cockatiel	*Nymphicus hollandicus*	B	5
Common Bronzewing	*Phaps chalcoptera*	B	2
Common Greenshank	*Tringa nebularia*	B	13
Common Sandpiper	*Actitis hypoleucos*	B	5
Crested Pigeon	*Ocyphaps lophotes*	B	12
Crimson Rosella	*Platycercus elegans elegans*	B	4
Curlew Sandpiper	*Calidris ferruginea*	B	2
Darter	*Anhinga novaehollandiae*	B	25
Dusky Moorhen	*Gallinula tenebrosa*	B	4
Eastern Great Egret	*Ardea modesta*	B	1
Eurasian Coot	*Fulica atra*	B	4
Fairy Martin	*Hirundo ariel*	B	3
Freckled Duck	*Stictonetta naevosa*	B	3
Galah	*Eolophus roseicapilla*	B	1
Glossy Ibis	*Plegadis falcinellus*	B	10
Great Cormorant	*Phalacrocorax carbo*	B	64
Great Crested Grebe	*Podiceps cristatus*	B	5
Grey Butcherbird	*Cracticus torquatus*	B	23
Grey Currawong	*Strepera versicolor*	B	13

Grey Shrike-thrush	*Colluricincla harmonica*	B	1
Grey Teal	*Anas gracilis*	B	3
Growling Grass Frog	*Litoria raniformis*	A	1
Hardhead	*Aythya australis*	B	11
Hoary-headed Grebe	*Poliocephalus poliocephalus*	B	13
Horsfield's Bronze-Cuckoo	*Chrysococcyx basalis*	B	1
Intermediate Egret	*Ardea intermedia*	B	1
Lace Goanna	*Varanus varius*	R	2
Laughing Kookaburra	*Dacelo novaeguineae*	B	3
Little Black Cormorant	*Phalacrocorax sulcirostris*	B	3
Little Corella	*Cacatua sanguinea*	B	10
Little Eagle	*Hieraaetus morphnoides*	B	6
Little Egret	*Egretta garzetta*	B	18
Little Friarbird	*Philemon citreogularis*	B	1
Little Grassbird	*Megalurus gramineus*	B	6
Little Pied Cormorant	*Microcarbo melanoleucos*	B	19
Little Raven	*Corvus mellori*	B	6
Magpie-lark	*Grallina cyanoleuca*	B	2
Mallee Ringneck	*Barnardius zonarius barnardi*	B	4
Marsh Sandpiper	*Tringa stagnatilis*	B	4
Masked Lapwing	*Vanellus miles*	B	1
Mistletoebird	*Dicaeum hirundinaceum*	B	18
Mueller's Skink	*Lerista muelleri*	R	4
Musk Duck	*Biziura lobata*	B	2
Nankeen Kestrel	*Falco cenchroides*	B	55
Nankeen Night Heron	*Nycticorax caledonicus*	B	1
Noisy Miner	*Manorina melanocephala*	B	3
Olive-backed Oriole	*Oriolus sagittatus*	B	8
Orange Chat	*Epthianura aurifrons*	B	1
Pacific Black Duck	*Anas superciliosa*	B	1
Pacific Golden Plover	*Pluvialis fulva*	B	1
Pallid Cuckoo	*Cuculus pallidus*	B	12
Painted Snipe	*Rostratula benghalensis*	B	1
Peaceful Dove	*Geopelia striata*	B	5
Peregrine Falcon	*Falco peregrinus*	B	27
Peron's Tree Frog	*Litoria peronii*	A	4
Peters's Blind Snake	*Ramphotyphlops bituberculatus*	R	3
Pied Butcherbird	*Cracticus nigrogularis*	B	2
Pied Cormorant	*Phalacrocorax varius*	B	7
Pink-eared Duck	*Malacorhynchus membranaceus*	B	4
Plains Froglet	*Crinia parinsignifera*	A	8
Purple Swamphen	*Porphyrio porphyrio*	B	1
Rainbow Bee-eater	*Merops ornatus*	B	2
Red Wattlebird	*Anthochaera carunculata*	B	1
Red-capped Plover	*Charadrius ruficapillus*	B	17
Red-capped Robin	*Petroica goodenovii*	B	1
Red-naped Snake	*Furina diadema*	R	1
Red-necked Avocet	*Recurvirostra novaehollandiae*	B	7
Red-necked Stint	*Calidris ruficollis*	B	4
Red-rumped Parrot	*Psephotus haematonotus*	B	1
Royal Spoonbill	*Platalea regia*	B	2
Rufous Songlark	*Cincloramphus mathewsi*	B	11
Rufous Whistler	*Pachycephala rufiventris*	B	1
Sacred Kingfisher	*Todiramphus sanctus*	B	8

Sand Goanna Group	*Varanus gouldii (group)*	R	2
Silver Gull	*Chroicocephalus novaehollandiae*	B	6
Singing Honeyeater	*Lichenostomus virescens*	B	5
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*	B	1
Spotless Crake	*Porzana tabuensis*	B	9
Spotted Marsh Frog	*Limnodynastes tasmaniensis*	A	1
Spotted Pardalote	*Pardalotus punctatus*	B	1
Straw-necked Ibis	*Threskiornis spinicollis*	B	1
Striated Pardalote	*Pardalotus striatus*	B	2
Stumpy-tailed Lizard	*Tiliqua rugosa*	R	2
Superb Fairy-wren	*Malurus cyaneus*	B	1
Swamp Harrier	*Circus approximans*	B	1
Tawny Frogmouth	*Podargus strigoides*	B	2
Unidentified ducks	*Anatidae sp.*	B	11
Unidentified ibis	*Threskiornis sp.*	B	7
Unidentified small waders	*Unidentified small waders*	B	1
Unidentified waders	*Charadriiformes spp.*	B	16
Varied Sittella	*Daphoenositta chrysoptera*	B	1
Variegated Fairy-wren	*Malurus lamberti*	B	1
Weebill	*Smicrornis brevirostris*	B	1
Welcome Swallow	*Hirundo neoxena*	B	23
Western Gerygone	*Gerygone fusca*	B	2
Whistling Kite	*Haliastur sphenurus*	B	17
White-backed Swallow	*Cheramoeca leucosternus*	B	1
White-browed Woodswallow	*Artamus superciliosus*	B	2
White-eared Honeyeater	*Lichenostomus leucotis*	B	12
White-faced Heron	*Egretta novaehollandiae*	B	2
White-necked Heron	*Ardea pacifica*	B	1
White-plumed Honeyeater	*Lichenostomus penicillatus*	B	11
White-winged Chough	*Corcorax melanorhamphos*	B	6
White-winged Fairy-wren	*Malurus leucopterus*	B	1
Willie Wagtail	*Rhipidura leucophrys*	B	7
Wood Sandpiper	*Tringa glareola*	B	4
Yellow Rosella	*Platycercus elegans flaveolus*	B	1
Yellow Thornbill	*Acanthiza nana*	B	11
Yellow-billed Spoonbill	*Platalea flavipes*	B	6
Yellow-plumed Honeyeater	*Lichenostomus ornatus*	B	1
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	B	7
Zebra Finch	*Taeniopygia guttata*	B	4

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

Fauna – Exotic

Common Name	***Scientific Name***	**Type**	**Records**
Black Rat	*Rattus rattus*	M	13
Common Blackbird	*Turdus merula*	B	2
Common Starling	*Sturnus vulgaris*	B	1
European Goldfinch	*Carduelis carduelis*	B	2
European Rabbit	*Oryctolagus cuniculus*	M	14
Rock Dove	*Columba livia*	B	5

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

APPENDIX 4: ECOLOGICAL VEGETATION CLASSES

Description of each EVC in the Merbein Common WMU

EVC no.	EVC name	Bioregional Conservation Status	Description
		Murray Scroll Belt	
818	Shrubby Riverine Woodland	Least Concern	Eucalypt woodland to open forest to 15 m tall of less flood-prone (riverine) watercourse fringes, principally on levees and higher sections of point-bar deposits. The understorey includes a range of species shared with drier floodplain habitats with a sparse shrub component, ground-layer patchily dominated by various life-forms. A range of large dicot herbs (mostly herbaceous perennial, several with a growth-form approaching that of small shrub) are often conspicuous.
102	Low Chenopod Shrubland	Depleted	Chenopod shrubland to 1 m tall occupying broad, flat alluvial terraces occur along the Murray River, west from Mildura to the border. Also found in narrow bands fringing raak and saline lakes such as Lake Tyrell and on relict lakebed surfaces such as Pine Plains. The field layer is characterised by succulents and a suite of annual herbs.
103	Riverine Chenopod Woodland	Depleted	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.
806	Alluvial Plains Semi-arid Grassland	Vulnerable	Grassland (turf) to herbland to < 0.2 m tall with only incidental shrubs. Flood-promoted flora, potentially including a wide range of opportunistic ephemeral / annual species occupying low-lying areas within at least previously flood-prone (mostly) higher-level terraces, which may be effectively shallow lakes when flooded. Also sometimes on flats along creeks of the further north-west, in habitat akin to that of Floodway Pond Herbland.
808	Lignum Shrubland	Least Concern	Relatively open shrubland of species of divaricate growth form. The ground-layer is typically herbaceous or a turf grassland, rich in annual/ephemeral herbs and small chenopods. Characterised the open and even distribution of relatively small Lignum shrubs. Occupies heavy soil plains along Murray River, low-lying areas on higher-level (but still potentially flood-prone) terraces.
104	Lignum Swamp	Vulnerable	Typically treeless shrubland to 4 m, tall with robust (but sometimes patchy) growth of lignum. Widespread wetland vegetation type in low rainfall areas on heavy soils, subject to infrequent inundation resulting from overbank flows from rivers or local runoff.
97	Semi-arid Woodland	Vulnerable	Non-eucalypt woodland or open forest to 12 m tall, of low rainfall areas. Occurs in a range of somewhat elevated positions not subject to flooding or inundation. The surface soils are typically light textured loamy sands or sandy loams.
98	Semi-arid Chenopod Woodland	Depleted	Sparse, low non-eucalypt woodland to 12 m tall of the arid zone with a tall open chenopod shrub-dominated understorey to a treeless, tall chenopod shrubland to 3 m tall. This EVC may occur as either a woodland (typically with a very open structure but tree cover >10%) or a shrubland (tree cover <10%) with trees as an occasional emergent.
823	Lignum Swampy Woodland	Depleted	Understorey dominated by Lignum, typically of robust character and relatively dense (at least in patches), in association with a low Eucalypt and/or Acacia woodland to 15 m tall. The ground layer includes a component of obligate wetland flora that is able to persist even if dormant over dry periods.
813	Intermittent Swampy Woodland	Depleted	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 a 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 and frequently slightly brackish soils.

APPENDIX 5 CULTURAL HERITAGE CONTINGENCY PLAN

CONTINGENCY PLANS

In the event that Aboriginal cultural heritage is found during the conduct of the activity, contingency measures are set out below. The contingency measures set out the sponsor's requirements in the event that Aboriginal cultural heritage is identified during the conduct of the activity.

1 Management of Aboriginal Cultural Heritage found during the Activity

In the event that new Aboriginal cultural heritage is found during the conduct of the activity, then the following must occur:

* The person who discovers Aboriginal cultural heritage during the activity will immediately notify the person in charge of the activity;
* The person in charge of the activity must then suspend any relevant works at the location of the discovery and within 5m of the relevant place extent;
* In order to prevent any further disturbance, the location will be isolated by safety webbing or an equivalent barrier and works may recommence outside the area of exclusion;
* The person in charge of the activity must contact the and the **Mallee CMA Indigenous Facilitator**
* Within a period not exceeding 1 working days a decision/ recommendation will be made by the the **Mallee CMA Indigenous Facilitator** and the **Aboriginal stakeholder** ;
* as to the process to be followed to manage the Aboriginal cultural heritage in a culturally appropriate manner, and how to proceed with the works;
  ○

Separate contingency plan has been developed in the event that suspected human remains are discovered during the conduct of the activity.

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2 Notification of the Discovery of Skeletal Remains during the carrying out of the Activity

1. Discovery:

* If suspected human remains are discovered, all activity in the vicinity must ***stop*** to ensure minimal damage is caused to the remains, and,
* The remains must be left in place, and protected from harm or damage.

2. Notification:

* Once suspected human skeletal remains have been found, Victoria Police (use the local number) and the Coroner's Office (1300 309 519) must be notified immediately;
* If there is reasonable grounds to believe that the remains could be Aboriginal, the DSE Emergency Co-ordination Centre must be immediately notified on 1300 888 544; and
* All details of the location and nature of the human remains must be provided to the relevant authorities.
* If it is confirmed by these authorities that the discovered remains are Aboriginal skeletal remains, the person responsible for the activity must report the existence of the human remains to the Secretary, DPCD in accordance with s.17 of the Act.

3. Impact Mitigation or Salvage:

* The Secretary, after taking reasonable steps to consult with any Aboriginal person or body with an interest in the Aboriginal human remains, will determine the appropriate course of action as required by

s.18(2)(b) of the Act.
∗ An appropriate impact mitigation or salvage strategy as determined by the Secretary must be implemented.

4. Curation and Further Analysis:

∗ The treatment of salvaged Aboriginal human remains must be in accordance with the direction of the Secretary.

5. Reburial:

∗ Any reburial site(s) must be fully documented by an experienced and qualified archaeologist, clearly marked and all details provide to AAV;
Appropriate management measures must be implemented to ensure that the remains

ARE NOT DISTURBED IN THE FUTURE