Environmental Water Management Plan

Photo: Psyche Bend Lagoon, Kings Billabong

Psyche Bend Lagoon and Woorlong Wetland

mallee
catchment management authority

Version Number	Description	Issued To	Issue Date
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8.	Whole EWMP review and update according to latest guidelines	G. Cranston	9/12/2021
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10	1st Draft for Mallee CMA review	A. Nunn	20/05/2022
11	1st Draft from Pinion Advisory with MCMA comments	T. Muster	09/06/2022
12	2nd Draft for Mallee CMA review, incorporating MCMA comments	A. Nunn	20/06/2022
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14	Final incorporating MCMA comments – Pinion Advisory	G. Cranston & A. Nunn	22/06/2022
15	Update to incorporate 2023 Community Consultation – Alluvium Consulting	E Johnstone	26/07/2023

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
DELWP	Department of Environment, Land, Water and Planning
DNRE	Department of Natural Resources and Environment
DSE	Department of Sustainability and Environment

EA	Ecological Associates
EC	Electrical Conductivity (µS/cm)
EPBC	Environment Protection and Biodiversity Conservation Act
EVC	Ecological Vegetation Class
EWMP	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

Executive Summary

Environmental Water Management Plans (EWMPs) have been developed for key sites in the Mallee region. The Mallee Waterway Strategy 2014-22 (Mallee CMA, 2014) covers 216 identified waterways which have been grouped into planning units according to hydrological interconnectedness and commonality of threats impacting on the waterways values; resulting in 23 Waterway Management Units. This Environmental Water Management Plan (EWMP) sets out the long-term objectives for the priority environmental values of Psyche Bend Lagoon and Woorlong Wetland. It is an important part of the Victorian Environmental Water Planning Framework and provides the long-term management intentions based on scientific information and stakeholder consultation that can be used by the respective agencies; Mallee Catchment Management Authority (CMA), Department of Environment, Land, Water and Planning (DELWP) and the Victorian Environmental Water Holder (VEWH); for both short and longer-term environmental water planning.

This EWMP is not a holistic management plan for the area, but is focused on environmental water management. A regional context document has been prepared to compliment the Mallee CMA EWMPs and should be read in conjunction with this document (North, 2014).

Psyche Bend Lagoon and Woorlong Wetland WMU sub-unit (Psyche/Woorlong) is located in the Robinvale Plains bioregion within the Mallee Catchment Management Authority (Mallee CMA) region 10 km south-east of Mildura and covers 1194.68 ha. This plan was developed in collaboration with key stakeholders namely Parks Victoria, First Peoples of the Millewa-Mallee aboriginal Corporation, the Department of Environment, Land, Water and Planning, and local interest groups.

The primary use of Psyche/Woorlong is for irrigation drainage disposal and the site plays an important role in the region's salinity management strategy. Pysche Bend Lagoon is a natural groundwater discharge site for the regional Parilla Sands Aquifer and contains highly saline water. Due to these conditions, there is potential for significant salinity impacts on the Murray River through surface water discharge from Psyche Bend Lagoon. Surface water levels are therefore carefully managed to reduce salinity impacts, while also allowing for salt to be removed through managed flushing events. These events are limited to flow events of >35,000 ML/day in the Murray River. The Mallee CMA acknowledges this will be the primary use for the site going forward and understands that any environmental and hydrological objectives recommended in this EWMP are secondary to the site's primary use. However, opportunities to protect the environmental values and improve conditions may be provided through environmental watering at this site.

Within Psyche/Woorlong many significant species exist and both permanent freshwater and semi-permanent saline wetlands provide a range of habitats. The whole of Psyche/Woorlong has a water requirement as a floodplain complex but the focus for this plan is restricted to a target area within Psyche/Woorlong of 377 ha. This target area is the extent to which environmental water is able to be managed with proposed infrastructure in place. Without infrastructure recommendations the target area does not exceed 102 ha. The target area does not encompass any private land.

The target area of Psyche/Woorlong covers four out of six wetlands. The four wetlands that have been included in the target area for this EWMP are Psyche Bend Lagoon (#11507), Psyche Runner (#11366), Woorlong Wetland (#11354) and Woorlong Drains (#11506). The target area also includes areas of floodplain, beyond the mapped extent of the wetlands.

The long term management goals of Psyche/Woorlong are to:

- Maintain Woorlong Wetland as a permanent open freshwater wetland supporting habitat for small fish, frogs and waterbirds.
- Maintain Psyche Bend Lagoon as a permanent saline wetland supporting healthy populations of salt tolerant aquatic vegetation, and supporting habitat for frogs and waterbirds.

To achieve this, ecological and hydrological objectives were designed with the consideration of short-term and longer term watering regimes.

The ecological objectives for Psyche/Woorlong target area are outlined below:

PW2: By 2030, maintain populations and extent of saline aquatic vegetation at Psyche Bend Lagoon, Psyche/Woorlong including benthic herblands with *Ruppia* beds containing both *R. polycarpa* and *R. megacarpa*.

PW3: By 2030, maintain representative populations of the shallow-water feeding guild of waterbirds (F2, after Jaensch 2002) at Pysche and Woorlong by maintaining shallow-water habitats.

PW4: By 2030, improve condition and maintain extent from baseline levels of Lignum (*Duma florulenta*) to sustain communities and processes reliant on Lignum communities at Woorlong Wetland, Psyche/Woorlong.

PW5a: By 2030, protect and restore biodiversity by maintaining representative populations of small bodied native fish at Woorlong, Psyche/Woorlong including Unspecked Hardyhead (*Craterocephalus stercusmuscarum fulvus*), Western Carp Gudgeon (*Hypseleotris klunzingeri*) and Flat-headed Gudgeon (*Philypnodon grandiceps*)

PW5b: By 2030, protect and restore biodiversity by maintaining representative populations of frogs at the Psyche Bend Lagoon and Woorlong Wetland asset.

PW6: By 2030, reduce the extent of invasive emergent macrophytes (Typha *Typha domingensis* and Common reed *Phragmites australis*) to prevent the decline of native vegetation at the Woorlong Wetlands, Psyche/Woorlong.

Environmental watering requirements and an intended watering regime has been developed to align with the environmental objectives and targets. The intended water regime required to achieve the environmental objectives for the target area are presented in Section 8. This watering regime will be implemented within the constraints of the agreed salinity management protocols at the site. The suitability of the watering regime will be assessed on an annual basis, with opportunities to manage water for environmental outcomes considered as a secondary driver in the planning and decision-making process, with the primary consideration being the agreed salinity management protocols and how these will be implemented within the current seasonal flow conditions.

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1 Introduction

This Environmental Water Management Plan (EWMP) has been prepared by the Mallee CMA to establish the long-term management goals of Psyche Bend Lagoon and Woorlong Wetland. Psyche Bend Lagoon and Woorlong Wetland are located on the Murray River floodplain approximately 10 km south east of Mildura.

The key purposes of the EWMP are to:

- identify the long-term objectives and water requirements for the wetland, identified as a high priority by the Mallee CMA;
- provide a vehicle for community consultation, including for the long-term objectives and water requirements of the wetlands;
- inform the development of seasonal watering proposals and seasonal watering plans; and
- inform the long-term watering plans to be developed under the Basin Plan requirements.

This EWMP was developed in 2015. The environmental objectives were reviewed and updated in 2020. The latest version of the EWMP (2022) has been updated to incorporate new information and align with the Department of Environment, Land, Water and Planning (DELWP) Draft EWMP Guidelines (Version 6 – April 2022).

2 Partnership and Consultation

2.1 TARGET AUDIENCE

This section identifies the target audience and modes of consultation necessary to manage environmental water delivery, report against stated objectives and targets, and promote adaptive management over the life of the EWMP.

Engagement with different stakeholder groups is based on the International Association of Public Participation (IAP2) spectrum (FIGURE 1). The spectrum allows for a tailored approach based on stakeholder groups and their needs.

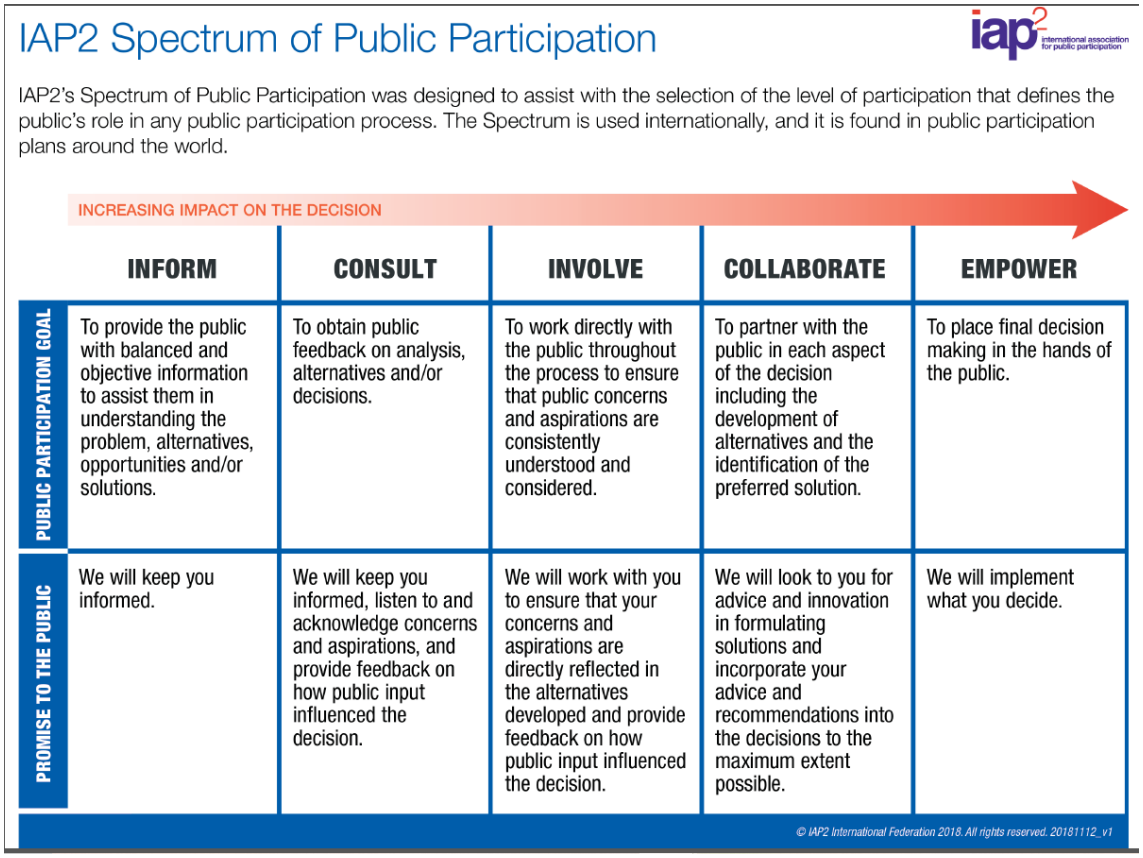


FIGURE 1 IAP2 SPECTRUM

Source: (c) International Association for Public Participation

Table 1 lists the main stakeholder groups with an interest in environmental water based on their needs and interests and level of engagement required. To read more about the role of specific stakeholders in overseeing environmental water at Psyche Woorlong, refer to Section 3.2.

Mallee CMA develops a communication and engagement plan each year that covers environmental watering events for the entire Mallee CMA region, including Psyche Woorlong. This ensures that all stakeholders and community members are aware of the Psyche Woorlong environmental watering operations.

TABLE 1 RECENT STAKEHOLDER CONSULTATION FOR PSYCHE WOORLONG EWMP

Stakeholder groups	Stakeholders	Needs and interest	IAP2 level	Consultation modes
Traditional Owners and Interested Parties	See Section 2.4: Traditional Owners	Ongoing connection to Country and protection of cultural heritage and values. Environmental impacts and benefits. environmental watering regimes and how these may be timed to support/promote cultural values.	Collaborate	Via Mallee CMA's Traditional Owner engagement team. Consultation is largely undertaken in-person and, where possible, on Country.
Victorian water holders	VEWH	Make decisions about annual environmental water usage.	Collaborate	Via formal meetings.
State government	DEECA	Monitoring and assessment	Collaborate	Via formal meetings.

Stakeholder groups	Stakeholders	Needs and interest	IAP2 level	Consultation modes
		Planning and preparation of annual environmental water documents and agreements		
River operators	Lower Murray Water	Manage water storage, land management responsibilities.	Collaborate	Via formal meetings.
Public land managers	Parks Victoria,	Managing impacts from watering such as access.	Collaborate	Via monthly meetings.
Local government	Mildura Rural City Council	Access during watering events.	Involve	Meetings, phone calls, correspondence.
Basin-wide river management	MDBA	River Murray operations.	Involve	Via formal meetings.
Private landowners and managers	Adjacent landholders and managers	Possible access to properties during operation as defined in landholder agreements.	Collaborate	Directly affected landholders will be informed of watering proposals and asked to provide feedback if relevant.
Community (interest groups)	Irrigators Community Advisory Groups Environmental, recreational and social groups	Consumptive water use/access. Watering benefits and impacts on local communities such as access to parks and river during watering events.	Inform	Via existing groups such as the Mallee CMA Land and Water Committee. Via Mallee CMA social media and news.
Media	Local, state and national media outlets	Across issues that interest the local community.	Inform	Media packs and media releases.

2.2 DEVELOPING/UPDATING THE EWMP

Mallee CMA carried out community consultation through the following channels:

- Mallee CMA Land and Water Advisory Committee
- surveys at community events such as farmers' markets
- workshops and on-country visits with Traditional Owners (see Section 2.4)
- campaign emails
- meeting with landholders
- social media channels.

Relevant government agencies were invited to participate in the consultation process via a formal letter. They have also been engaged through existing channels, with discussions and presentations. The key outcomes from this engagement were:

- ensuring that Traditional Owner values were represented in the ecological outcomes
- building more frequent initial watering into the proposed watering regime to help the landscape recover and monitoring outcomes to determine future water needs, in response to Traditional Owner feedback.

2.2.1 Verifying asset values

Asset values at Psyche Woorlong have been established through environmental assessments and the development of previous versions of this EWMP. Consultation has been a key part of these processes with Traditional Owners, community members and technical specialists. Mallee CMA has continued to engage on asset values throughout the development of the EWMP, particularly with Traditional Owners and private and public landholders.

2.2.2 Informing proposed management objectives, targets and approaches

Mallee CMA has long worked with those who have an extensive knowledge of Psyche Woorlong and floodplain ecosystems. This work has been central to providing a basis for local knowledge and expertise.

Combined with the Seasonal Watering Proposal, the data and knowledge from the will guide future watering events, as part of the adaptive management approach.

2.2.3 Promoting adaptive management

Mallee CMA and other partners will take an adaptive management approach taking into account both varying seasonal conditions and lessons learned from previous events.

After the annual adaptive management checkpoint, Mallee CMA will adapt the EWMP if needed, which would then go through consultation, giving stakeholders the opportunity to see any updates.

2.3 COMMUNITY

Community stakeholders were engaged via an online survey, which was hosted on the Mallee CMA website in January-February 2023. The survey was designed to enable landholders, recreational users, Landcare groups, environmental groups and other interested parties to provide input to the updated plans. A summary of the survey value rankings is shown in TABLE 2 and further detail is provided in Appendix 4.

TABLE 2 - COMMUNITY VALUES RANKINGS - WOORLONG WETLANDS (TWO COMPLETED SURVEYS)

Community Value	Value Ranking
Unique landscape features and natural beauty	Unique landscape features and natural beauty were of extremely high importance to survey respondents (score 5/5). One of two survey respondents use Woorlong Wetlands for Nature Appreciation.
Recreational opportunities (e.g. birdwatching, fishing)	Recreational opportunities were of extremely high importance to both of survey respondents (score 5/5).
Exercise (trails for walking, running, cycling)	Both survey respondents considered the exercise values of Kings Billabong to be of extremely high importance (score 5/5). Both respondents use Woorlong wetlands for running/walking.
Work or Education opportunities	Work or education opportunities were of extremely high importance to both respondents (score 5/5).
Socialising	One of two survey respondents used Woorlong Wetlands for socialising
Commercial or business opportunities	Commercial or business opportunities were of mixed importance to respondents (score 2.5/5) with one considering these opportunities as of high importance, while the second respondent scored such opportunities as not important at all.

The survey supplements earlier community engagement about the Psyche Bend Lagoon and Woorlong Wetland EWMP, and annual community engagement that informs the Seasonal Watering Proposal (SWP). Community consultation occurs at the IAP2 level of CONSULT.

2.4 TRADITIONAL OWNERS

Psyche Bend Lagoon and Woorlong Wetland are located within the formally recognised Country of the First People of the Millewa-Mallee Aboriginal Corporation (FPMMAC). FPMMAC has indicated in DEECA's EWMP guidelines how they would like to be consulted about environmental watering. Consultation with FPMMAC, in-line with the EWMP guidelines, is ongoing. Engagement with Traditional Owners is conducted on a one-on-one basis at the COLLABORATE level of the IAP2 framework, with the level of interest and involvement self-determined.

FPMMAC were engaged in March 2023 to collaborate on the EWMP update process. This involved a presentation to a group of TO's from FPMMAC about the sites included in the update.

Discussions included ecological, social and cultural outcomes and watering regimes to support these. Engagement and discussions about these topics will be on going and essential to future watering programs.

3 Asset Overview

The Mallee CMA region is situated in the north-west of Victoria. The area of responsibility is close to 39,000 km^2 (3.9 million ha) and has a regional population estimated to be 65,000. Population centres include Mildura, Birchip, Sea Lake, Ouyen, Robinvale, Red Cliffs and Merbein. The boundaries of the Mallee CMA region cover almost one fifth of Victoria, making it the largest area managed by a CMA in the state.

Approximately 40% of the land area within the Mallee CMA boundary is public land, consisting mainly of national parks, reserves, wilderness, and large areas of riverine and dryland forests. The other 60% is predominantly dryland crops, but there is also a significant investment in irrigated horticulture including grapes, citrus, almonds, olives and vegetables along the Murray River corridor. Irrigated crops contribute over 40% of the value of agricultural production for the region.

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

This EWMP has been developed for a sub-unit of the Karadoc WMU. Karadoc covers a series of unconnected sub-units from Nangiloc to Kings Billabong. This sub-unit

includes Psyche Bend Lagoon and Woorlong Wetland, and will be referred to as Psyche/Woorlong for the purposes of this EWMP. Psyche/Woorlong is located between river km 923 and river km 952, 10km south-south-east of Mildura (**Figure 2**).

A regional context document (North, 2014) has been prepared to compliment the Mallee CMA EWMPs and should be read in conjunction with this document.

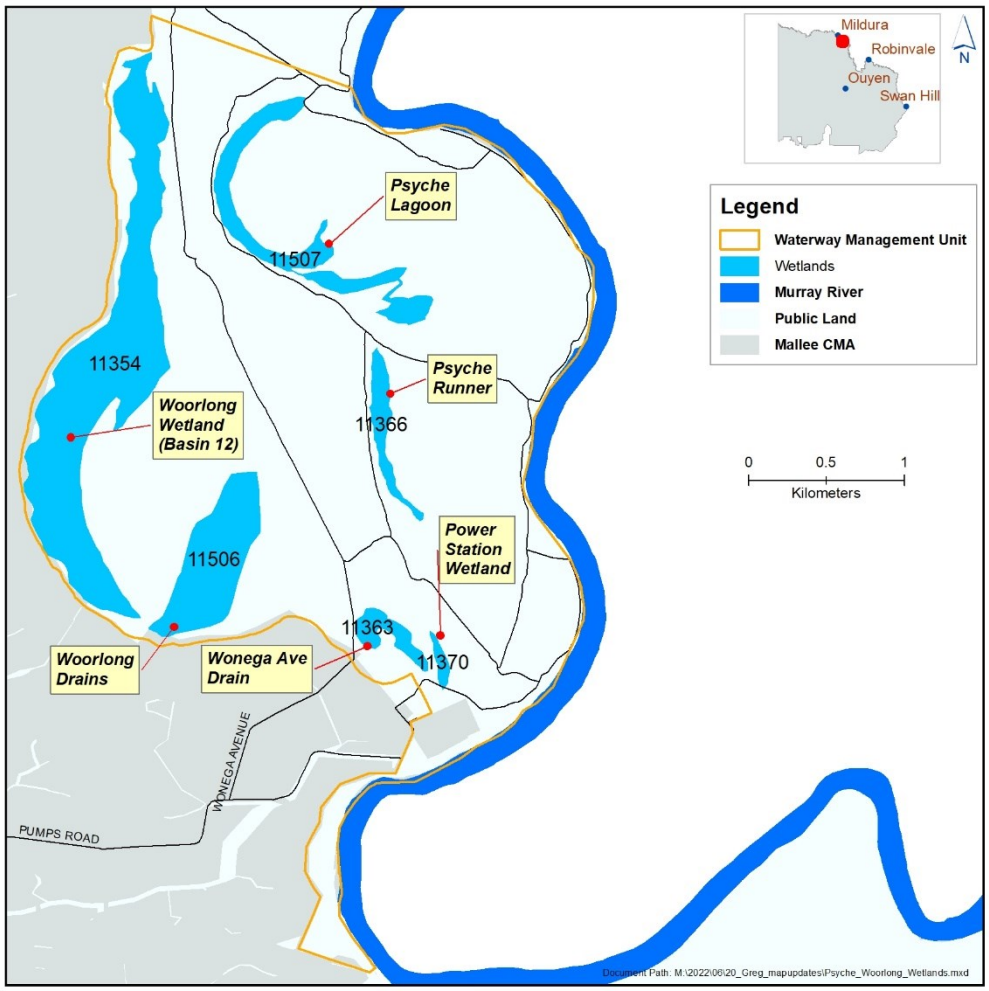


Figure 2. Psyche/Woorlong WMU Sub-unit.

3.1 CATCHMENT SETTING

Psyche/Woorlong is located in the Robinvale Plains bioregion within the Mallee CMA region 10 km south east of Mildura. The Robinvale Plains bioregion is characterised by a narrow gorge confined by the cliffs along the Murray River, which is entrenched within older up-faulted Cainozoic sedimentary rocks. Alluvium deposits from the Cainozoic period gave rise to the red brown earths, cracking clays and texture contrast soils (Dermosols, Vertosols, Chromosols and Sodosols) this supports Riverine Grassy Forest and Riverine Grassy Chenopod Woodland ecosystems.

3.2 LAND STATUS AND MANAGAGEMENT

There are many agencies and groups involved in managing the land and water at Psyche/Woorlong (**Table 3**). The Psyche/Woorlong area is managed as part of the Kings Billabong Park, following recommendations in the River Red Gum Forests Investigation (VEAC 2008). Prior to 2008 the Park was managed as Kings Billabong Wildlife Reserve. The change in land status does not affect the land management as Parks Victoria continues to manage the area. Land status is shown in **Figure 3**. Lower Murray Water manages the substantial irrigation water resources and infrastructure within the park. An historic pump station is operated and maintained by the Sunraysia Steam Preservation Society Inc.

Table 3. Stakeholders for the Psyche/Woorlong EWMP

Group	Role
Parks Victoria	Land Manager
Mallee CMA	Regional waterway and environmental management
Department of Environment, Land, Water and Planning (DELWP)	State level environmental management planning, land manager, threatened species manager
Lower Murray Water	River Murray operations Owner/operator of Psyche Bend Lagoon inlet/outlet regulator
Mildura Rural City Council	Local government
Victorian Environmental Water Holder (VEWH)	Manager of Victoria's environmental water entitlements – Project Partners
First People of the Millewa-Mallee Aboriginal Corporation	Registered Aboriginal Party of the area
Sunraysia Bird Observers Club, Friends of Kings Billabong	Flora and Fauna interest
Commonwealth Environmental Water Holder (CEWH)	Environmental Water - Project Partners

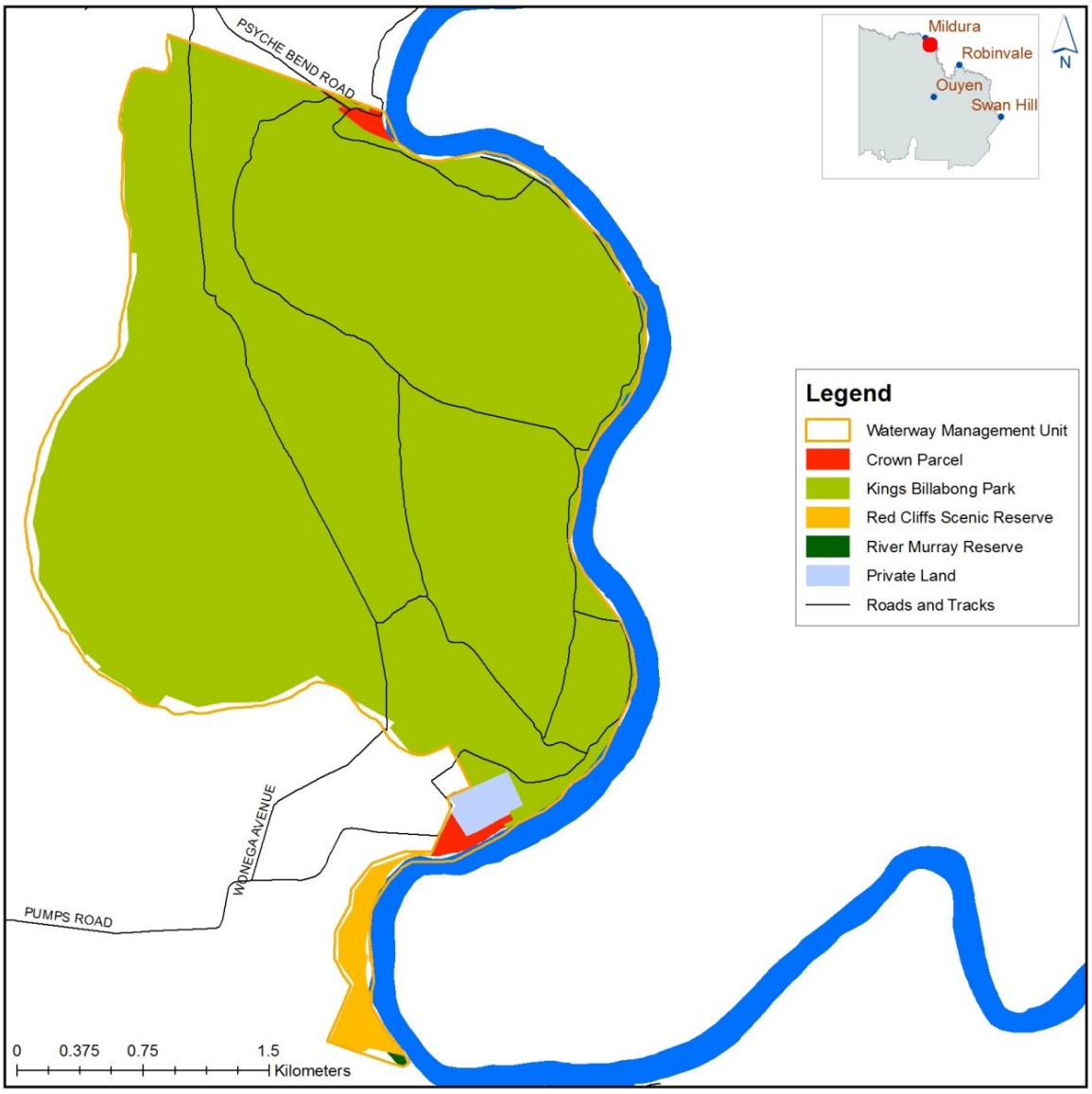


Figure 3. Psyche/Woorlong land management boundaries.

3.3 ASSET CHARACTERISTICS

Psyche Bend Lagoon and Woorlong Wetland is located 10 km south-east of Mildura and covers 1194.68 ha. Psyche/Woorlong consists of two distinct areas Psyche Bend Lagoon and Woorlong Wetlands.

"Psyche Bend Lagoon" consists of two semi-permanent saline wetlands covering an area of approximately 39 hectares. These wetlands are Psyche Bend Lagoon (#11507), and Psyche Runner (#11366). These wetlands are dominated by Lignum Shrubland and Lignum Swampy Woodland.

Woorlong Wetland consists of Woorlong Wetland (Basin 12) (#11354) and Woorlong Drains #11506. These wetlands cover an area of approximately 153 ha. Vegetation communities consist of Spike-sedge Wetland, Lignum Swamp, and Lignum Swampy Woodland vegetation communities.

Two out of six wetlands (#11363 - Wonega Ave Drain and #11370 – Power Station Wetland) have been excluded because they are either:

- higher on the floodplain and watering them would inundate lower lying non-target areas; or
- are not able to be watered with the current or proposed infrastructure.

Wetlands identified with numbers in **Figure 4** and Table 4 have been categorised according to the DELWP Victorian Wetland Inventory (Current) map layer..

The four wetlands that have been included in the target area for this EWMP are Psyche Bend Lagoon (#11507), Psyche Runner (#11366), Woorlong Wetland (#11354) and Woorlong Drains (#11506) (**Figure 4**).

The primary use of Psyche/Woorlong is for irrigation drainage disposal and the site plays an important role in the region's salinity management strategy. Pysche Bend Lagoon is a natural groundwater discharge site for the regional Parilla Sands Aquifer and contains highly saline water. Due to these conditions, there is potential for significant salinity impacts on the Murray River through surface water discharge from Psyche Bend Lagoon. Surface water levels are therefore carefully managed to reduce salinity impacts, while also allowing for salt to be removed through managed flushing events. These events are limited by agreed protocols to flow events of >35,000 ML/day in the Murray River.

Table 4. Wetland Characteristics at Psyche/Woorlong

Characteristics	Description
Name	Psyche/Woorlong WMU Sub-unit
Mapping ID **(Wetland Current layer)**	Psyche Bend Lagoon: 11507(29.98 ha) Psyche Runner: 11366 (9.17 ha) Woorlong Wetland (Basin 12): 11354 (115.91 ha) Woorlong Drains: 11506 (37.39 ha) Wonega Ave Drain: 11363 (7.17 ha – outside target area) Power Station Wetland: 11370 (2.18 ha – outside target area)
Area of wetlands in target area	192.45 ha of wetlands (1194.68 ha WMU sub-unit)
Bioregion	Robinvale Plains
Conservation status	Bioregion conservation status: areas of EVCs listed as Vulnerable, Depleted, and Least Concern
Land status	Kings Billabong Park
Land manager	Parks Victoria
Surrounding land use	Irrigated horticulture, rural township

Water supply	Regulated natural connection under influence of Lock 11 weir pool. Option to fill from drainage channel to Woorlong wetland.
Wetland category (Wetland Current layer)	Psyche Bend Lagoon: 6 -Semi-permanent saline Psyche Runner: 6 - Semi-permanent saline Woorlong Wetland (Basin 12): 5 - Permanent open freshwater Woorlong Drains: No category Wonega Ave Drain: 6 - Semi-permanent saline Power Station Wetland: 6 - Semi-permanent saline
Wetland depth at capacity	Woorlong Wetland >5m Psyche Lagoon >2m

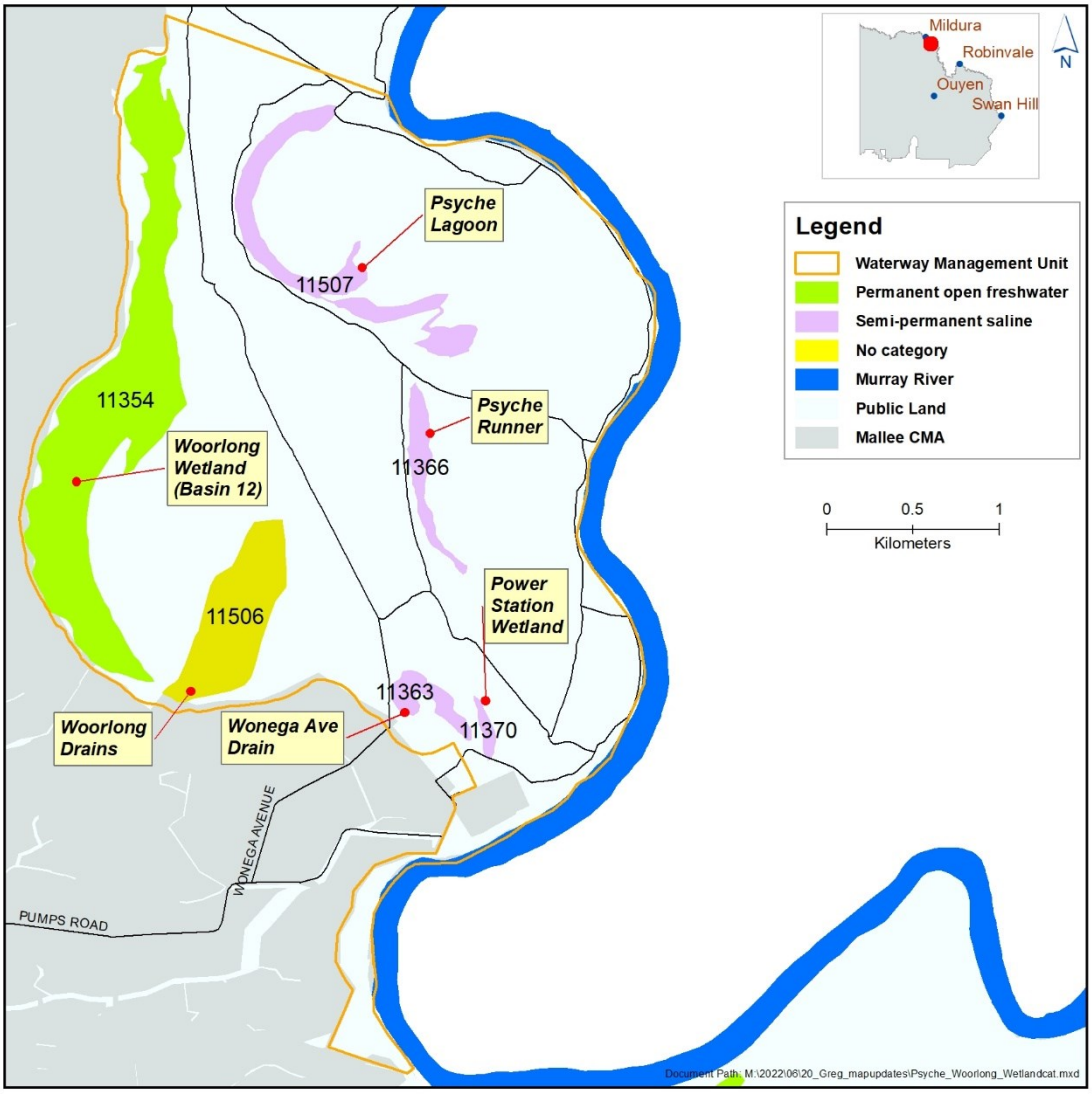


Figure 4. Psyche/Woorlong wetland types.

3.4 ENVIRONMENTAL WATER SOURCES

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

The Victorian Minister for Environment, Climate Change and Water appointed Commissioners to Victoria's first independent body for holding and managing environmental water on 1 July 2011 – The Victorian Environmental Water Holder (VEWH) is responsible for holding and managing Victoria's environmental water entitlements, and making decisions on their use.

Environmental water for the target area may be sourced from the water entitlements and their responsible agencies listed in **Table 5**. Detailed descriptions of these sources can be found in the Mallee CMA 'Regional Context Document for Environmental Water Management Plans' (North 2014).

Table 5. Summary of Environmental Water Sources available to Psyche/Woorlong

Water entitlement	Responsible agency
Bulk Entitlement (River Murray - Flora and Fauna) Conversion Order 1999	Victorian Environmental Water Holder
Environmental Entitlement (River Murray – NVIRP Stage 1) 2012	Victorian Environmental Water Holder
Commonwealth environmental water holdings	Commonwealth Environmental Water Holder
Donated Water	Victorian Environmental Water Holder

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

4 Current/Historical Hydrological Regime 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 the physical form of the wetland, 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 Psyche/Woorlong Waterway Management Unit is located on the Victorian floodplain of the Murray River (chainage 904 km to 910 km). The Mildura gauge (#425010) is located downstream of the target area.

Under natural conditions, flow is understood to have been strongly seasonal, with median daily discharge highest in spring and lowest in autumn (**Figure 5**) (Ecological Associates 2007). According to Ecological Associates (2007), prior to river regulation, floodplain inundation would have occurred more frequently than under current regulated conditions. In order to inundate low areas of floodplain and many wetlands, the flows would have needed to be 20,000 to 60,000 ML/d. These flow levels would have occurred more often and with longer duration than under the current baseline conditions (Ecological Associates 2007). This is supported by the more recent spells analysis by Gippel (2014) for natural and baseline flows downstream of Euston (**Figure 6**).

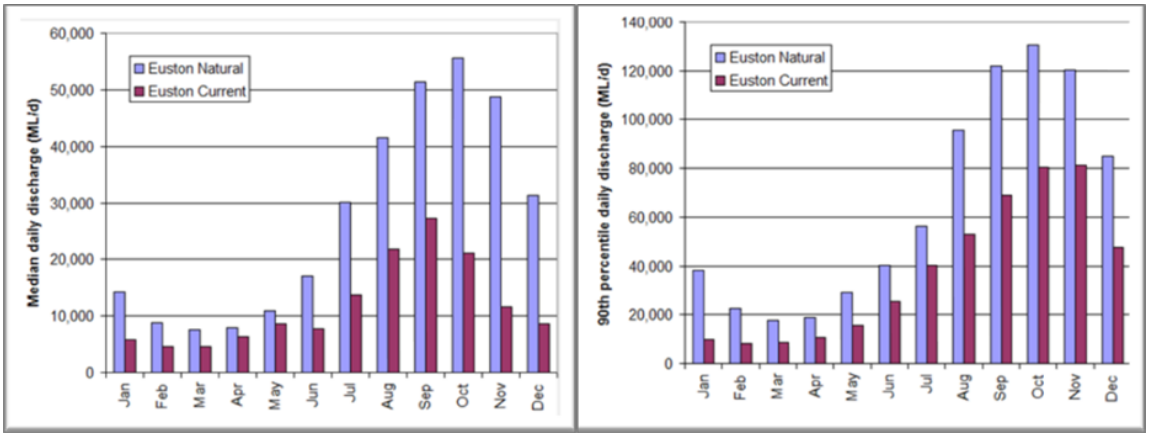


Figure 5. Distribution of median flows and 90th per centile flows for each month in the Murray River through Euston Weir for pre-regulated (natural) and regulated (current) conditions. Source: derived from MDBC MSM-Bigmod 109-year data (Ecological Associates 2007b).

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 its tributaries (Thoms et al., 2000).

The commence to flow rates for the wetlands, measured in ML/day, downstream of Euston Weir or upstream of Mildura weir for the wetlands at Psyche/Woorlong are:

- Woorlong Wetland 170,100 ML/day
- Psyche Bend Lagoon – currently at Lock 11 Weir pool height of 34.4m AHD, a regulator prevents the lagoon from connecting to the Murray River. The regulator is opened during flows of >35,000 ML/day to allow a flushing event to occur, as per the agreed Psyche Bend flushing protocols, providing that the salinity of the water discharged to the river does not exceed 25,000 EC (measured at the regulator). The regulator is overtopped at flows of >60,000 ML/day.

Spells analysis undertaken by Gippel (2014) was reviewed to better understand the frequency of inundation of Woorlong Wetland under post-regulation conditions (**Figure 6**). The percentage of years with the threshold event 170,100 ML/d from pre-regulation to post-regulation (baseline) have significantly reduced. The interval between events has also increased. This is shown in **Error! Reference source not found.**.

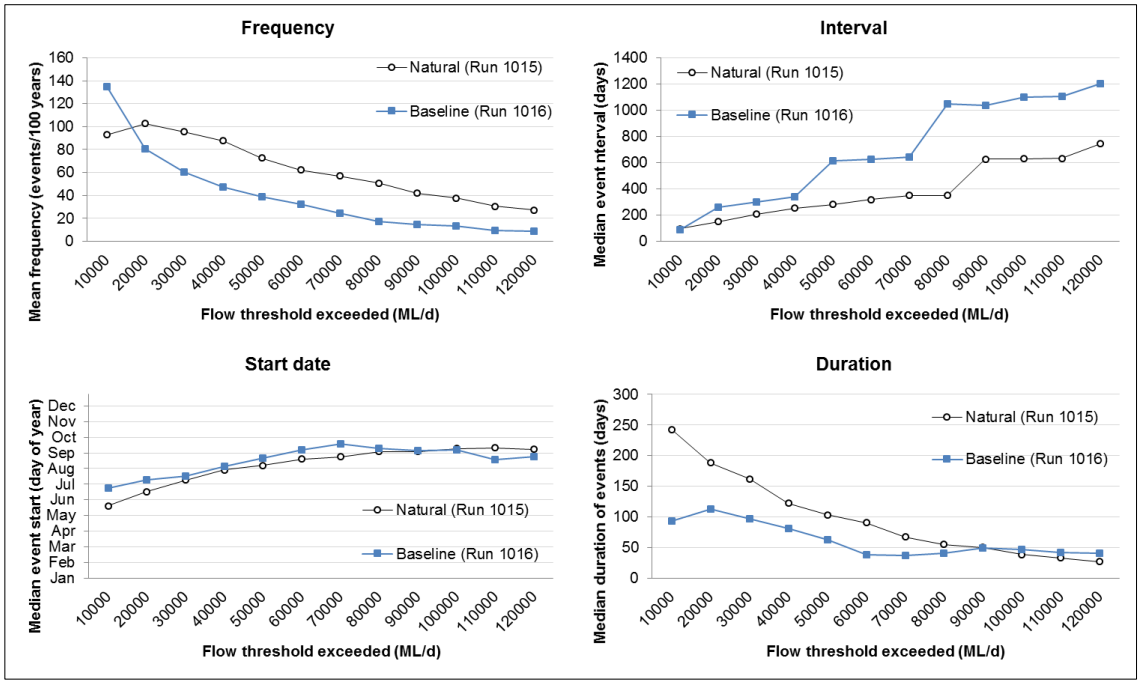


Figure 6. Comparison of statistical properties of events at Euston under the natural and baseline modelled flow scenarios, over a 114 year period (Gippel 2014)

Table 6 Modelled natural and baseline flows for a flow threshold of 170,100 ML/d downstream of Euston

Natural (N)/ Baseline (B)	Threshold ML/d	Frequency Mean (/100yrs)	Median Interval (days)	Median Duration (days)	Median Event Start date	Percentage of years with Event
N	170,100	6.1	4976	34	3rd Sept	5%
B	170,100	2.6	8136	51	31st Aug	2%

4.1 GROUNDWATER AND SALINITY INTERACTIONS

Psyche/Woorlong has been the subject of various salinity studies and management plans due to the use of these basins for irrigation drainage water disposal and saline groundwater discharge from the regional Parilla Sands Aquifer into Psyche Bend Lagoon. Investigations have also been conducted into the effect of irrigation drainage on ground water levels surrounding the wetlands.

A Preliminary Salinity Impact Assessment study (SKM 2014) was undertaken to investigate environmental watering proposals at Psyche/Woorlong. This study tested three phases of watering regimes for Psyche Bend Lagoon and Woorlong Wetlands focussing on surface water salinity processes and groundwater salinity processes as described in **Table 7**

Table 7. Scenarios considered in the salinity risk assessment for Psyche/Woorlong including major salinity processes identified for each scenario. (SKM, 2014)

Scenario	Description	Salinity Process
1	Base case (typical conditions)	Surface water process Surface salt wash Salt in surface water mobilised during draining of wetland Groundwater process Recharge of shallow saline groundwater and displacement of saline groundwater to the Murray River
2	Emptying of Psyche Bend Lagoon – Phase 1 from 34.4m AHD	Surface water process Salt mobilised during draining of wetlands to the Murray River
3	Inundation of Psyche Bend Lagoon – Phase 2 to 36m AHD	Surface water process Surface salt wash-off Salt in surface water mobilised during transit across floodplain and discharge to Murray River Groundwater process Recharge of shallow saline groundwater system and displacement of saline groundwater to Murray River
4	Inundation of Psyche Bend Lagoon – Phase 3 to 36m AHD	Surface water process Surface salt wash-off Salt in surface water mobilised during transit across floodplain No discharge to the Murray River and surface water held in Psyche Bend Lagoon– evaporative loss Groundwater process Recharge of shallow saline groundwater system and displacement of saline groundwater to Murray River

5	Inundation of Woorlong Wetlands – Phase 1, to 37.1m AHD Surface water process	Surface water process Surface salt wash-off Salt mobilised during draining of wetlands No discharge to Psyche Bend Lagoon and surface water held in Woorlong Wetlands Groundwater process Recharge of shallow saline groundwater system and displacement of saline groundwater to Murray River
6	Inundation of Woorlong Wetlands – Phase 2, to 37.5m AHD	Surface water process Surface salt wash-off Salt in surface water mobilised during draining of wetlands and discharge to Psyche Bend Lagoon Groundwater process Recharge of shallow saline groundwater system and displacement of saline groundwater to Murray River
7	Inundation of Woorlong Wetlands – Phase 3, to 37.5m AHD	Surface water process Surface salt wash-off Salt in surface water mobilised during draining of wetlands and discharge to Psyche Bend Lagoon Groundwater process Recharge of shallow saline groundwater system and displacement of saline groundwater to Murray River
8	Discharge of salt from Psyche Bend lagoon into River @ 7,000 ML/day flow	Surface water process Direct discharge to river
9	Discharge of salt from Psyche Bend lagoon into River @ 13,000 ML/day flow	Surface water process Direct discharge to river

This preliminary investigation estimated that the salinity impacts at Morgan, due to environmental watering scenarios at these sites, to be between 0.01 EC and 0.2 EC (SKM 2014). This is presented in Table 8.

According to the MDBA Basin Salinity Management Strategy (BSMS) Operational Protocols; a significant effect is a change in the average daily salinity at Morgan of at least 0.1 EC over a 100 year timeframe. This protocol is incorporated into a salinity strategy with an indicative target of keeping river salinity at Morgan, South

Australia, below the 800 EC thresholds at least 95 per cent of the time. The BSMS requires that any action that increases river salinity (debit) in the Murray River to be offset by an action that removes the equivalent amount of salt from the river (Aquaterra 2010).

Table 8. Summary of preliminary estimates of salinity impacts (shaded cells indicate estimated impact >0.1EC at Morgan) (SKM, 2014)

Location	Inundation area	Local EC impact	EC impact at Morgan	Location	Inundation area
Psyche Bend Lagoon	Scenario 1	NA	Negligible	NA	EC impacts at Morgan are derived from groundwater-related processes
	Scenario 2	NA	0.02	NA	
	Scenario 3	NA	0.02	NA	
Psyche Bend Lagoon	Scenario 4	NA	0.006	NA	
	Scenario 5	NA	0.01	NA	
	Scenario 6	NA	0.06	NA	
Murray River Flows	Scenario 7	35.6 for Phase 1, 8.5 for Phase 2 (constant flow conditions in Murray River)	0.4 for Phase 1 and 0.1 for Phase 2	0.4 for Phase 1 and 0.1 for Phase 2	Based on discharges from Psyche Bend Lagoon of 5 ML/d in Phase 1 and 20 ML/d in Phase 2, no discharge from Woorlong Wetland and well mixed conditions in the Murray River
	Scenario 8	19.2 for Phase 1, 4.6 for Phase 2 (constant flow conditions in Murray River)	0.4 for Phase 1 and 0.1 for Phase 2	0.4 for Phase 1 and 0.1 for Phase 2	
	Scenario 9	12.5 for Phase 1, 3.0 for Phase 2 (constant flow conditions in Murray River)	0.4 for Phase 1 and 0.1 for Phase 2	0.4 for Phase 1 and 0.1 for Phase 2	

Notes:

1. The proposed environmental watering regimes used in this preliminary salinity assessment were designed to provide an indication of the greatest impact for selected sites or worst case scenario. This information will be used to inform future decisions regarding operational frequency, duration and extent of inundation for the environmental watering activities at each of these sites and will differ from those described within this report.
2. Conservatism has been built into the preliminary estimates of salinity impact to address areas of uncertainty. These numbers must only be used in conjunction with the assumptions and limitation that underpin the calculations.
3. These preliminary estimates do not account for the implementation of mitigation strategies that may reduce the magnitude of the salinity impact.
4. The preliminary estimates have been calculated using an analytical approach and available data. The quantum of salinity impact described in this report is likely to change when the Basin Plan modelling tool is applied.

As the salinity impacts of the proposed watering actions at Psyche/Woorlong exceed 0.1 EC at Morgan they are therefore considered an accountable action under the BSMS strategy. This identifies the need for an additional salinity impact assessment to be conducted.

In April 2014, watering occurred at Psyche/Woorlong, but this time water was held in the wetland followed by managed discharge to the Murray River in August 2014, 3 months after inundation. Through consultation with discharge operations groups the discharge event was actively managed to maintain Murray River salinity within acceptable salinity targets (locally for the Lower Murray Water off-take as well as Basin Plan targets). (CDM Smith 2014).

The aim of this flushing event was to:

- reduce salt loads from the wetlands;
- improve the health of the wetlands and floodplain vegetation;
- provide habitat, feeding and breeding opportunities for fauna; and
- increase the abundance, distribution and diversity of native wetland species in the study area.

During this event the mass of salt exported during discharge was monitored and indicated that the river salinity was maintained within or below the 200—to 300 EC (µS/cm) threshold that was set by Lower Murray Water. The mass of salt stored within Psyche Bend Lagoon following the discharge increased from 3,843 tonnes to 4,967 tonnes (**Table 9**), due to the mixing of layers within the waterbody.

Table 9. Summary of salt store in Psyche Bend Lagoon

Salinity survey date	Psyche Bend Lagoon water elevation (mAHD)	Salt store (tonnes)
2 July 2014	35.5	3,358
30 July 2014	34.3	730
7 August 2014	34.6	3,843
8 October 2014	35	4,967

This indicates that implementing an environmental watering program through regular managed flushing events reduces the risk of salinity spikes during high natural flows.

The conceptualisation shown in **Error! Reference source not found.** (CDM Smith, 2 014) describes the salt mobilisation processes, pre-discharge conditions, and post-discharge conditions for the 2014 discharge event.

Coinciding with the inundation of Psyche Ben Lagoon, 353ML of water was pumped into Woorlong Wetland. The aim of this environmental watering was to reduce the salt levels in the wetland and improve the health of the surrounding vegetation.

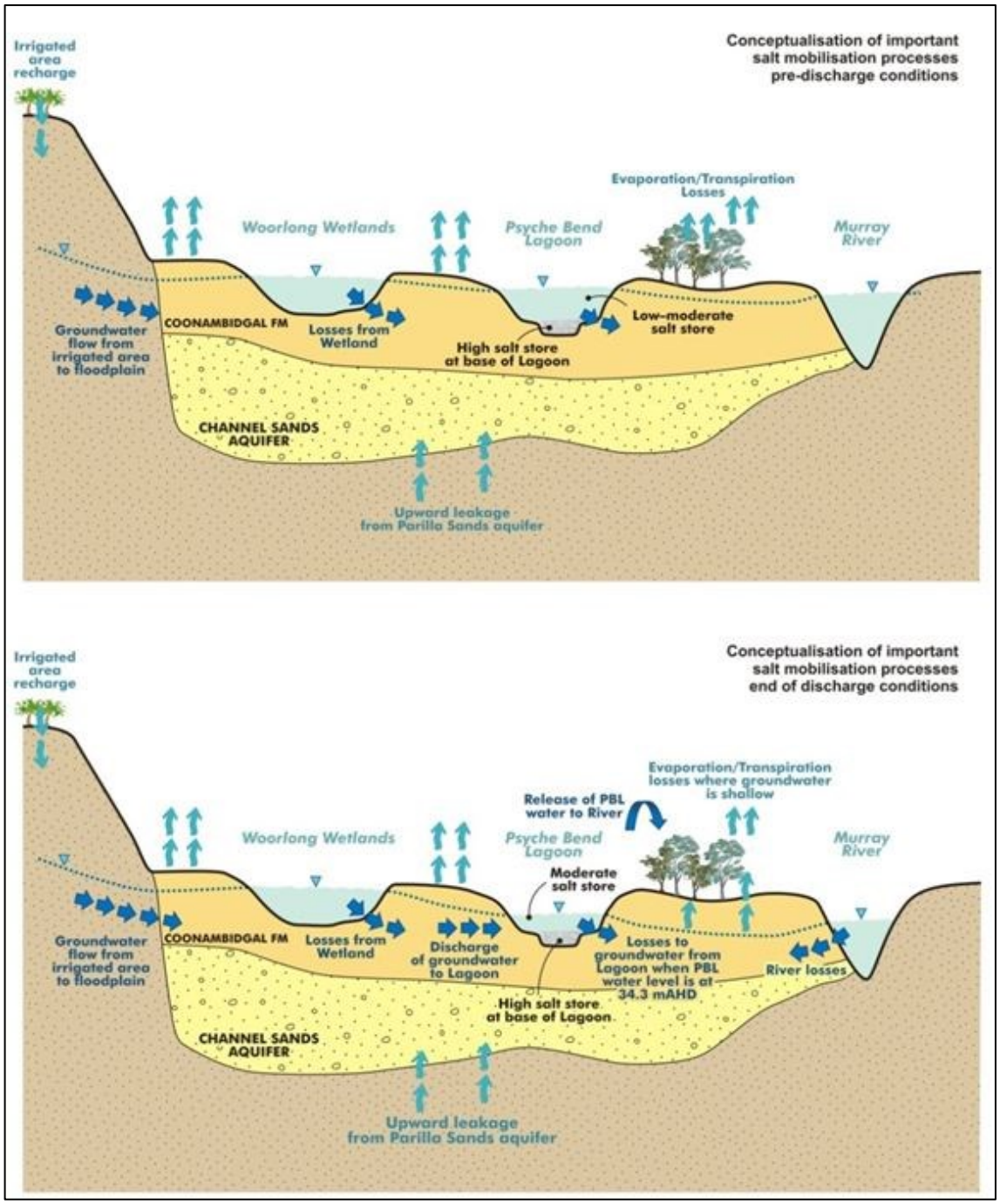


Figure 7. Conceptualisation of important salt mobilisation processes pre-discharge and post-discharge conditions at Psyche Bend Lagoon (CDM Smith, 2014).

4.2 ENVIRONMENTAL WATERING

Management intervention began at Psyche/Woorlong with salt flushing events in summer 2010/11, autumn 2012 and spring 2012 to reduce salt loads from Psyche Bend Lagoon. This was undertaken in accordance with agreed protocols requiring river flows of greater than 35,000 ML/day. When 35,000 ML/day is achieved, the gates connecting Psyche Bend Lagoon with Woorlong Wetland and the Murray River are opened to allow inflow (RPS Aquaterra 2013). Analysis of data from the flushing events showed a correlation between the frequency of flushing events and a

reduction in salt loads. In one year between the April 2011 and March 2012 events, salt loads increased significantly, due to the mixing of the stratified waterbody, spreading the bottom hypersaline layer throughout the water column. Whereas two flushing events within five months of each other (May and October 2012) reduced salt loads by half. Refer to Table 10 and Table 11.

Table 10. Salt load trends for the flushing surveys

Survey Date	Lagoon Elevation (mAHD)	SKM		RPS Aquaterra	
		Salt Load Estimate (tonnes)	Volume in Store (ML)	Salt Load Estimate (tonnes)	Volume in Store (ML)
January 2011 (mid-event survey)	36.15	8,070**	990	8,701*	1,115
April 2011 (post flushing survey)	35.27	5,670	315	6,981*	335
March 2012 (Pre-flushing survey)	34.45	5,244	-	7,468*	110
May 2012 (post flushing survey)	34.8	3,709	110	5,219*	189
October 2012 (post flushing survey)	34.77	-	-	4,363	183

*Recalculation using RPS hypsographic model and salt concentration survey data from MCMA and LMW.

**Calculated as pre-flush salt load of 7950 t, plus 120 tonnes of salt introduced from Murray River (SKM, 2011)

Table 11. Salt loads exported for each flushing event

Flushing Event	Flushing Dates	Duration (days)	Estimated salt load exported (tonnes)
Summer 2010/11	17 December 2010 – 4 April 2011	110	1,720
Autumn 2012	29 March 2012 – 15 May 2012	48	2,249
Spring 2012	24 August 2012 – 9 October 2012	47	856
		Total	4,825

5 Water Dependant Values

Wetlands and waterways on the floodplain are a vital component of the landscape and support flora and fauna which vary 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.

Psyche/Woorlong provides a range of shelter and food resources for indigenous fauna, flora and vegetation communities. The types of habitat provided, and consequently the species that utilise the site, change as water fills the wetlands, creek and floodplain and recedes again.

5.1 ENVIRONMENTAL VALUES

5.1.1 Ecosystem type

Victoria's wetlands were mapped 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 ground truthing. This database is commonly known as the 1994 wetland layer.

During this mapping, 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 therefore been possible to estimate the depletion of wetland types across the state using the primary category only, based on a comparison of wetland extent between the 1788 and 1994 wetland layers (Table 12).

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

Corrick category (Current)	No of wetlands in target area	Total area (ha)	Percentage change in wetland area from 1788 to 1994		
			Change in Victoria	Change in Mallee CMA	Change in Robinvale Plains Bioregion
Permanent Open Freshwater	1	115.91	-6%	+5%	-1%
Semi-permanent Saline	2	37.08	-7	+9	+100

The 1788 and 1994 wetland layers have since been updated. The Victorian Wetland Inventory (Pre-European) layer shows the estimated extent of wetlands in Victoria prior to European settlement, with the most recent update in 2021. The Victorian Wetland Inventory (Current) layer shows the extent and types of wetlands currently in Victoria, with the most recent update in 2021.

The Psyche/Woorlong contains six wetlands, four of which are in the target area. These wetlands have been classified using the Corrick-Norman wetland classification system as Permanent Open Freshwater and Semi-permanent Saline (Table 13). There has been a small decrease in the Permanent Open Freshwater wetland types in the Robinvale Plains Bioregion (Table 12). Semi-permanent Saline wetlands are now the most common type of wetland in the Mallee CMA region. These wetlands have increased in number and area since European settlement due

to river regulation, clearing of native vegetation and the use of low-lying areas for saline irrigation drainage (MCMA 2006). This pattern is reflected at Psyche/Woorlong with a review of wetland mapping data on MapshareVic (DELWP 2022) indicating that there has been an increase in the number and area of Semi-permanent Saline wetlands since European settlement (Table 13). The data indicates that two of the four wetlands in the target area have changed from a freshwater wetland type to Semi-permanent Saline wetlands.

The wetland mapping data also indicates that there has been a decline in wetland extent since European Settlement. The data indicates that the three wetlands in the target area that are mapped in the pre-European wetland layer have all declined in size since European settlement (Table 13).

Table 13. Changes in area of the wetlands in the target area by Corrick classification Source: DELWP MapshareVic, Mallee Wetland Strategy.

Wetland name	Corrick category (Pre - European)	Corrick category (Current)	Total area (ha)		Percentage change in wetland area (Pre-European to Current)
			Current	Pre-European	
Woorlong Wetland (Basin 12)	Permanent open freshwater	Permanent Open Freshwater	115.91	185.89	-38%
Woorlong Drains	No category	No category	37.39	Not mapped	N/A
Psyche Bend Lagoon	Permanent open freshwater	Semi-permanent Saline	29.98	41.12	-27%
Wonega Ave Drain	Deep Freshwater Marsh	Semi-permanent Saline	7.17	12.47	-42%

5.1.2 Flora and Fauna Values

Ecological Vegetation Classes

Psyche/Woorlong is positioned close to the western end of the Robinvale Plains bioregion, and close to the boundary with the Murray Mallee bioregion.

Within the target area of Psyche/Woorlong are a range of water dependent Ecological Vegetation Classes (EVCs) as shown in Figure 8. The conservation status of each of the represented EVCs is shown in Table 14**Error! Reference source not found.**. The three most extensive EVCs are dominated by Lignum (*Duma* spp.); (#104) Lignum Swamp, (#823) Lignum Swampy Woodland and Lignum Shrubland (#808). These EVC's are listed as vulnerable, depleted and least concern, respectively, within the Robinvale Plains bioregion.

Table 14. Ecological Vegetation Classes modelled as present within the Psyche/Woorlong target area

EVC no.	EVC name	Area modelled as present within target area (ha)	Bioregional conservation status
813	Intermittent Swampy Woodland	0.98	Depleted
808	Lignum Shrubland	67.77	Least Concern
104	Lignum Swamp	40.32	Vulnerable
823	Lignum Swampy Woodland	128.73	Depleted
102	Low Chenopod Shrubland	0.18	Depleted
103	Riverine Chenopod Woodland	32.96	Depleted
819	Spike-sedge Wetland	18.04	Vulnerable
821	Tall Marsh	0.84	Depleted

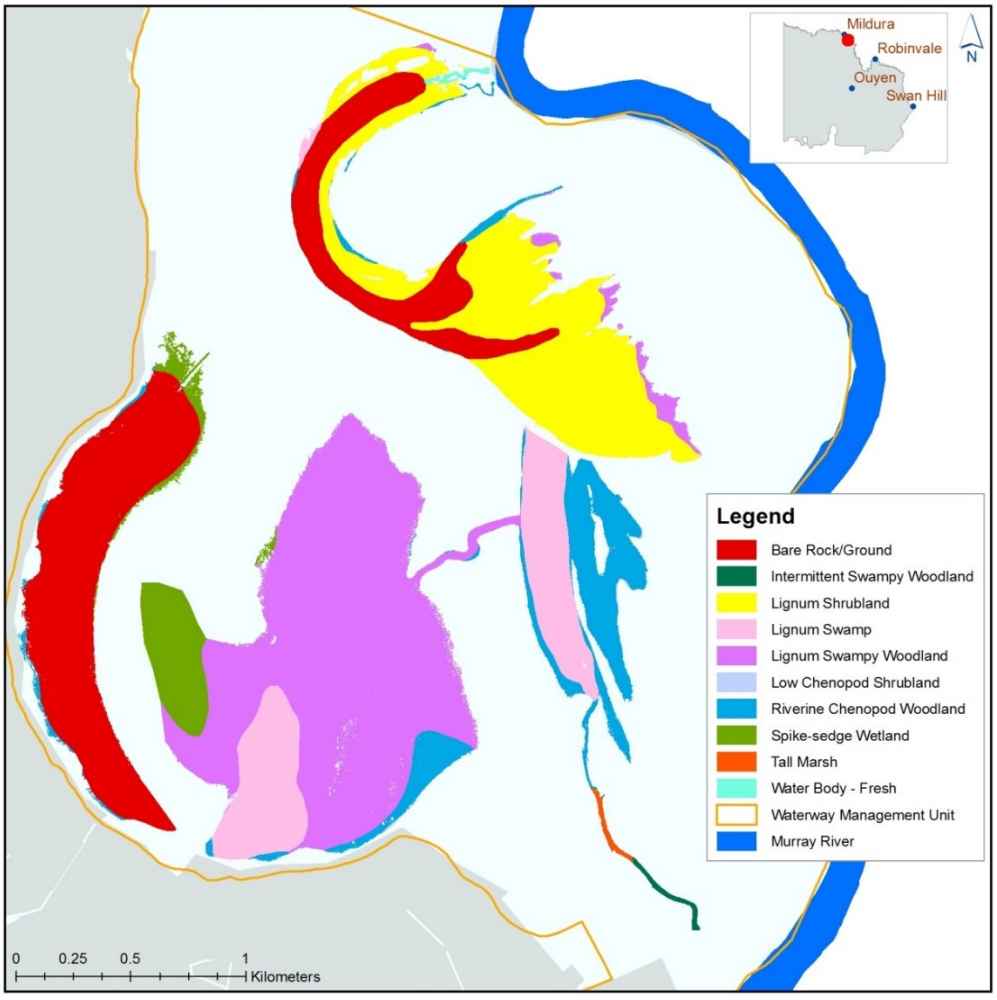


Figure 8. Ecological Vegetation Classes present in the Psyche/Woorlong target area.

Lignum Shrubland occurs around the edges of Psyche Lagoon at slightly higher elevations than the wetland bed. This EVC would experience a flooding frequency of one event every four to ten years under natural conditions, with a critical interval of 15 years between events (VEAC 2008). Ponding of two to four months is required to sustain plants, but continuous flooding is not tolerated.

A large area of Lignum Swampy Woodland occurs in the eastern lobe of Woorlong Wetland (Woorlong Drains #11506), along with a smaller area of Lignum Swamp. Lignum Swampy Woodland also supports stands for River Red Gum (*Eucalyptus camaldulensis*) and Black Box (*Eucalyptus largiflorens*). At Psyche Lagoon these EVC's are found at slightly higher elevations than the wetland bed. These EVC's would have experienced more frequent flooding under natural conditions of approximately one event every two to eight years. For these EVC's there is a critical interval of 15 years between flood events and ponding duration of two to six months. As Lignum does not respond well to prolonged inundation it is important to note that the proposal to keep water in Woorlong Wetland on a more permanent basis does not apply to this eastern lobe. Instead, this ponding would occur in the western lobe in the wetland bed covered by Bare Rock/Ground EVC (Figure 8).

For further detail of these and other the EVCs within the target area see Appendix 2.

Water-dependant fauna

Psyche Bend Lagoon and the Woorlong Wetland are located within the Kings Billabong Park, an area that provides habitat for a large range of fauna. The Kings Billabong Park was previously classified as a Wildlife Reserve and is recognised as a significant conservation area. The list of species recorded at Kings Billabong Park includes five species of frogs (three of which have been recorded at Psyche/Woorlong) including the FFG and EPBC listed Growling Grass Frog (*Litoria raniformis*) as well as seventeen reptile species including all three species of turtles that occur in the region (SKM 2002). Of special interest and responsibility are the water dependent species listed in legislation, agreements or conventions (Table 15). A full list of all fauna recorded at Kings Billabong Park, which may be found at Psyche/Woorlong is provided in Appendix 1.

Table 15. Listed water-dependant fauna recorded at the Kings Billabong Park.

Common name	Scientific name	Type	International agreements	EPBC status	Victorian Status - FFG
Australasian Shoveler	*Anas rhynchotis*	B	-	-	VU
Plumed Egret	*Ardea intermedia plumifera*	B	-	-	CE
Eastern Great Egret	*Ardea alba modesta*	B	JAMBA CAMBA	-	VU
Hardhead	*Aythya australis*	B	-	-	VU
Silver Perch	*Bidyanus bidyanus*	F	-	CE	EN
Musk Duck	*Biziura lobata*	B	-	-	VU
Bush Stone-curlew	*Burhinus grallarius*	B	-	-	CE
Curlew Sandpiper	*Calidris ferruginea*	B	Bonn, CAMBA,	CE	CE
Broad-shelled Turtle	*Chelodina expansa*	R		-	EN
Little Egret	*Egretta garzetta nigripes*	B	-	-	EN

Common name	Scientific name	Type	International agreements	EPBC status	Victorian Status - FFG
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	B	CAMBA	-	EN
Caspian Tern	*Hydroprogne caspia*	B	CAMBA	-	VU
Australian Little Bittern	*Ixobrychus dubius*	B	-	-	EN
Growling Grass Frog	*Litoria raniformis*	A	-	VU	VU
Murray River Rainbowfish	*Melanotaenia fluviatilis*	F	-	-	EN
Carpet Python*	*Morelia spilota metcalfei*	R	-	-	EN
Blue-billed Duck	*Oxyura australis*	B	-	-	VU
Regent Parrot*	*Polytelis anthopeplus monarchoides*	B	-	VU	VU
Freckled Duck	*Stictonetta naevosa*	B	-	-	EN
Freshwater Catfish	*Tandanus tandanus*	F	-	-	EN
Legend: EPBC threatened status/Victorian Status - FFG: VU = Vulnerable, EN = Endangered, CE = Critically Endangered, T = Threatened, EX = Extinct					

**indirectly water dependent*

Of the 20 listed water dependant species recorded at Kings Billabong Park, the Carpet Python (*Morelia spilota metcalfei*) and the Regent Parrot (*Polytelis anthopeplus monarchoides*) are considered indirectly water dependent as they require riparian trees for shelter and nesting. The remaining species are directly dependent on water due to food, shelter or breeding requirements.

The current degraded state of vegetation surrounding the Psyche/Woorlong target area may limit the occurrence of some of these species in the southern half of Kings Billabong Park. Evidence from previous salt flushing/environmental watering events indicates that by implementing a more regular salt flushing/environmental watering regime will lead to an increase in vegetation health and improved habitat values for the diverse range of flora and fauna recorded in the park.

Flora

Water dependent flora species listed in the various Acts and agreements which have been recorded in the Kings Billabong Park and may be found in Psyche/Woorlong are listed in Table 16. An appropriate environmental water program will ensure the maintenance of these species and their associated EVCs, protecting these listed species as well as the wide range of water dependent flora in the target area. A full list of flora recorded at the site can be found in Appendix 1.

Table 16. Listed water dependent flora species recorded at the Kings Billabong Park.

Common Name	Scientific Name	EPBC threatened status	Victorian status FFG
Jerry-jerry	*Ammannia multiflora*		EN
Small Water-fire	*Bergia trimera*		EN
Billabong Daisy	*Brachyscome gracilis subsp. robusta*		CE

Common Name	Scientific Name	EPBC threatened status	Victorian status FFG
Lax Flat-sedge	*Cyperus flaccidus*		EN
Curly Flat-sedge	*Cyperus rigidellus*		T
Bearded Flat-sedge	*Cyperus squarrosus*		EX
Riverine Flax-lily	*Dianella porracea*		CE
Twin-flower Saltbush	*Dissocarpus biflorus var. biflorus*		CE
Cane Grass	*Eragrostis australasica*		CE
Purple Love-grass	*Eragrostis lacunaria*		EN
Bristly Love-grass	*Eragrostis setifolia*		EN
Spreading Emu-bush	*Eremophila divaricata subsp. divaricata*		VU
Spotted Emu-bush	*Eremophila maculata subsp. maculata*		CE
Veiled Fringe-sedge	*Fimbristylis velata*		EN
Hydrilla	*Hydrilla verticillata*		VU
Veined Peppercress	*Lepidium phlebopetalum*		EN
Goat Head	*Malacocera tricornis*		VU
Bush Minuria	*Minuria cunninghamii*		VU
Smooth Minuria	*Minuria integerrima*		VU
Water Nymph	*Najas tenuifolia*		EN
Long Tails	*Ptilotus polystachyus*		EN
Pin Sida	*Sida fibulifera*		EN
Legend: EPBC threatened status/Victorian Status - FFG: VU = Vulnerable, EN = Endangered, CE = Critically Endangered, T = Threatened, EX = Extinct			

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). Wetland birds that breed over water, such as Egrets, use flooded Lignum shrublands for resting and Blue-billed and Freckled Ducks nest on Lignum. Considering the large area of Lignum dominated EVC's within the target area (Table 14) the potential for environmental watering to restore valuable habitat is high.

Aquatic macrophytes, including floating, submerged and emergent, such as submerged Salt tolerant Ruppia species are present at Psyche Lagoon and are important to the ecosystem. These plants are rooted to the wetland floor with their canopies floating on top of, very near, or well below 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 including the Murray Hardyhead (Ecological Associates 2007b). Aquatic macrophytes are highly productive wetland habitats also providing shelter for macro-invertebrates and dabbling ducks such as the FFG listed Freckled Duck (*Stictonetta naevosa*) that graze on this vegetation and the macro-invertebrates within it (Ecological Associates 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 (Ecological Associates 2007b). Ellis (2013, pers. comm. 11th Dec) suggests that a gradual drawdown in water level may be required for Ruppia re-establishment and found the abundance of zooplankton increased in wetlands which underwent drawdown phases. Brock (1981) states that the drying of seeds and substrate

during a drawdown is likely to break seed coating and make seeds more permeable to water on rewetting of the wetland.

5.1 SHARED BENEFITS

Kings Billabong Park is located close to Mildura and is popular for many community activities including bushwalking, camping, four-wheel driving, bird watching, canoeing, and fishing. Kings Billabong Park also has significant Indigenous and European cultural heritage values. These values are closely linked with the ecological values that are protected and enhanced by environmental watering. No new water-dependent values were identified by respondents in the 2023 Psyche/Woorlong community values survey.

The primary use of Psyche/Woorlong is for irrigation drainage disposal and the site plays an important role in the region's salinity management strategy. This will remain the primary use for the site into the future and any environmental watering undertaken at the site must ensure that salinity management strategies are not compromised. However, opportunities to protect the environmental values and improve conditions may be provided through environmental watering at the site, while implementing management measures to decrease and/or mitigate salinity management risks.

5.2 TRADITIONAL OWNER CULTURAL VALUES

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

In Indigenous culture, water is inseparable from the land, air, plants and animals. Caring for, and healing, Country is an inherited cultural obligation that is reliant upon having water in the landscape in the right place, at the right time of year. Water creates and sustains life, and is a living and cultural entity that connects Traditional Owners to Ancestors, Country, cultural practice and identity.

Within the Mallee CMA region, the Murray River and its associated waterways continue to be culturally significant habitation areas for many Aboriginal groups. The high number of Indigenous cultural heritage sites throughout the Murray floodplain is unique in Victoria because of their concentration and diversity. It is typical to find high densities of identified Indigenous cultural heritage sites located around, or close to, freshwater sources.

Kings Billabong Park is an important cultural site for the local Indigenous people. Earth features, shell deposits, scar trees and burial sites have been documented and records are held by Aboriginal Affairs Victoria (Parks Vic 2008). As is the case for most of the Murray River floodplain and beyond, it is recognised that waterways and floodplains are highly significant in Aboriginal culture, but the true extent of the number and types of sites present is still unknown.

The Aboriginal Heritage Regulations 2018 define "areas of cultural heritage sensitivity" which include land within 200 m of named waterways and land within 50 m of registered Aboriginal cultural heritage places. A review of the Aboriginal Cultural Heritage Register and Information System (ACHRIS) confirms that the entire Kings Billabong park (which includes Psyche Bend Lagoon and Woorlong Wetland) is defined as an area of cultural heritage sensitivity. A contingency plan

(Appendix 3) is in place should any further evidence of cultural heritage sites be discovered during site visits or works.

The current Registered Aboriginal Party (RAP) for the area is the First People of the Millewa-Mallee Aboriginal Corporation (FPMMAC). Their Action Plan and Country and Water Plan "seek to repair the natural environment and our people's place in the environment" (Mallee CMA, 2022). The Mallee CMA have engaged with the FPMMAC about this EWMP, and are committed to working with FPMMAC to ensure that tangible and intangible Aboriginal culture and heritage is protected, and that Traditional Owner led practices are imbedded in the management and healing of Country (Mallee CMA, 2022).

5.3 RECREATIONAL VALUES

The Kings Billabong Park is close to Mildura and is popular for swimming, camping, fishing, boating, canoeing, kayaking, four wheel driving, picnics, barbeques, trail bike riding, horse riding and walking, and these uses will continue in the park. The park contains numerous walking/cycling trails and recreational facilities. An all-abilities canoe launching ramp at Psyche Pumps provides access to Psyche Creek and Kings Billabong (Parks Victoria, 2018). The Park is also popular for wildlife and bird watching, with a bird hide overlooking Kings Billabong.

5.4 CURRENT CONDITION

One method for assessing the current condition of a wetland is the Index of Wetland Condition (IWC) developed by DELWP. 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 Woorlong Wetland was assessed in December 2009.

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

The overall IWC score for Woorlong Wetland assessed in December 2009 was 6 out of 10, which is considered to be moderate (Table 17).

Table 17 - IWC sub index and overall scores for Woorlong Wetland

Wetland Name	Wetland Catchment	Physical Form	Hydrology	Water Properties	Soils	Biota (Vegetation)	Overall IWC Category
Woorlong Wetland (Basin 12)	Moderate	Excellent	Moderate	Moderate	Excellent	Very Poor	Moderate

Although the Woorlong Wetland scored moderate to excellent for most sub-indexes, the effects of salinity on the wetland and floodplain landscape are best reflected in the biota (vegetation) sub-index score of 'very poor'.

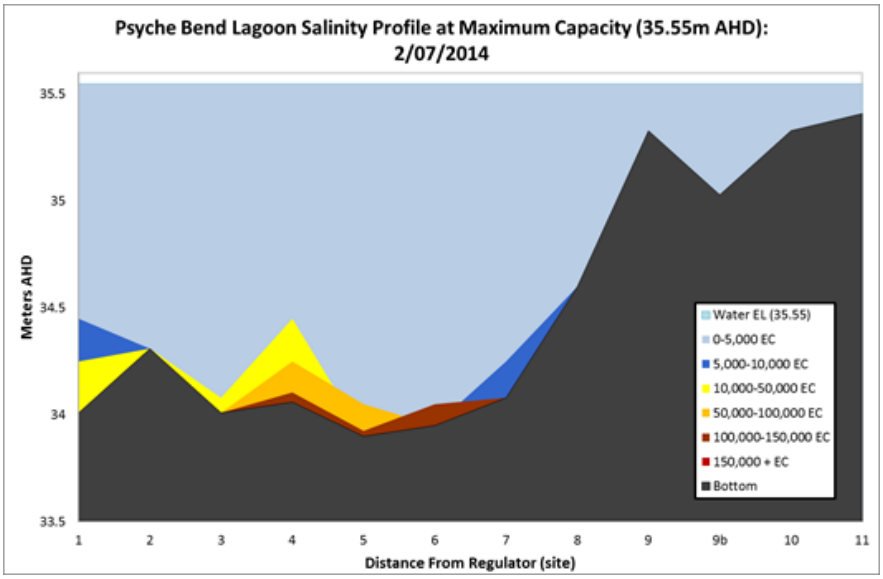
The altered water regime is considered the major threat for the target area and is the primary factor behind the development of this environmental water management plan.

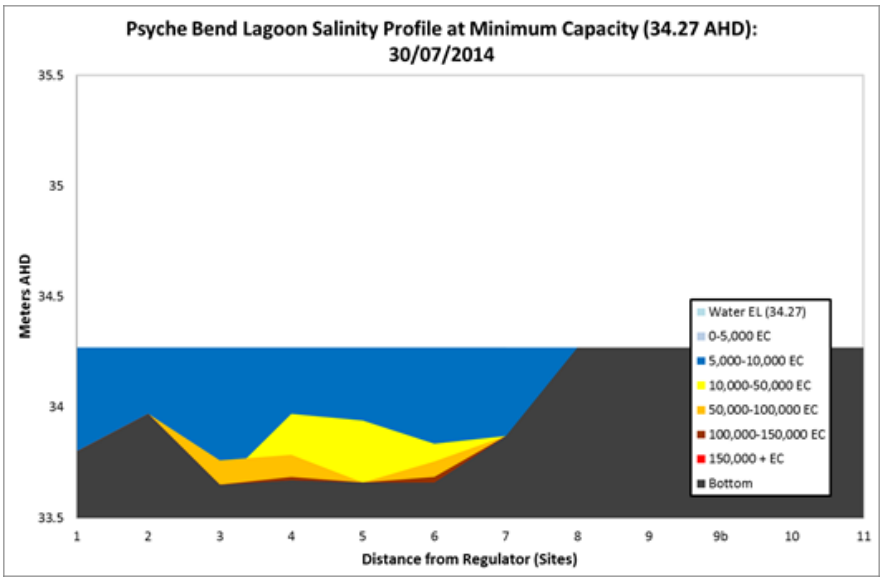
Salinity and water quality

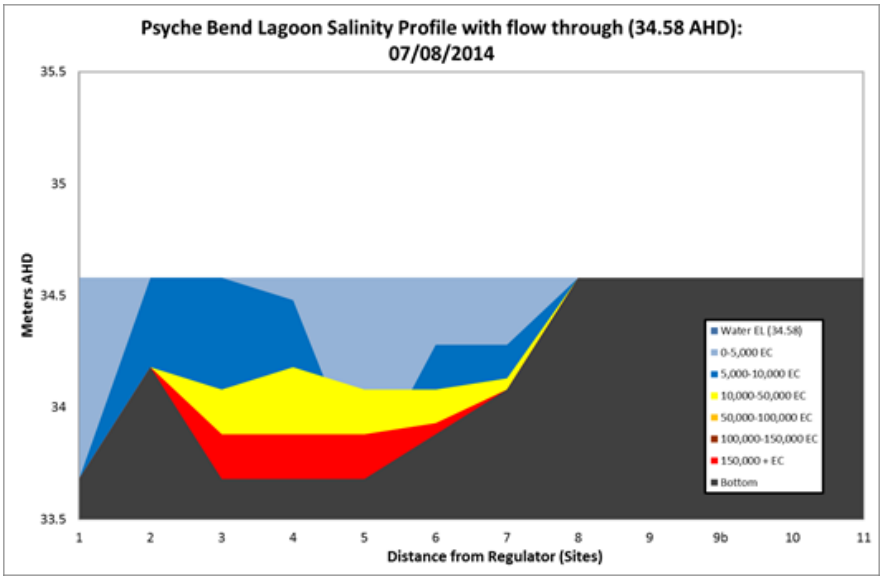
Psyche Bend Lagoon is an important component in the region's salinity management strategy and has been equipped with several monitoring sites including gauging boards for water elevation and telemetry monitors for measuring electrical conductivity (EC) and salinity data to support salinity accounting (**Error! R eference source not found.**).

Figure 9. Telemetry monitor at Psyche Bend Lagoon

Water quality data collected by the Mallee CMA has indicated that Psyche Bend Lagoon is subject to stratification of the water column, meaning that denser saltier water sits at the bottom due to hydrostatic pressure, and fresher water sits on top. Figure 10 demonstrates the presence of stratification at Psyche Bend Lagoon showing that salinities of 100,000 - 150,000 EC exist at the bottom of the water column throughout the environmental watering/flushing event. One month following the event, evidence of stratification remains.


Psyche Bend Lagoon Salinity Profile at Maximum Capacity (35.55m AHD): 2/07/2014
Meters AHD
35.5
35
34.5
34
33.5
1
2
3
4
5
6
7
8
9
9b
10
11
Distance From Regulator (site)
Water EL (35.55)
0-5,000 EC
5,000-10,000 EC
10,000-50,000 EC
50,000-100,000 EC
100,000-150,000 EC
150,000 + EC
Bottom


Psyche Bend Lagoon Salinity Profile at Minimum Capacity (34.27 AHD): 30/07/2014
Meters AHD
35.5
35
34.5
34
33.5
1
2
3
4
5
6
7
8
9
9b
10
11
Distance from Regulator (Sites)
Water EL (34.27)
0-5,000 EC
5,000-10,000 EC
10,000-50,000 EC
50,000-100,000 EC
100,000-150,000 EC
150,000 + EC
Bottom


Psyche Bend Lagoon Salinity Profile with flow through (34.58 AHD): 07/08/2014
Meters AHD
35.5
35
34.5
34
33.5
1
2
3
4
5
6
7
8
9
9b
10
11
Distance from Regulator (Sites)
Water EL (34.58)
0-5,000 EC
5,000-10,000 EC
10,000-50,000 EC
50,000-100,000 EC
100,000-150,000 EC
150,000 + EC
Bottom

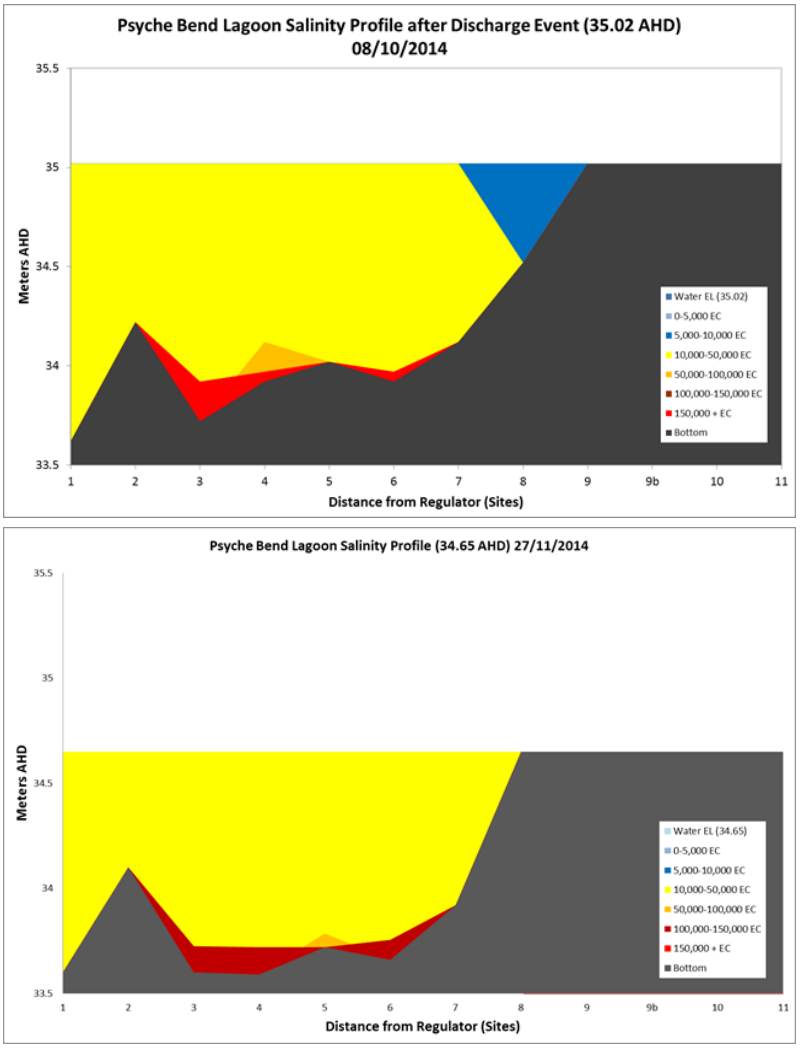


Figure 10 – Salinity long sections within the Psyche Bend Lagoon during and post an environmental watering/flushing event undertaken in 2014.

A study on groundwater in the vicinity of Psyche Bend Lagoon was undertaken during January 2014 (Macumber 2014). This study identified the presence of the algae (Dunaliella salina) which concentrates β-carotene and is found in hyper-saline lakes and evaporation basin across northern Victoria. This study examined the hydrogeology and salinity within groundwater bores in order to examine the relationship between salinity and groundwater interactions within the lagoon.

Bore data indicates that in the vicinity of Psyche Bend lagoon the trench sediments are in direct connection with the regional saline Parilla Sand aquifer (Figure 10) with no aquitard present. Hydrograph data indicates a significant upwards hydraulic gradient between the deeper saline Parilla Sand aquifer and the shallow Channel Sand aquifer within the lagoon.

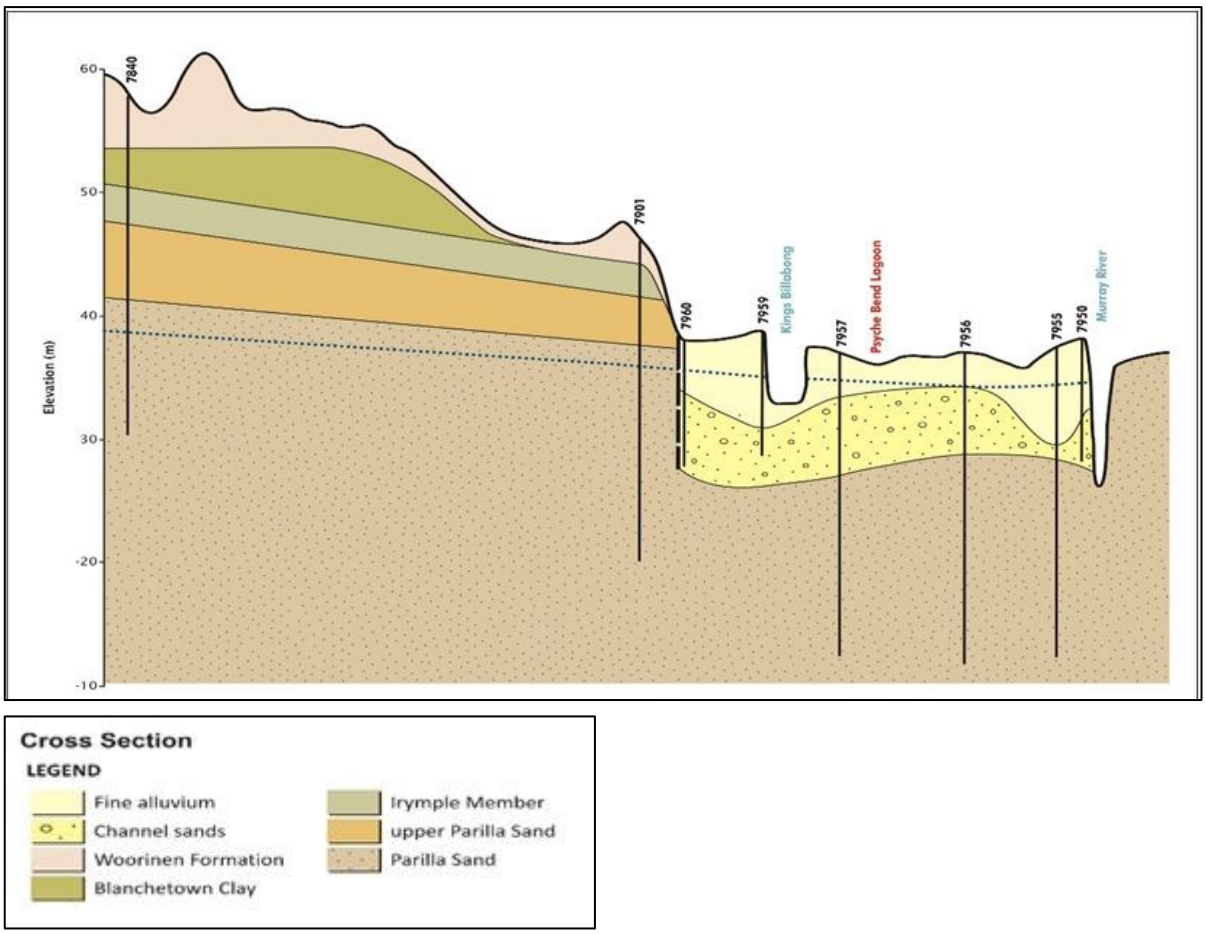


Figure 11 – Stratigraphic Cross Section through Psyche Bend Lagoon and the Woorlong Wetland (Thorne et al., 1990)

Macumber (2014) suggested two options to reduce salinity in Psyche Bend Lagoon:

- Surface water flushing to be carried out opportunistically during flood times or whenever surface water is available for such purposes.
- Loading of the lagoon to appropriate levels to enable downwards flushing into the aquifer, without requiring flushing into the downstream surface system. The levels of loading must be sufficient to reverse the present upwards directed groundwater gradient and move the saline water back into the aquifer(s) and hence down-gradient towards the river, which is the natural outlet for the wider groundwater system.

5.5 TRAJECTORY OF CHANGE

Without management intervention in the form of environmental watering the ecological condition within the target area is expected to further decline. Dry conditions and salinity will continue to impact already severely stressed vegetation, including key species like Lignum, River Red Gum and Black Box and recovery of these communities is unlikely. This will result in loss of valuable habitat for listed fauna within the target area. Wetland productivity and biodiversity, which is directly dependent on water, will continue to decline.

The floodplain will continue to become drier and saltier resulting in reduced productivity, less carbon flux, and reduced functioning. Due to river regulation, flooding alone may not be enough to sustain floodplain vegetation communities as

events of necessary magnitude to reach these wetlands have reduced in frequency and duration (Ecological Associates 2007b).

Previous studies and watering events have provided evidence that the application of environmental water to the wetlands will improve conditions and provide habitat for a range of waterbirds.

6 Managing Water Related Threats

Some of the threats which may have an impact at Psyche/Woorlong include:

- Changed water regime
- Loss or reduction of wetland connectivity
- Poor water quality
- Invasive species

Changed water regime

The regulation of the Murray River has seen the water regime through the Psyche/Woorlong Wetland section altered. Flow events of the magnitude required to allow flows into the creeks and wetlands of the floodplain are less frequent and of shorter duration. This combined with dry conditions affects the vigour of the vegetation and places trees under stress, affecting the productivity and functioning of the floodplain ecosystem.

Permanent inundation of wetlands alters the hydrology and reduces water circulation. This can impact water temperature, dissolved oxygen, salinity and pH levels. Nutrient outflow can be reduced resulting in a build-up of salinity and/or pollutants. Sedimentation within the wetlands can lead to smothering of key habitat features. Biodiversity can decline as breeding cues and recruitment of flora and fauna are lost.

Poor water quality

The use of Psyche Lagoon and Woorlong Wetland as an irrigation drainage basin has led to issues with salinity and resulted in degradation of the floodplain and its vegetation. At Woorlong Wetland Black Box woodland health has diminished and extensive succession of species such as Cumbungi (*Typha* spp.) and Spiny-rush (*Juncus acutus*) has resulted on the wetland edge (Ecological Associates 2007b). Psyche Lagoon and approximately 110ha of surrounding floodplain vegetation has been severely degraded by saline drainage and ground water (Ecological Associates 2007b).

Woorlong Wetland also receives stormwater from the Red Cliffs township. 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).

Invasive species

Introduced fauna such as Common Carp (*Cyprinus carpio*) pose a serious threat to the ecology of Psyche/Woorlong wetlands. Carp have been found to contribute to the loss of aquatic vegetation and increased turbidity, resulting in loss of habitat for waterfowl (Purdy & 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). 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 (*Litoria raniformis*).

Agricultural and other weeds are an ongoing threat and management issue along the Murray River floodplain. At Woorlong Wetland dense stands of Cumbungi surround the wetland edge. Although this plant is native it uses large amounts of water and can alter the wetland character, reduce plant diversity and obstruct water flow (Roberts & Marston 2011). Environmental water can be used to manage this species by maintaining ponding at high enough levels to submerge the dense Cumbungi stands for prolonged periods.

Table 18. Risk Rating of Water Related Threats.

Cause	Threat	Likelihood	Consequence	Risk	Management measure (risk treatment)	Residual Risk
Maintenance of static water levels in the Lock 11 Weir Pool due to regulation of the Murray River	Altered water regime to off channel wetlands that impacts aquatic and riparian vegetation structure and composition	Likely	Moderate	High	Introduce appropriate water regime	Moderate
Saline groundwater discharge and irrigation drainage disposal	Salinity impacts reduce the quality of floodplain and wetland vegetation	Likely	High	High	Introduce appropriate water regime to flush salt form Pysche/Woorlong	Moderate
High populations of invasive fish (European Carp)	Loss of aquatic vegetation, increased turbidity, predation, and competition with native fish	Likely	Moderate	High	Management options limited by current use for irrigation drainage disposal. Unable to introduce drying phase if high numbers of adult European Carp are present	High
Maintenance of static water levels within Woorlong Wetlland	Establishment of invasive emergent macrophytes (Typha *Typha domingensis* and Common reed *Phragmites australis* around wetland edge	Likely	Moderate	High	Introduce water regime to submerge invasive emergent macrophytes for appropriate periods of time	High

7 Management Goals, Objectives and Targets

7.1 MANAGEMENT GOAL

The long term management goals for Psyche/Woorlong are:

- Maintain Woorlong Wetland as a permanent open freshwater wetland supporting habitat for small fish, frogs and waterbirds.
- Maintain Psyche Bend Lagoon as a permanent saline wetland supporting healthy populations of salt tolerant aquatic vegetation, and supporting habitat for frogs and waterbirds.

They are strongly linked to the goals of the Mallee Waterway Strategy 2014-22 (Mallee CMA 2014)

- To maintain or improve habitat within waterways and on surrounding riparian land;
- To manage all land tenures for water quality benefits and respond appropriately to threatening events (both natural and pollution based);
- To restore appropriate water regimes and improve connectivity;
- To protect the extent and condition of Cultural Heritage (Indigenous and non-Indigenous) sites associated with waterways; and
- To increase community capacity for, awareness of and participation in waterway management.

7.2 ENVIRONMENTAL OBJECTIVES AND TARGETS

Environmental objectives represent the desired environmental outcomes of the site based on the management goals, above, as well as the key values outlined in the Water Dependent Values section (Section 5). It is intended that EWMP objectives will be described in terms of the primary environmental outcomes, in most cases ecological attributes. The focus of the objectives should be on the final ecological outcomes and not the drivers per se.

During 2020, the environmental objectives (formally ecological objectives) undertook a refinement process with the intent of improving the specificity and measurability of the objectives through the development of targets, and to improve line of sight to the Basin Plan (Table 19). While the process attempted to maintain the intent and integrity of the original objectives, it provided an opportunity to reassess the suitability of these objectives for the asset. The rationalisation, assessment of SMARTness, mapping to Basin Plan and update of each objective for Psyche Bend Lagoon and Woorlong Wetland can be found in Section 5.23.1 of Butcher et al. (2020) and Appendix 3.

While every attempt has been made to make the following objectives and targets as complete as possible, there still remains gaps as critical information is not currently available. As such, baselines are not able to be set at this time. In the interests of moving forward, the objectives and targets have been written in a way (i.e. red highlighted text) that allows this information to be included at a later stage as this information becomes available.

Table 19. Updated Environmental objectives and Targets for Psyche Bend Lagoon and Woorlong Wetland.

Environmental objective	Target
PW2: By 2030, maintain populations and extent of saline aquatic vegetation at Psyche Bend Lagoon, Psyche Woorlong including benthic herblands with *Ruppia* beds containing both *R. polycarpa* and *R. megacarpa*.	By 2030, vigorous populations of saline aquatic vegetation at Psyche Bend Lagoon, Psyche Woorlong: - improve cover of *Ruppia* to ≥30% and at least 10 live (green) shoots per core at 80% of sites assessed - measured by taking sediment 5 core samples (75mmx4cm deep) at transects of dry zone above waterline, waterline, 30cm and 60cm depths - up to five random transects per site minimum of 200m apart To achieve this specific water regime and salinity levels will need to be established – i.e. once a baseline is established these targets may be modified. • Sampling method modified from Paton et al. (2018). Suggested salinity threshold of 30ppt should support growth/germination and condition of both species (see Sim et al. 2006). Flowering is likely to require 3 months at <15ppt salinity (Sim et al. 2006). These thresholds need to be confirmed for this wetland system.
PW3: By 2030, maintain representative populations of the shallow-water feeding guild of waterbirds (F2, after Jaensch 2002) at Pysche and Woorlong by maintaining shallow-water habitats.	By 2030, 80% of representative F2 species recorded at Pysche and Woorlong, in 8 years out of any 10-year period where conditions are suitable. • Representative F2 species of small waders includes: Masked Lapwing (*Vanellus miles*), Red-necked Avocet (*Recurvirostra novaehollandiae*) Red-capped Plover (*Charadrius ruficapillus*), Black-fronted Dotterel (*Elseyornis melanops*), Red-kneed Dotterel (*Erythrogonys cinctus*), Black-winged Stilt (*Himantopus himantopus*), and Sharp-tailed Sandpiper (*Calidris acuminata*) • Feeding habitat defined as shallow feeding areas (<0.5 m depth and or drying mud) with intermittent inundation of densely vegetated shrublands.
PW4: By 2030, improve condition and maintain extent from baseline levels of Lignum (*Duma florulenta*) to sustain communities and processes reliant on Lignum communities at Woorlong Wetland, Psyche Woorlong	By 2030, condition in standardised transects that span the floodplain elevation gradient and existing spatial distribution, ≥70% of Lignum plants in • good condition with a Lignum Condition Score (LCI) ≥4.
PW5a: By 2030, protect and restore biodiversity by maintaining representative populations of small bodied native fish at Woorlong, Psyche Woorlong including Unspecked Hardyhead (*Craterocephalus stercusmuscarum fulvus*), Western Carp Gudgeon (*Hypseleotris klunzingeri*) and Flat-headed Gudgeon (*Philypnodon grandiceps*)	By 2030, maintain self-sustaining populations of Unspecked Hardyhead (*Craterocephalus stercusmuscarum fulvus*), Western Carp Gudgeon (*Hypseleotris klunzingeri*) and Flat-headed Gudgeon (*Philypnodon grandiceps*) at Woorlong, Psyche Woorlong, measured as: • Adults or YoY for each species recorded in 8 out of 10 years

PW5b: By 2030, protect and restore biodiversity by maintaining representative populations of frogs at the Psyche Bend Lagoon and Woorlong Wetland asset.	By 2030, maintain self-sustaining populations of frogs at the Psyche Bend Lagoon and Woorlong Wetland asset: • Barking marsh frog (*Limnodynastes fletcheri*), Plains froglet (*Crinia parainsignifera*), Southern bullfrog (*Limnodynastes dumerilii*), and Spotted marsh frog (*Limnodynastes tasmaniensis*) - Need to confirm frog species at the site
PW6: By 2030, reduce the extent of invasive emergent macrophytes (Typha *Typha domingensis* and Common reed *Phragmites australis*) to prevent the decline of native vegetation at the Woorlong Wetlands, Psyche Woorlong	By 2030, reduce the spatial extent of Typha *Typha domingensis* and Common reed *Phragmites australis* in Woorlong wetlands, Psyche Woorlong by 25%

7.3 REGIONAL SIGNIFICANCE

Psyche/Woorlong supports a range of environmental values of local, regional and Basin significance as described in Section 5. These values are linked to the management goals and environmental objectives and targets described in Section 0. Details of the links between the environmental objectives and environmental outcomes at a regional/Basin scale are provided in Appendix 3.

The management goals and environmental objectives and targets are aligned with the goals of the Mallee Waterway Strategy as described in Section 7.1. The Mallee Waterway Strategy identifies Psyche Lagoon and Woorlong Wetland as high priority wetlands, and Wonega Ave Drain and Woorlong Drains as medium priority wetlands within the Karadoc WMU.

7.4 ALIGNMENT TO BASIN PLAN

The primary environmental outcome of the Basin Plan is the protection and restoration of water-dependent ecosystems and ecosystem functions in the Murray-Darling Basin, with strengthened resilience to a changing climate. The MDBA is required to measure progress towards achieving the objectives of the Basin Plan Environmental Watering Plan (EWP) (Chapter 8 of the Basin Plan) by using the targets in Schedule 7 and having regard to the long-term average sustainable diversion limits, ecological objectives and ecological targets. These are set out in Long-Term Watering Plan's (LTWP), the Basin-wide Environmental Watering Strategy (BWS) and annual Basin environmental watering priorities. Details on the alignment of the updated Pysche/Woorlong EWMP environmental objectives to the Basin Plan are provided in Table 20 and Appendix 3.

7.5 DOCUMENTING EWMP UPDATES AND MAPPING TO BASIN PLAN AND OTHER POLICY DOCUMENTS

The updated objectives are aligned with the Basin Plan, Basin-wide EWS objectives and State level LTWP objectives. Table 20 maps line of sight linkages between these objectives and each of the updated EWMP objectives. Further details of these linkages and the rationale behind the updates for each objective is provided in Appendix 3.

Table 20. Mapping updated Psyche Bend Lagoon and Woorlong Wetland EWMP objectives to Basin Plan Environmental Watering Plan (EWP) objectives, Basin Plan Schedule 7 targets, Basin wide Environmental Watering strategy (BWS) quantified environmental expected outcomes (QEEO) (MDBA 2019), and Long-term Watering Plan (LTWP) Victorian Murray objective (DELWP 2015).

EWMP objective	Basin Plan EWP objective	Relevant Basin Plan Schedule 7 target	Relevant BWS QEEO*	LTWP objective
PW2	8.05,3(b)	Extent and contiguousness of native water dependent vegetation Condition of priority asset - prevention of decline in native biota	B2.11	LTWPVM4
PW3	8.05,3(b)	Condition of priority asset - prevention of decline in native biota Condition of priority asset - vital habitat - feeding, breeding, nursery	B3.1	LTWPVM13 LTWPVM12
PW4	8.05,3(b) 8.06,6(b)	Condition of priority asset - prevention of decline in native biota Diversity of native water dependent vegetation Condition of water-dependent vegetation Condition of priority ecosystem functions - creation of vital habitat - habitat for prevention of decline in native species	B2.10	LTWPVM8
PW5	8.05,3(b) SBF	Condition of priority asset - prevention of decline in native biota Recruitment and populations of native fish	B4.5	LTWPMV15
	8.05,3(b) Frogs 8.05,3(a)	Condition of priority asset - prevention of decline in native biota Condition of priority asset – supports EPBC listed species Recruitment and populations of other native water-dependent biota	None specified	LTWPVM19 LTWPVM20
PW6	Not applicable	Not applicable	None specified	None specified

8 Environmental Water Requirements and Intended Water Regime

8.1 WATERING REQUIREMENTS AND INTENDED WATERING REGIMES

The environmental watering requirements and intended watering regime has been derived from the environmental objectives and targets. The intended water regime required to achieve the environmental objectives for the target area are presented in Table 21.

As previously outlined Psyche/Woorlong plays an important role in the region's salinity management strategy with surface water management driven by agreed protocols for managing salt flushing events. These protocols drive the management of surface water within Pysche/Woorlong with flushing events limited to flows of >35,000 ML /day in the Murray River. The Mallee CMA acknowledges this will be the primary use for the site going forward, however, there are opportunities to protect

the sites ecological values through environmental watering and thus environmental and hydrological objectives have been set. These environmental and hydrological objectives will need to be implemented within the constraints of the agreed salinity management protocols at the site. The suitability of the watering regime will be assessed on an annual basis, with opportunities to manage water for environmental outcomes considered as a secondary driver in the planning and decision-making process, with the primary consideration being the agreed salinity management protocols and how these will be implemented within the current seasonal flow conditions.

The environmental objectives at this site are centred on reducing salt loads in the wetlands and improving the condition of aquatic and fringing vegetation. In addition to this, water levels at Woorlong Wetland will be maintained at a suitable level over summer. Evidence from the previous flushing events showed a correlation between the frequency of flushing and a reduction in salt loads. Where events took place within five months of each other, rather than a year between events, salt was removed more effectively from the system and there was less time for salt loads to accumulate between events. More effective removal of salt from the system should also increase the opportunity for the improvement of the vegetation surrounding the wetlands. Therefore, two flushing events per year with no more than 6 months between events may be the most effective hydrological regime to achieve the environmental objectives for the target area. This will need to continue into the long term due to the wetlands direct connection with the saline Parilla Sands aquifer to enable continual freshening of the water column as recommended by Macumber (2014). Water will need to be maintained in Woorlong Wetland over summer and regular variation in water level should occur to reduce Cumbungi infestation and promote natural wetland function.

River Red Gum stands are found in the fringing areas and floodplain 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 River Red Gum woodlands is five to seven years to prevent deterioration of tree condition (Roberts and Marston 2011).

Black Box stands occur in the fringing areas and floodplain 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 affect 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 and 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 plants in this state 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).

Woorlong Wetland

Woorlong wetland will be gradually filled to 37.5m AHD via the numerous irrigation drainage channels and through connection with Psyche Bend Lagoon via the connecting channel at 907 river km and will require approximately 346 ML of water. Woorlong will either be discharged via this route or via the drainage channel that runs along the top of Psyche Bend Lagoon and discharges on the northern side of the pumping station. This course of discharge will be dependent on the salinity impact assessment that is currently being undertaken.

In order to reduce cumbungi stands environmental water can be held in the wetland at a suitable height to drown out the plants. Cumbungi prefers slow flowing or still water less than 2 m deep and readily colonises waterways with static water levels (Clark & Flanery 2007). After the initial drowning to reduce cumbungi cover, establishing a long-term water regime which ensures water levels fluctuate regularly may help prevent reinfestation. Regular environmental water delivery can also be used to freshen the wetland and reduce salinity.

Psyche Bend Lagoon

With proposed infrastructure in place and the northern regulator at 904 river km closed, Psyche Bend Lagoon will be filled to 36m AHD via the water course connecting Psyche Bend Lagoon with the Murray River at 910 river kilometres, requiring >2700 ML. As with previous watering events; to allow flushing of Psyche Bend Lagoon the gates at the northern end at river km 904 connecting all three wetland to the Murray River will be opened.

Although continuous flooding may seem appropriate for aquatic macrophytes such as *Ruppia spp*., seasonal variation in water levels is also beneficial for these plants. Brock (1981) states that the drying of seeds and substrate during a dry phase in ephemeral wetlands habitats is likely to break the seed coating and make seeds more permeable to water on rewetting of the wetland. These aquatic species may persist in wetlands that are frequently flooded but if complete drying of the wetland occurs over summer they will die off and be replaced by lake bed herbs (Ecological Associates 2007b). Roberts & Marston (2011) states a slow drawdown of water level is required to prevent collapse of plants. Ellis (2013, pers. comm., 11th Dec) supports this, suggesting a gradual drawdown phase is essential for *Ruppia spp*. establishment. Drawdown of water level in the wetlands is proposed to occur naturally through evaporation.

Table 21 – Environmental water requirements and intended water regime for Psyche Bend Lagoon and Woorlong Wetland target area

Environmental Objective	Water management area	Intended Watering Regimes										
		Mean frequency of events (Number per 10 years)			Tolerable interval between events (years)		Duration of Ponding (months)			Preferred timing of inflows	Target supply level (m) AHD	Volume to fill to TSL (ML)	Volume to maintain at TSL (ML)	Volume per event (ML)
		Min	Opt	Max	Min	Max	Min	Opt	Max					
Extensive beds of Ruppia spp. in wetland	Psyche Bend Lagoon	Variability in water level					Permanent ponding with variation in water levels			Late winter/early spring	36	951	951	951
Provide shallow water habitat and exposure of mudflats to support foraging and resting of small waders	Psyche Bend Lagoon, Woorlong Wetland and floodplain fringe	Variability in water level					Permanent ponding with variable water level to alternately inundate/expose fringing vegetation and mud flats			Late winter/early spring	36 - 37.5	1643	692-951	1643
Healthy and productive Lignum and chenopod communities	Woorlong Wetland and floodplain	3	5	10	2	7	3	5	7	Winter/Spring	36 – 37.5	1643		1643
Provide seasonal aquatic habitat that supports a diverse range of small fish	Woorlong Wetland and floodplain fringe	Variability in water level					Permanent ponding with variable water level to alternately inundate/expose fringing vegetation and mud flats			Late winter/early spring	36 - 37.5	1643	692-951	1643
Provide seasonal aquatic habitat that supports a diverse range of frogs	Psyche Bend Lagoon, Woorlong	Variability in water level					Permanent ponding with variable water level to alternately inundate/expose			Late winter/early spring	36 - 37.5	1643	692-951	1643

Environmental Objective	Water management area	Intended Watering Regimes										
		Mean frequency of events (Number per 10 years)			Tolerable interval between events (years)		Duration of Ponding (months)			Preferred timing of inflows	Target supply level (m) AHD	Volume to fill to TSL (ML)	Volume to maintain at TSL (ML)	Volume per event (ML)
		Min	Opt	Max	Min	Max	Min	Opt	Max					
	Wetland and floodplain fringe						fringing vegetation and mud flats							
Reduce the area of Woorlong wetland dominated by reed (Phragmites and Cumbungi) communities	Woorlong Wetland	Variability in water level					Regular fluctuations			Late winter/early spring	37.5	692	692	692

8.2 EXPECTED WATERING EFFECTS

This section aims to explicitly outline the potential watering actions and expected watering effects needed to achieve the stated environmental objective.

Table 22. Expected watering effects and potential watering action required to achieve environmental objectives

Objective Code	Environmental objective	Potential watering action	Expected watering effects
PW2a	By 2030, maintain populations and extent of saline aquatic vegetation at Psyche Bend Lagoon, Psyche Woorlong including benthic herblands with Ruppia beds containing both R. polycarpa and R. megacarpa.	• Maintain permanent ponding with variations in water levels • Surcharge to 36 m AHD in late winter/early spring • Allow water levels to recede over summer/autumn	Maintain appropriate seasonal variation in water levels to provide suitable habitat and salinity levels to support the growth and recruitment of Ruppia
PW3	By 2030, maintain representative populations of the shallow-water feeding guild of waterbirds (F2, after Jaensch 2002) at Pysche and Woorlong by maintaining shallow-water habitats.	• Maintain permanent ponding with variations in water levels • Surcharge Psyche Bend Lagoon to 36 m AHD and Woorlong Wetland to 37.5 m AHD in late winter/early spring • Allow water levels to recede over summer/autumn	Provide suitable habitat (food, refuge, nesting sits) in flooded wetland and floodplain vegetation in spring and summer. Provide foraging habitat in shallow open water (<0.5m depth) and mudflats as water recedes over summer and autumn.
PW4	By 2030, improve condition and maintain extent from baseline levels of Lignum (*Duma florulenta*) to sustain communities and processes reliant on Lignum communities at Woorlong Wetland, Psyche Woorlong	• Maintain permanent ponding with variations in water levels • Surcharge Woorlong Wetland to 37.5 m AHD in late winter/early spring • Allow water levels to recede over summer/autumn	Maintain appropriate watering regime to support the growth and recruitment of Lignum.
PW5	By 2030, protect and restore biodiversity by maintaining representative populations of small bodied native fish at Woorlong, Psyche Woorlong including Unspecked Hardyhead (Craterocephalus stercusmuscarum fulvus), Western Carp Gudgeon (Hypseleotris klunzingeri) and Flat-headed Gudgeon (Philypnodon grandiceps)	• Maintain permanent ponding with variations in water levels • Surcharge Woorlong Wetland to 37.5 m AHD in late winter/early spring • Allow water levels to recede over summer/autumn	Inundate areas of exposed sediments in spring to increase zooplankton abundance and available vegetation to coincide with breeding Expose sediments around the fringe of the wetland in summer to allow for consolidation of sediments and germination of terrestrial plants to provide cover and spawning substrate upon re-inundation.
PW5b	By 2030, protect and restore biodiversity by maintaining representative populations of frogs at the Psyche Bend Lagoon and Woorlong Wetland asset.	• Maintain permanent ponding with variations in water levels • Surcharge Psyche Bend Lagoon to 36 m AHD and Woorlong Wetland to 37.5 m AHD in late winter/early spring	Maintain appropriate watering regime to provide suitable habitat for frogs

		• Allow water levels to recede over summer/autumn	
PW6	By 2030, reduce the extent of invasive emergent macrophytes (Typha Typha domingensis and Common reed Phragmites australis) to prevent the decline of native vegetation at the Woorlong Wetlands, Psyche Woorlong	• Maintain permanent ponding with variations in water levels • Surcharge Woorlong Wetland to 37.5 m AHD in late winter/early spring • Allow water levels to recede over summer/autumn	Maintain appropriate seasonal variation in water levels to prevent the growth and spread of invasive emergent macrophytes

8.3 SEASONALLY ADAPTIVE APPROACH

To allow for adaptive and integrated management, the watering requirements have been framed using an adaptive approach which identifies priorities for environmental watering under different seasonal conditions. 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 planning scenarios under different seasonal conditions for Psyche/Woorlong are described in Figure 12.

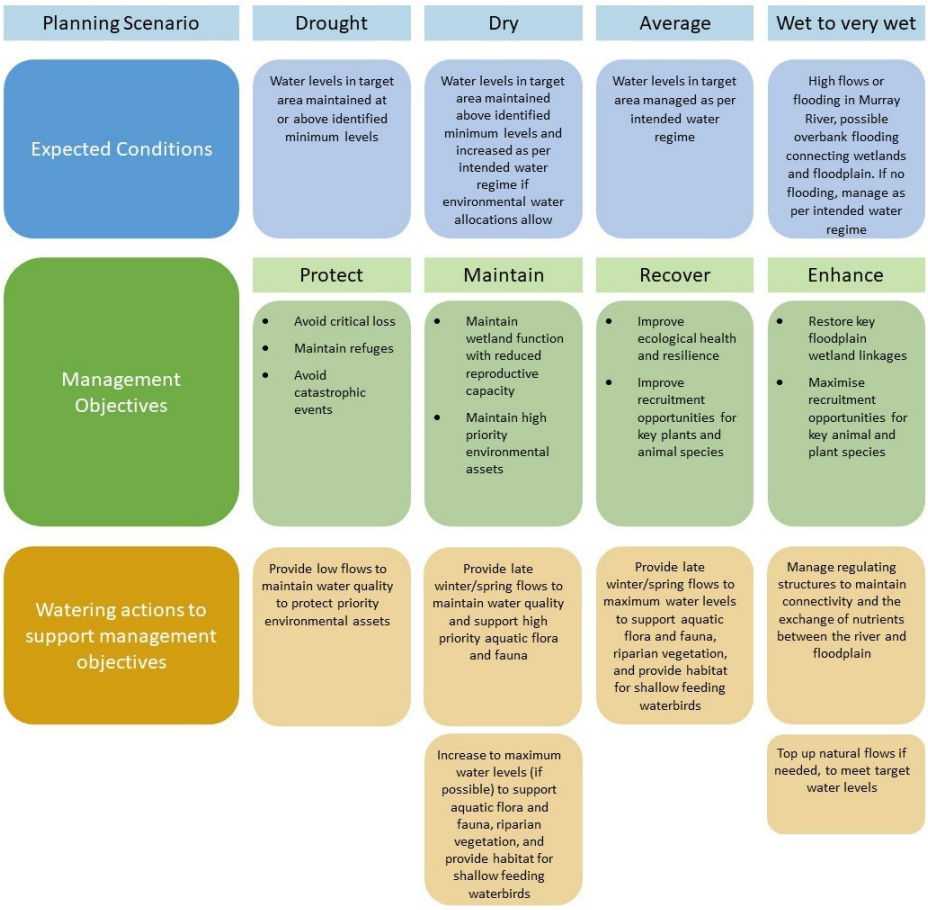


Figure 12. Planning scenarios for Psyche Bend Lagoon and Woorlong Wetland under a range of seasonal conditions

9 Environmental Water Delivery Infrastructure

9.1 WATER DELIVERY INFRASTRUCTURE

Existing infrastructure

Existing infrastructure at Psyche/Woorlong consists of a regulator at the connection between the Psyche Bend Lagoon and the Murray River. The regulator is closed, except during managed flushing events during flows of >35,000 ML/day in the Murray River. The regulator is overtopped at flows of >60,000 ML/day.

Complimentary works

Current infrastructure limits the extent of wetland area which can be inundated by environmental watering at Psyche/Woorlong to 102 ha. Currently water begins to break 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 Mallee CMA is working with Lower Murray Water who manage the irrigation infrastructure within the Kings Billabong Park to ensure that future irrigation modernisation will incorporate consideration of the environmental values of the Psyche Bend and Woorlong wetland areas.

Ecological Associates (2007) concluded that the best environmental value for money spent at Psyche/Woorlong would be achieved by operating the regulator at the main connection between Psyche Bend Lagoon and the River Murray to promote wetland conservation values. However, while this option may improve salinity levels in the wetland, the discharge of highly saline water into the Murray under this option is unacceptable under Basin Salinity Management Strategy protocols.

A second, more expensive, but more appropriate option suggested by Ecological Associates (2007) involves lowering sills and creating connections to Psyche Lagoon from the south to enhance flooding opportunities.

Works to enable management of the billabongs at Psyche/Woorlong are shown in **Error! Reference source not found.** and 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.
- Rehabilitation of levees and weirs to assist with water management. See Figure 13.

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

Detailed designs for these infrastructure upgrades will be explored in future when appropriate funding becomes available.

9.2 CONSTRAINTS

As well as being constrained by the existing infrastructure, environmental water delivery is constrained by the use of the site for irrigation drainage water disposal and the associated salinity management issues that exist at the site. As previously outlined in this EWMP this is the primary use of the site and it will remain the primary use of the site into the future. Any proposed environmental water regime and associated works will need to be implemented within these constraints.

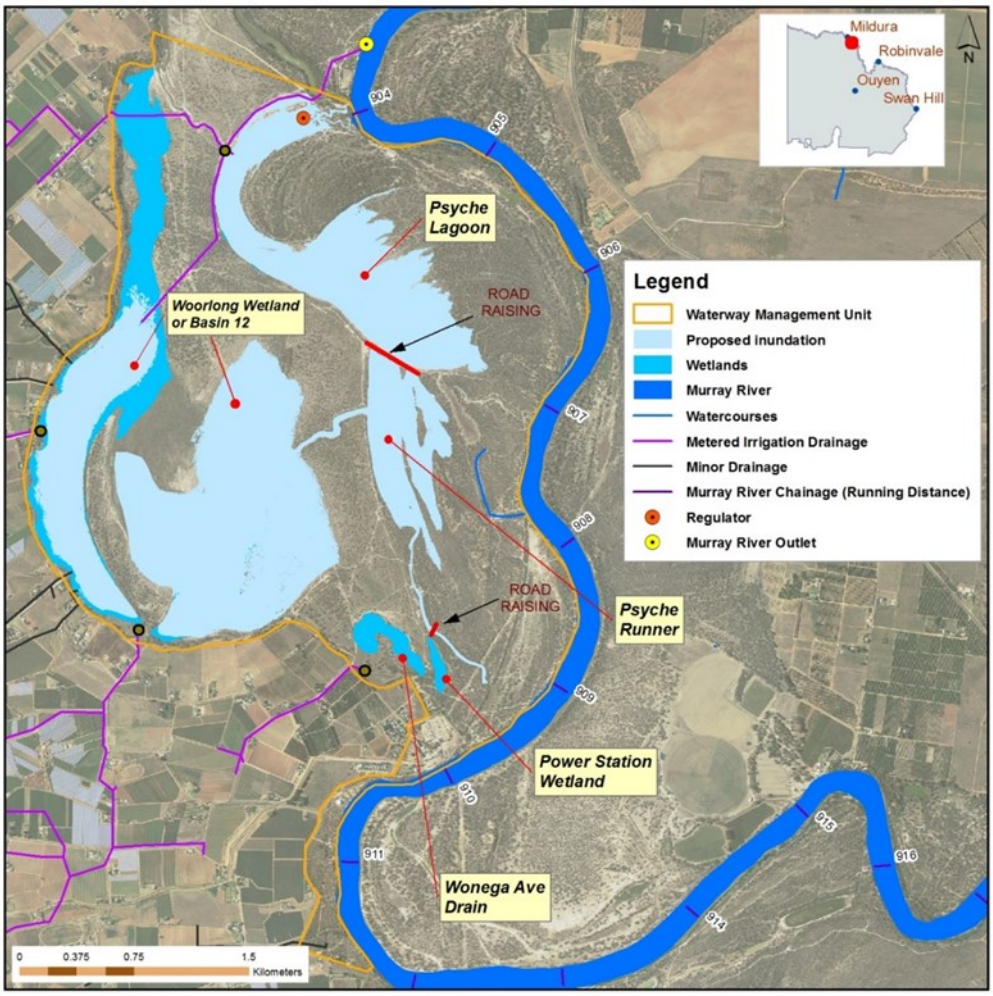


Figure 13. Anticipated inundation extent of Psyche/Woorlong target area with proposed infrastructure in place

10 Demonstrating Outcomes

Monitoring Priorities at Psyche Bend Lagoon and Woorlong Wetland

Ecological monitoring is required to demonstrate the effectiveness of environmental watering in achieving environmental objectives, to help manage environmental risks and to identify opportunities to improve the efficiency and effectiveness of the program. The following monitoring is recommended:

- Monitoring of water quality condition on a regular basis, including monitoring of salinity levels through the water column to identify seasonality of stratification. Water quality monitoring would occur throughout the year and would intensify during watering events.
- Monitoring of groundwater bores to identify salinity and water table levels, and to confirm that watering will abate the leaching of highly saline groundwater through the Parilla Sands aquifer into the wetlands.
- Monitoring of water quality in release water.

- Photo point monitoring will be conducted before and after watering events to measure the success of environmental water in improving wetland and riparian vegetation communities.
- Other incidental observations that may occur in the course of the monitoring methods above, such as visitation by waterbirds and other species to the wetlands during and after watering events;
- Index of Wetland Condition assessments should be undertaken every 5 years at the site to monitor the health of the vegetation communities in response to the implementation of the EWMP.

Detailed monitoring of environmental water delivery would be dependent on funding from the State or Commonwealth governments.

The following priorities for monitoring have been identified for the Psyche/Woorlong target area (Table 23). These monitoring priorities will enable environmental water managers to assess progress against targets and assist in the adaptive management of the target area to achieve the stated environmental objectives and outcomes. The link between stated objectives and monitoring priorities are described in Table 23.

Table 23. Links between environmental objectives, monitoring questions and monitoring priorities

Objective number	Monitoring focus	Monitoring question	Method	When
Overarching management goal				
N/A	Waterbird community in Psyche Bend Lagoon and Woorlong Wetland	By 2030 do Psyche Bend Lagoon and Woorlong Wetland support a diverse waterbird community?	Refer to waterbird monitoring below (MC2)	See below
	Frog community in Psyche Bend Lagoon and Woorlong Wetland	By 2030 do Psyche Bend Lagoon and Woorlong Wetland support a diverse frog community?	Refer to frog monitoring below (MC1a and MC1b)	See below
	Small fish community in Woorlong Wetland	By 2030 does Woorlong Wetland support a healthy small bodied fish population ?	Refer to fish monitoring in Woorlong Wetland below (MC7)	See below
	Saline aquatic vegetation in Psyche Bend Lagoon	By 2030 does Psyche Bend Lagoon support vigorous populations of saline aquatic vegetation?	Refer to Ruppia monitoring below	
	Wetland condition	Has there been an overall rehabilitation in the condition of the target area by 2030?	Undertake IWC method assessment	Every five years
Fish objectives				

Objective number	Monitoring focus	Monitoring question	Method	When
PW5a	Small-bodied native fish at Woorlong Wetland	By 2030 are adults or YoY for nominated species recorded in 8 out of 10 years	Undertake fish surveys targeting small-bodied native fish	Annually
Frog Objectives				
PW5b	Frogs in Psyche Bend Lagoon and Woorlong Wetland	By 2030 are self-sustaining populations of frogs maintained at Psyche Bend Lagoon and Woorlong Wetland	Undertake frog monitoring	Annually when conditions are suitable
Waterbird objectives				
PW3	Representative F2 species of small waders	By 2030 are 80% of representative F2 species recorded at Psyche Bend Lagoon and Woorlong Wetland in 8 years out of any 10-year period where conditions are suitable?	Undertake waterbird surveys	Annually when conditions are suitable
Vegetation objectives				
PW2	Saline aquatic vegetation (Ruppia) at Psyche Bend Lagoon	By 2030 has there been an improvement in cover of *Ruppia* to ≥ 30% and at least 10 live (green) shoots per core at 80% of sites assessed?	Undertake 5 sediment core samples (75mm x 4cm deep) at transects of dry zone above waterline, waterline, 30 cm and 60cm depths. Up to five random transects per site minimum of 200m apart	Every three years
PW4	Lignum at Woorlong Wetland	By 2030 ≥70% of Lignum plants in good condition with a Lignum Condition Score (LCI) ≥4	Undertake Lignum population monitoring using standardised transects that span the floodplain elevation gradient and existing spatial distribution	Every three years
PW6	Phragmites and Cumbungi	By 2030 the spatial extent of Phragmites and Cumbungi has been reduced by 25% at Woorlong Wetlands	Monitor and map the spatial extent of Phragmites and Cumbungi	Every three years

11 Knowledge gaps and recommendations

This plan is based on best information at the time of writing. 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 Victorian Biodiversity Atlas 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.

Some areas where further knowledge would be beneficial are outlined in Table 24.

A cultural heritage management plan and salinity impact assessment would be essential before any on ground works could be undertaken.

Table 24 – Knowledge gaps and recommendations for the target area

Knowledge gaps and data	Action recommended	Responsibility
Conceptual and detail designs for the management of infrastructure works	Engage consultants to carry out investigations and report	MCMA / LMW
Impacts of nearby irrigation on wetland health	Investigation of surface water, groundwater and irrigation water interaction	MCMA
Role of wetland on fish breeding and population	Monitoring of fish population	MCMA
Accurate depth and volumes for the wetland	Install depth gauges and bathymetric survey	MCMA
Flora and fauna surveys	Data collection and monitoring	MCMA
Impacts of climate variability	Data collection and monitoring	MCMA
Assessment of salinity impacts on the Murray River under proposed watering regimes	Engage consultants to carry out investigations and report	MCMA
Continue to build understanding of the optimal salinity conditions for Psyche Bend Lagoon and Woorlong Wetland, including the long term interactions with groundwater, irrigation and drainage.	Ongoing investigation of surface water groundwater and irrigation water interaction.	MCMA

12 References

Aboriginal Cultural Heritage Register and Information System (ACHRIS), First Peoples – State Relations, https://achris.vic.gov.au/#/onlinemap [accessed 18/05/2022]

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

Backhouse, G., Lyon, J. & Cant, B. (2008*). National Recovery Plain for the Murray hardyhead Craterocephalus fluviatilis.* Department of Sustainability and Environment, East Melbourne, Victoria.

Brock, M. A. (1981). Biology of the salinity tolerant genus Ruppia L. in saline lakes in South Australia. I. Morphological variation within and between species and ecophysiology. *Aquatic Botany* 13, 219-248 (online Elsevier).

Bluml, M. (1992*). Sunraysia Salinity Management Plan Environmental Report*. Department of Conservation and Environment.

Butcher, R., Cottingham, P. and Fenton, A. (2020) Briefing paper: Update of Mallee EWMP objectives, Report prepared by Water's Edge Consulting for Mallee Catchment management Authority, Mooroolbark, Victoria.

Clark, E. & Flanery, F. (2007). Cumbungi – friend or foe? You asked for it. Hot topics in native vegetation management. Greening Australia. Number 2.

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

DELWP. Mapshare, https://mapshare.vic.gov.au/mapsharevic/ [Accessed 16/05/2022]

DELWP Planning (2015) Long-term Watering Plan- Victorian Murray, Victoria Department of Environment, Land, Water and Planning, Melbourne, Victoria.

DEWHA (2008). *Commonwealth Environmental Water Holder 2008-09 Business Plan*, Department of Environment, Water, Heritage and the Arts, Canberra, ACT.

DNRE (1997). Victoria's Biodiversity – Our Living Wealth – Sustaining Our Living Wealth and Directions in Management. Department of Natural Resources and Environment, East Melbourne, Victoria

DSE, (2001). Action Statement; Great Egret Ardea alba, Intermediate Egret Ardea intermedia, Little Egret Egretta garzetta. Department of Sustainability and Environment, East Melbourne, Victoria.

DSE (2004). *Kerang Wetlands Ramsar Site; Strategic Management Plan*. Department of Sustainability and Environment, East Melbourne, Victoria.

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

DSE, (2008). NVIRP clarification of net water savings, net environmental gain and refurbishment of water infrastructure to the current best environmental practice. Compiled by John Cooke and Paulo Lay, Department of Sustainability and Environment, East Melbourne, Victoria

DSE, (2009). *Northern Region: Sustainable Water Strategy*. Department of Sustainability and Environment, East Melbourne, Victoria.

DSE (2010). Determining the Suitability of Selected Wetlands for the Potential Translocation of the Murray hardyhead (Craterocephalus fluviatilis) in Northern Victoria. Department of Sustainability and Environment.

DSE, 2013. *EVC Bioregion Benchmark for Vegetation Quality Assessment. Robinvale Plains Bioregion*. East Melbourne, Victoria: Department of Sustainability and Environment.

EA (2007a). *Feasibility Investigation of Options for Hattah Lakes*, Final Report. Ecological Associates for Mallee Catchment Management Authority Mildura, Victoria.

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

Ellis, I. (2005). Ecology and breeding seasonality of the Murray hardyhead Craterocephalus fluviatilis (McCulloch), Family Atherinidae, in two lakes near Mildura, Victoria. Report to the Mallee Catchment Management Authority. Murray-Darling Freshwater Research Centre.

Ellis, I., Carr, L. & Pyke, L. (2010). Conservation of the Murray hardyhead, Craterocephalus fluviatilis, in Victoria: status of population monitoring, translocation and captive breeding programs. Final Report prepared for the Mallee Catchment Management Authority by The Murray-Darling Freshwater Research Centre, MDFRC Publication, 18/2011, June, 49pp.

Ellis, I. (2013). *Murray hardyhead recovery in Victoria: population monitoring, translocation and captive breeding programs 2012-13*. Final Report prepared for the Victorian Department of Environment and Primary Industries by The Murray-Darling Freshwater Research Centre, MDFRC Publication 22/2013, June, 33pp.

Gippel, C.J. 2014. Spells analysis of modelled flow for the River Murray from Swan Hill to the south Australia Border. Fluvial Systems Pty Ltd, Stokton. Mallee CMA, November.

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

Ho, S., Ellis, I., Suitor, L., McCarthy, B. & Meredith, S. (2004). Distributions of aquatic vertebrates within the Mallee region: A baseline survey of fish, turtles and frogs, February to May 2004. The Murray-Darling Freshwater Research Centre, Mildura, Victoria.

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

Lintermans, M. 2007. *Fishes of the Murray-Darling Basin: An introductory guide*. Murray-Darling Basin Comission, Canberra, ACT.

Macumber, P. 2014. Groundwater flow in the vicinity of Psyche Bend Lagoon. Final report prepared for the Mallee Catchment Management Authority. 2014.

Madsen, T. & Shine, R. (1996). Seasonal Migration of Predators and Prey – A Study of Pythons and Rats in Tropical Australia. *Ecology 77*, 149-156.

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

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

Mallee Catchment Management Authority, (2006A) *Mallee Wetland Strategy*. Mallee Catchment Management Authority Mildura, VictoriaMcKane, B (1992) *Environmental Report: Nyah – South Australian Border Salinity Management Plan.* Department of Conservation and Environment Mildura, Victoria.

MCMA (2013). Groundwater & Drainage Water Monitoring Workshop. Draft workshop record, Mallee Catchment Management Authority, Mildura, Victoria.

MDBA (2007). *Basin Plan*. Murray Darling Basin Authority, Canberra, ACT.

MDBA (2001). Basin Salinity Management Strategy (2001 – 2015). Murray Darling Basin Administrative Council. 2001

MDBA (2019) Basin-wide environmental watering strategy, Murray–Darling Basin Authority Canberra, ACT.

North, L., (2014) Regional Context Document for Environmental Water Management Plans. Final Report prepared for the Mallee Catchment Management Authority by Sunraysia Environmental.

Parks Victoria and Mallee Catchment Management Authority (2008). *Kings Billabong Wildlife Reserve Management Plan.* Parks Victoria, Melbourne, Victoria.

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

Richardson, S. (2014) *Preliminary Salinity Impact Assessment – Psyche Bend Lagoon and Woorlong Wetland*. Final report prepared on behalf of the Mallee Catchment Management Authority, Mildura, Victoria.

RPS Aquaterra (2013*). Psyche Bend Lagoon – Flushing Analysis (2011/2012 Events).* Prepared for Mallee Catchment Management, Mildura, Victoria.

Roberts, J. & Marston, F. (2011). Water Regime for Wetland and Floodplain Plants; a source book for the Murray-Darling Basin. National Water Commission, Canberra, ACT.

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

Russell, R. C. (1999). Constructed Wetlands and Mosquitoes: Health Hazards and Management Options – An Australian Perspective. *Ecological Engineering* 12, 107-124.

Sainty, G. R. & Jacobs, S. W. L (1981). *Water Plants of New South Wales*. Water Resources Commission, New South Wales.

SCSWG (1991) *Sunraysia Draft Salinity Management Plan.* Sunraysia Community Salinity Working Group.

Sinclair SJ (2004) *River Red Gum decline in the Nyah-Piangil Area: Is the semi-parasitic Pale-fruit Ballart involved?* Report to Mallee CMA. Arthur Rylah Institute for Environmental Research. Heidelberg, Victoria

SKM (2002). *Kings Billabong Wetland Management Plan*. Sinclair Knight Merz Pty Limited, Armadale, Victoria.

SKM (2014). Preliminary Salinity Impact Assessment, Psyche Bend Lagoon and Woorlong Wetland. Sinclair Knight Merz, Adelaide.

Stoessel, D., Fairbrother, P., Fanson, B., Nicol, M., Raadik, T., Dodd, L., and Raymond, S. (2018). *Addressing critical knowledge gaps to improve conservation outcomes for Murray hardyhead (Craterocephalus fluviatilis)*. A project of the Biodiversity On-ground Actions Regional Partnerships and Targeted Actions program. Arthur Rylah Institute for Environmental Research, Department of Environment, Land, Water and Planning, Heidelberg, Victoria

Thomas, MC, Suter, P., Roberts, J., Koehn, J., Jones, G., Hillman, T. and Close, A. (2000). Report of the River Murray Scientific Panel on Environmental Flows: River Murray – Dartmouth to Wellington and the Lower Darling River, River Murray Scientific Panel on Environmental Flows, Murray Darling Basin Commission, Canberra ACT

VEAC (2008). Identifying flood-dependent natural values on the Victorian floodplains of the River Murray and its tributaries. Victorian Environmental Assessment Council, East Melbourne, Victoria.

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

APPENDIX 1.

FLORA AND FAUNA SPECIES LIST

Flora – Native

Common Name	Scientific Name	Records
Small Cooba	*Acacia ligulata*	1
Mallee Wattle	*Acacia montana*	1
Spine Bush	*Acacia nyssophylla*	3
Umbrella Wattle	*Acacia oswaldii*	1
Willow Wattle	*Acacia salicina*	1
Eumong	*Acacia stenophylla*	8
Cattle Bush	*Alectryon oleifolius subsp. canescens*	4
Buloke	*Allocasuarina luehmannii*	1
Lesser Joyweed	*Alternanthera denticulata s.l.*	3
Lesser Joyweed	*Alternanthera denticulata s.s.*	2
Jerry-jerry	*Ammannia multiflora*	1
Box Mistletoe	*Amyema miquelii*	2
Nodding Chocolate-lily	*Arthropodium fimbriatum*	1
Common Woodruff	*Asperula conferta*	2
Small Saltbush	*Atriplex eardleyae*	2
Slender-fruit Saltbush	*Atriplex leptocarpa*	5
Spreading Saltbush	*Atriplex limbata*	1
Flat-top Saltbush	*Atriplex lindleyi*	13
Corky Saltbush	*Atriplex lindleyi subsp. inflata*	3
Old-man Saltbush	*Atriplex nummularia*	1
Dwarf Old-man Saltbush	*Atriplex nummularia subsp. omissa*	1
Coral Saltbush	*Atriplex papillata*	6
Mat Saltbush	*Atriplex pumilio*	1
Silver Saltbush	*Atriplex rhagodioides*	1
Berry Saltbush	*Atriplex semibaccata*	7
Spiny-fruit Saltbush	*Atriplex spinibractea*	4
Saltbush	*Atriplex spp.*	1
Sprawling Saltbush	*Atriplex suberecta*	8
Common Wallaby-grass	*Austrodanthonia caespitosa*	1
Bristly Wallaby-grass	*Austrodanthonia setacea*	3
Graceful Spear-grass	*Austrostipa acrociliata*	1
Plump Spear-grass	*Austrostipa aristiglumis*	1
Balcarra Spear-Grass	*Austrostipa nitida*	1
Knotty Spear-grass	*Austrostipa nodosa*	2
Rough Spear-grass	*Austrostipa scabra subsp. falcata*	2
Spear Grass	*Austrostipa spp.*	1
Pacific Azolla	*Azolla filiculoides*	2
Ferny Azolla	*Azolla pinnata*	1
Small Water-fire	*Bergia trimera*	1
Marsh Club-sedge	*Bolboschoenus medianus*	4
Billabong Daisy	*Brachyscome aff. gracilis (Kings Billabong)*	4
Woodland Swamp-daisy	*Brachyscome basaltica var. gracilis*	1
Variable Daisy	*Brachyscome ciliaris*	3

Common Name	Scientific Name	Records
Variable Daisy	*Brachyscome ciliaris var. lanuginosa*	1
Lobe-seed Daisy	*Brachyscome dentata*	4
Hard-head Daisy	*Brachyscome lineariloba*	16
Leek Lily	*Bulbine semibarbata*	1
Small Purslane	*Calandrinia eremaea*	7
Slender Cypress-pine	*Callitris gracilis subsp. murrayensis*	2
Pale Beauty-heads	*Calocephalus sonderi*	11
Blue Burr-daisy	*Calotis cuneifolia*	4
Hairy Burr-daisy	*Calotis hispidula*	11
Yellow Burr-daisy	*Calotis lappulacea*	1
Rough Burr-daisy	*Calotis scabiosifolia*	1
Tufted Burr-daisy	*Calotis scapigera*	1
Plains Sedge	*Carex bichenoviana*	3
Spiked Centaury	*Centaurium spicatum*	1
Hornwort	*Ceratophyllum demersum*	1
Flat Spurge	*Chamaesyce drummondii*	3
Crested Goosefoot	*Chenopodium cristatum*	1
Small-leaf Goosefoot	*Chenopodium desertorum subsp. microphyllum*	1
Nitre Goosefoot	*Chenopodium nitrariaceum*	6
Windmill Grass	*Chloris spp.*	1
Windmill Grass	*Chloris truncata*	1
Pink Bindweed	*Convolvulus erubescens spp. agg.*	1
Common Cotula	*Cotula australis*	3
Cotula	*Cotula spp.*	2
Dense Crassula	*Crassula colorata*	8
Swamp Crassula	*Crassula helmsii*	1
Purple Crassula	*Crassula peduncularis*	2
Sieber Crassula	*Crassula sieberiana s.l.*	7
Rosinweed	*Cressa australis*	1
Native Scurf-pea	*Cullen australasicum*	1
Hoary Scurf-pea	*Cullen cinereum*	3
Grey Scurf-pea	*Cullen discolor*	1
Woolly Scurf-pea	*Cullen pallidum*	1
Tough Scurf-pea	*Cullen tenax*	3
Golden Dodder	*Cuscuta tasmanica*	1
Couch	*Cynodon dactylon*	2
Native Couch	*Cynodon dactylon var. pulchellus*	2
Variable Flat-sedge	*Cyperus difformis*	3
Tall Flat-sedge	*Cyperus exaltatus*	2
Lax Flat-sedge	*Cyperus flaccidus*	1
Flecked Flat-sedge	*Cyperus gunnii subsp. gunnii*	4
Spiny Flat-sedge	*Cyperus gymnocaulos*	4
Curly Flat-sedge	*Cyperus rigidellus*	2
Bearded Flat-sedge	*Cyperus squarrosus*	1
Yelka	*Cyperus victoriensis*	2
Star Fruit	*Damasonium minus*	1
Wallaby Grass	*Danthonia s.l. spp.*	1
Pale Flax-lily	*Dianella longifolia s.l.*	1

Common Name	Scientific Name	Records
Riverine Flax-lily	*Dianella porracea*	4
Silky Umbrella-grass	*Digitaria ammophila*	3
Rounded Noon-flower	*Disphyma crassifolium subsp. clavellatum*	5
Twin-flower Saltbush	*Dissocarpus biflorus var. biflorus*	1
Slender Hop-bush	*Dodonaea viscosa subsp. angustissima*	1
Globular Pigweed	*Dysphania glomulifera ssp. glomulifera*	1
Yellow Twin-heads	*Eclipta platyglossa*	2
Nodding Saltbush	*Einadia nutans subsp. nutans*	12
Small Elachanth	*Elachanthus pusillus*	1
Waterwort	*Elatine gratioloides*	1
Common Spike-sedge	*Eleocharis acuta*	2
Pale Spike-sedge	*Eleocharis pallens*	1
Small Spike-sedge	*Eleocharis pusilla*	1
Common Wheat-grass	*Elymus scaber var. scaber*	1
Ruby Saltbush	*Enchylaena tomentosa var. tomentosa*	10
Common Bottle-washers	*Enneapogon avenaceus*	1
Spider Grass	*Enteropogon acicularis*	8
Tall Nut-heads	*Epaltes cunninghamii*	7
Cane Grass	*Eragrostis australasica*	1
Common Love-grass	*Eragrostis brownii*	1
Close-headed Love-grass	*Eragrostis diandra*	1
Mallee Love-grass	*Eragrostis dielsii*	5
Southern Cane-grass	*Eragrostis infecunda*	4
Purple Love-grass	*Eragrostis lacunaria*	3
Weeping Love-grass	*Eragrostis parviflora*	1
Bristly Love-grass	*Eragrostis setifolia*	2
Love Grass	*Eragrostis spp.*	1
Spreading Emu-bush	*Eremophila divaricata subsp. divaricata*	22
Common Emu-bush	*Eremophila glabra*	1
Spotted Emu-bush	*Eremophila maculata var. maculata*	4
Woolly-fruit Bluebush	*Eriochiton sclerolaenoides*	1
Blue Heron's-bill	*Erodium crinitum*	1
River Red-gum	*Eucalyptus camaldulensis*	9
Black Box	*Eucalyptus largiflorens*	13
Grey Mallee	*Eucalyptus socialis subsp. socialis*	1
Annual Cudweed	*Euchiton sphaericus*	7
Leafless Ballart	*Exocarpos aphyllus*	1
Pale-fruit Ballart	*Exocarpos strictus*	1
Summer Fringe-sedge	*Fimbristylis aestivalis*	1
Veiled Fringe-sedge	*Fimbristylis velata*	1
Sea Heath	*Frankenia spp.*	1
Hairy Carpet-weed	*Glinus lotoides*	1
Slender Carpet-weed	*Glinus oppositifolius*	1
Indian Cudweed	*Gnaphalium polycaulon*	1
Silky Goodenia	*Goodenia fascicularis*	1
Pale Goodenia	*Goodenia glauca*	1
Spreading Goodenia	*Goodenia heteromera*	1
Cut-leaf Goodenia	*Goodenia pinnatifida*	1
Small-flower Goodenia	*Goodenia pusilliflora*	1

Common Name	Scientific Name	Records
Goodenia	*Goodenia spp.*	2
Comb Grevillea	*Grevillea huegelii*	3
Silver Needlewood	*Hakea leucoptera subsp. leucoptera*	1
Hooked Needlewood	*Hakea tephrosperma*	1
Rough Raspwort	*Haloragis aspera*	4
Toothed Raspwort	*Haloragis odontocarpa*	1
May Smocks	*Harmsiodoxa blennodioides*	1
Short Cress	*Harmsiodoxa brevipes var. brevipes*	1
Common Heliotrope	*Heliotropium europaeum*	1
Hydrilla	*Hydrilla verticillata*	1
Grass Cushion	*Isoetopsis graminifolia*	3
Inland Club-sedge	*Isolepis australiensis*	1
Broad-fruit Club-sedge	*Isolepis cernua var. platycarpa*	1
Tussock Rush	*Juncus aridicola*	3
Toad Rush	*Juncus bufonius*	2
Gold Rush	*Juncus flavidus*	4
Common Blown-grass	*Lachnagrostis filiformis*	1
Common Blown-grass	*Lachnagrostis filiformis var. 1*	3
Thin Duckweed	*Landoltia punctata*	1
Stalked Plover-daisy	*Leiocarpa websteri*	2
Warty Peppercress	*Lepidium papillosum*	7
Veined Peppercress	*Lepidium phlebopetalum*	1
Native Peppercress	*Lepidium pseudohyssopifolium*	2
Peppercress	*Lepidium spp.*	4
Brown Beetle-grass	*Leptochloa fusca subsp. fusca*	3
Button Rush	*Lipocarpha microcephala*	1
Red Bird's-foot Trefoil	*Lotus cruentus*	1
Clove-strip	*Ludwigia peploides subsp. montevidensis*	2
Box Thorn	*Lycium spp.*	1
Harlequin Mistletoe	*Lysiana exocarpi*	1
Grey Bluebush	*Maireana appressa*	1
Short-leaf Bluebush	*Maireana brevifolia*	2
Black Cotton-bush	*Maireana decalvans*	8
Hairy Bluebush	*Maireana pentagona*	11
Goat Head	*Malacocera tricornis*	1
Narrow-leaf Nardoo	*Marsilea costulifera*	3
Common Nardoo	*Marsilea drummondii*	6
Nardoo	*Marsilea spp.*	3
Moonah	*Melaleuca lanceolata subsp. lanceolata*	1
Bush Minuria	*Minuria cunninghamii*	1
Smooth Minuria	*Minuria integerrima*	8
Blue Rod	*Morgania glabra spp. agg.*	1
Tangled Lignum	*Muehlenbeckia florulenta*	10
Creeping Myoporum	*Myoporum parvifolium*	1
Mousetail	*Myosurus australis*	1
Coarse Water-milfoil	*Myriophyllum caput-medusae*	1
Robust Water-milfoil	*Myriophyllum papillosum*	1
Water-milfoil	*Myriophyllum spp.*	3
Red Water-milfoil	*Myriophyllum verrucosum*	1

Common Name	Scientific Name	Records
Water Nymph	*Najas tenuifolia*	1
Pimelea Daisy-bush	*Olearia pimeleoides*	1
Austral Adder's-tongue	*Ophioglossum lusitanicum*	1
Upright Adder's-tongue	*Ophioglossum polyphyllum*	3
Babbagia	*Osteocarpum acropterum var. deminutum*	1
Bonefruit	*Osteocarpum salsuginosum*	1
Swamp Lily	*Ottelia ovalifolia subsp. ovalifolia*	1
Grassland Wood-sorrel	*Oxalis perennans*	2
Wood Sorrel	*Oxalis spp.*	1
Hairy Panic	*Panicum effusum*	2
Knottybutt Grass	*Paspalidium constrictum*	1
Warrego Summer-grass	*Paspalidium jubiflorum*	5
Slender Knotweed	*Persicaria decipiens*	2
Common Reed	*Phragmites australis*	1
Sandhill Spurge	*Phyllanthus lacunellus*	1
Earth Moss	*Physcomitrella patens subsp. readeri*	1
Austral Pillwort	*Pilularia novae-hollandiae*	1
Weeping Pittosporum	*Pittosporum angustifolium*	2
Clay Plantain	*Plantago cunninghamii*	2
Plantain	*Plantago spp.*	1
Crowned Plantain	*Plantago turrifera*	2
Forde Poa	*Poa fordeana*	2
Poached-eggs Daisy	*Polycalymma stuartii*	1
Curly Pondweed	*Potamogeton crispus*	1
Blunt Pondweed	*Potamogeton ochreatus*	1
Fennel Pondweed	*Potamogeton pectinatus*	1
Perfoliate Pondweed	*Potamogeton perfoliatus s.l.*	1
Floating Pondweed	*Potamogeton tricarinatus s.l.*	2
Jersey Cudweed	*Pseudognaphalium luteoalbum*	6
Spiny Mud-grass	*Pseudoraphis spinescens*	1
Yellow Tails	*Ptilotus nobilis var. nobilis*	2
Long Tails	*Ptilotus polystachyus var. polystachyus*	1
Crimson Tails	*Ptilotus sessilifolius var. sessilifolius*	1
Inland Buttercup	*Ranunculus pentandrus var. platycarpus*	1
Hedge Saltbush	*Rhagodia spinescens*	2
Paper Sunray	*Rhodanthe corymbiflora*	1
Slender Dock	*Rumex brownii*	2
Narrow-leaf Dock	*Rumex tenax*	1
Prickly Saltwort	*Salsola tragus*	1
Prickly Saltwort	*Salsola tragus subsp. tragus*	3
Beaded Glasswort	*Sarcocornia quinqueflora*	1
Sarcozona	*Sarcozona praecox*	1
Prickly Fan-flower	*Scaevola spinescens*	1
River Club-sedge	*Schoenoplectus tabernaemontani*	3
Short-wing Saltbush	*Sclerochlamys brachyptera*	9
Grey Copperburr	*Sclerolaena diacantha*	3
Black Roly-poly	*Sclerolaena muricata*	2
Spear-fruit Copperburr	*Sclerolaena patenticuspis*	1
Streaked Copperburr	*Sclerolaena tricuspis*	5

Common Name	Scientific Name	Records
Slender Groundsel	*Senecio glossanthus s.l.*	10
Cotton Fireweed	*Senecio quadridentatus*	1
Desert Cassia	*Senna artemisioides spp. agg.*	1
Variable Sida	*Sida corrugata*	1
Pin Sida	*Sida fibulifera*	1
Twiggy Sida	*Sida intricata*	1
Sida	*Sida spp.*	1
Narrow-leaf Sida	*Sida trichopoda*	1
Quena	*Solanum esuriale*	1
Lesser Sea-spurrey	*Spergularia marina s.s.*	1
Salt Sea-spurrey	*Spergularia sp. 3*	2
Spreading Nut-heads	*Sphaeromorphaea australis*	1
Rat-tail Couch	*Sporobolus mitchellii*	21
Star Bluebush	*Stelligera endecaspinis*	4
Small-leaf Swainson-pea	*Swainsona microphylla*	1
Dwarf Swainson-pea	*Swainsona phacoides*	1
Silky Swainson-pea	*Swainsona sericea*	1
Desert Spinach	*Tetragonia eremaea s.l.*	1
Annual Spinach	*Tetragonia moorei*	1
Grey Germander	*Teucrium racemosum s.l.*	3
Grey Germander	*Teucrium racemosum s.s.*	1
Caltrop	*Tribulus terrestris*	1
Spurred Arrowgrass	*Triglochin calcitrapa s.l.*	1
Porcupine Grass	*Triodia scariosa*	1
Needle Grass	*Triraphis mollis*	1
Narrow-leaf Cumbungi	*Typha domingensis*	1
Bullrush	*Typha spp.*	1
Eel Grass	*Vallisneria americana var. americana*	2
Common Verbena	*Verbena officinalis s.l.*	1
Annual New Holland Daisy	*Vittadinia cervicularis*	1
Annual New Holland Daisy	*Vittadinia cervicularis var. subcervicularis*	1
Fuzzy New Holland Daisy	*Vittadinia cuneata*	1
Dissected New Holland Daisy	*Vittadinia dissecta s.l.*	2
New Holland Daisy	*Vittadinia spp.*	1
River Bluebell	*Wahlenbergia fluminalis*	4
Annual Bluebell	*Wahlenbergia gracilenta s.l.*	1
Bluebell	*Wahlenbergia spp.*	1
Green-tufted Stubble-moss	*Weissia controversa*	1
Common Early Nancy	*Wurmbea dioica*	1
Sand Twin-leaf	*Zygophyllum ammophilum*	2
Scrambling Twin-leaf	*Zygophyllum angustifolium*	1
Pointed Twin-leaf	*Zygophyllum apiculatum*	3
Pale Twin-leaf	*Zygophyllum glaucum*	3
Twin-leaf	*Zygophyllum spp.*	4

Flora – Exotic

Common Name	Scientific Name	Records
Orange Fox-tail	*Alopecurus aequalis*	1
Bridal Creeper	*Asparagus asparagoides*	1
Asparagus	*Asparagus officinalis*	2
Onion Weed	*Asphodelus fistulosus*	2
Aster-weed	*Aster subulatus*	9
Hastate Orache	*Atriplex prostrata*	1
Bearded Oat	*Avena barbata*	2
Oat	*Avena spp.*	2
Mediterranean Turnip	*Brassica tournefortii*	1
Lesser Quaking-grass	*Briza minor*	1
Great Brome	*Bromus diandrus*	2
Red Brome	*Bromus rubens*	7
Ward's Weed	*Carrichtera annua*	1
Malta Thistle	*Centaurea melitensis*	1
Rhodes Grass	*Chloris gayana*	1
Spear Thistle	*Cirsium vulgare*	2
Camel Melon	*Citrullus lanatus*	1
Water Buttons	*Cotula coronopifolia*	2
Paddy Melon	*Cucumis myriocarpus subsp. leptodermis*	1
Couch	*Cynodon dactylon var. dactylon*	1
Drain Flat-sedge	*Cyperus eragrostis*	1
Curry Flat-sedge	*Cyperus hamulosus*	1
Nutgrass	*Cyperus rotundus*	1
Stinkwort	*Dittrichia graveolens*	1
Barnyard Grass	*Echinochloa crus-galli*	1
Water Hyacinth	*Eichhornia crassipes*	1
Spiny Emex	*Emex australis*	1
Stink Grass	*Eragrostis cilianensis*	1
Fumitory	*Fumaria spp.*	1
Northern Barley-grass	*Hordeum glaucum*	4
Barley-grass	*Hordeum leporinum*	1
Barley-grass	*Hordeum murinum s.l.*	1
Smooth Cat's-ear	*Hypochoeris glabra*	14
Flatweed	*Hypochoeris radicata*	1
Spiny Rush	*Juncus acutus subsp. acutus*	1
Willow-leaf Lettuce	*Lactuca saligna*	1
Prickly Lettuce	*Lactuca serriola*	4
Golden-top	*Lamarckia aurea*	2
Common Peppercress	*Lepidium africanum*	1
Hoary Cress	*Lepidium draba*	4

Common Name	Scientific Name	Records
Wimmera Rye-grass	*Lolium rigidum*	3
Horehound	*Marrubium vulgare*	1
Little Medic	*Medicago minima*	3
Burr Medic	*Medicago polymorpha*	4
Lucerne	*Medicago sativa subsp. sativa*	1
Bokhara Clover	*Melilotus albus*	1
Sweet Melilot	*Melilotus indicus*	1
Melilot	*Melilotus spp.*	1
Common Ice-plant	*Mesembryanthemum crystallinum*	2
Small Ice-plant	*Mesembryanthemum nodiflorum*	1
Common Evening-primrose	*Oenothera stricta subsp. stricta*	1
Soursob	*Oxalis pes-caprae*	1
Coast Barb-grass	*Parapholis incurva*	1
Paspalum	*Paspalum dilatatum*	1
Water Couch	*Paspalum distichum*	5
Fog-fruit	*Phyla canescens*	15
Rice Millet	*Piptatherum miliaceum*	2
Ribwort	*Plantago lanceolata*	1
Prostrate Knotweed	*Polygonum aviculare s.l.*	1
Annual Beard-grass	*Polypogon monspeliensis*	1
Wiry Noon-flower	*Psilocaulon granulicaule*	2
False Sow-thistle	*Reichardia tingitana*	4
Tiny Bristle-grass	*Rostraria pumila*	6
Wild Sage	*Salvia verbenaca*	2
Arabian Grass	*Schismus barbatus*	4
Whorled Pigeon-grass	*Setaria verticillata*	1
Mallee Catchfly	*Silene apetala var. apetala*	4
Smooth Mustard	*Sisymbrium erysimoides*	3
London Rocket	*Sisymbrium irio*	1
Rough Sow-thistle	*Sonchus asper s.l.*	3
Common Sow-thistle	*Sonchus oleraceus*	16
Lesser Sand-spurrey	*Spergularia diandra*	2
Red Sand-spurrey	*Spergularia rubra s.l.*	2
Cluster Clover	*Trifolium glomeratum*	1
Woolly Clover	*Trifolium tomentosum var. tomentosum*	3
Arrowleaf Clover	*Trifolium vesiculosum var. vesiculosum*	2
Small Nettle	*Urtica urens*	1
Common Vetch	*Vicia sativa*	1
Rat's-tail Fescue	*Vulpia myuros*	4
Rat's-tail Fescue	*Vulpia myuros f. myuros*	3
Bathurst Burr	*Xanthium spinosum*	1

Common Name	Scientific Name	Records
Noogoora Burr species aggregate	*Xanthium strumarium spp. agg.*	1

Fauna – Native

Common Name	Scientific Name	Type	Records
Freshwater Shrimp	*Paratya australiensis*	I	1
Inland River Prawn	*Macrobrachium australiense*	I	1
Unspecked Hardyhead	*Craterocephalus stercusmuscarum fulvus*	F	3
Golden Perch	*Macquaria ambigua*	F	1
Western Carp Gudgeon	*Hypseleotris klunzingeri*	F	3
Flat-headed Gudgeon	*Philypnodon grandiceps*	F	4
Little Pied Cormorant	*Microcarbo melanoleucos*	B	30
Pied Butcherbird	*Cracticus nigrogularis*	B	16
Brown Quail	*Coturnix ypsilophora australis*	B	1
Little Button-quail	*Turnix velox*	B	1
Peaceful Dove	*Geopelia striata*	B	17
Common Bronzewing	*Phaps chalcoptera*	B	16
Crested Pigeon	*Ocyphaps lophotes*	B	21
Buff-banded Rail	*Gallirallus philippensis*	B	1
Australian Spotted Crake	*Porzana fluminea*	B	3
Baillon's Crake	*Porzana pusilla palustris*	B	3
Spotless Crake	*Porzana tabuensis*	B	1
Black-tailed Native-hen	*Gallinula ventralis*	B	3
Dusky Moorhen	*Gallinula tenebrosa*	B	10
Purple Swamphen	*Porphyrio porphyrio*	B	11
Eurasian Coot	*Fulica atra*	B	33
Australasian Grebe	*Tachybaptus novaehollandiae*	B	11
Hoary-headed Grebe	*Poliocephalus poliocephalus*	B	17
Great Cormorant	*Phalacrocorax carbo*	B	17
Little Black Cormorant	*Phalacrocorax sulcirostris*	B	23
Pied Cormorant	*Phalacrocorax varius*	B	10
Darter	*Anhinga novaehollandiae*	B	30
Australian Pelican	*Pelecanus conspicillatus*	B	49
Whiskered Tern	*Chlidonias hybridus javanicus*	B	3
Caspian Tern	*Hydroprogne caspia*	B	15
Silver Gull	*Chroicocephalus novaehollandiae*	B	10
Red-kneed Dotterel	*Erythrogonys cinctus*	B	3
Masked Lapwing	*Vanellus miles*	B	19
Banded Lapwing	*Vanellus tricolor*	B	1
Red-capped Plover	*Charadrius ruficapillus*	B	4
Black-fronted Dotterel	*Elseyornis melanops*	B	10

Common Name	Scientific Name	Type	Records
Red-necked Avocet	*Recurvirostra novaehollandiae*	B	2
Common Greenshank	*Tringa nebularia*	B	1
Marsh Sandpiper	*Tringa stagnatilis*	B	1
Curlew Sandpiper	*Calidris ferruginea*	B	1
Sharp-tailed Sandpiper	*Calidris acuminata*	B	2
Bush Stone-curlew	*Burhinus grallarius*	B	1
Australian White Ibis	*Threskiornis molucca*	B	18
Straw-necked Ibis	*Threskiornis spinicollis*	B	6
Royal Spoonbill	*Platalea regia*	B	1
Yellow-billed Spoonbill	*Platalea flavipes*	B	14
Little Egret	*Egretta garzetta nigripes*	B	1
Intermediate Egret	*Ardea intermedia*	B	1
Eastern Great Egret	*Ardea modesta*	B	23
White-faced Heron	*Egretta novaehollandiae*	B	28
White-necked Heron	*Ardea pacifica*	B	7
Nankeen Night Heron	*Nycticorax caledonicus hillii*	B	1
Little Bittern	*Ixobrychus minutus dubius*	B	2
Australian Wood Duck	*Chenonetta jubata*	B	33
Black Swan	*Cygnus atratus*	B	61
Plumed Whistling-Duck	*Dendrocygna eytoni*	B	1
Australian Shelduck	*Tadorna tadornoides*	B	51
Pacific Black Duck	*Anas superciliosa*	B	69
Chestnut Teal	*Anas castanea*	B	4
Grey Teal	*Anas gracilis*	B	64
Australasian Shoveler	*Anas rhynchotis*	B	4
Pink-eared Duck	*Malacorhynchus membranaceus*	B	2
Freckled Duck	*Stictonetta naevosa*	B	5
Hardhead	*Aythya australis*	B	5
Blue-billed Duck	*Oxyura australis*	B	2
Musk Duck	*Biziura lobata*	B	8
Swamp Harrier	*Circus approximans*	B	17
Brown Goshawk	*Accipiter fasciatus*	B	2
Little Eagle	*Hieraaetus morphnoides*	B	5
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	B	1
Whistling Kite	*Haliastur sphenurus*	B	24
Black Kite	*Milvus migrans*	B	8
Australian Hobby	*Falco longipennis*	B	4
Grey Falcon	*Falco hypoleucos*	B	1
Peregrine Falcon	*Falco peregrinus*	B	1
Nankeen Kestrel	*Falco cenchroides*	B	6
Southern Boobook	*Ninox novaeseelandiae*	B	1
Sulphur-crested Cockatoo	*Cacatua galerita*	B	2

Common Name	Scientific Name	Type	Records
Major Mitchell's Cockatoo	*Lophocroa leadbeateri*	B	1
Little Corella	*Cacatua sanguinea*	B	3
Long-billed Corella	*Cacatua tenuirostris*	B	1
Galah	*Eolophus roseicapilla*	B	13
Regent Parrot	*Polytelis anthopeplus monarchoides*	B	3
Crimson Rosella	*Platycercus elegans*	B	27
Red-rumped Parrot	*Psephotus haematonotus*	B	30
Tawny Frogmouth	*Podargus strigoides*	B	2
Laughing Kookaburra	*Dacelo novaeguineae*	B	22
Sacred Kingfisher	*Todiramphus sanctus*	B	16
Rainbow Bee-eater	*Merops ornatus*	B	3
Pallid Cuckoo	*Cuculus pallidus*	B	4
Black-eared Cuckoo	*Chrysococcyx osculans*	B	1
Horsfield's Bronze-Cuckoo	*Chrysococcyx basalis*	B	3
Welcome Swallow	*Petrochelidon neoxena*	B	25
Tree Martin	*Petrochelidon nigricans*	B	12
Fairy Martin	*Petrochelidon ariel*	B	1
Grey Fantail	*Rhipidura albiscarpa*	B	4
Willie Wagtail	*Rhipidura leucophrys*	B	31
Restless Flycatcher	*Myiagra inquieta*	B	1
Red-capped Robin	*Petroica goodenovii*	B	9
Hooded Robin	*Melanodryas cucullata cucullata*	B	7
Rufous Whistler	*Pachycephala rufiventris*	B	17
Grey Shrike-thrush	*Colluricincla harmonica*	B	21
Magpie-lark	*Grallina cyanoleuca*	B	27
Crested Shrike-tit	*Falcunculus frontatus*	B	1
Crested Bellbird	*Oreoica gutturalis gutturalis*	B	1
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	B	14
White-bellied Cuckoo-shrike	*Coracina papuensis*	B	1
White-winged Triller	*Lalage sueurii*	B	3
White-browed Babbler	*Pomatostomus superciliosus*	B	3
Chestnut-crowned Babbler	*Pomatostomus ruficeps*	B	3
White-fronted Chat	*Epthianura albifrons*	B	1
Crimson Chat	*Epthianura tricolor*	B	1
Western Gerygone	*Gerygone fusca*	B	1
Weebill	*Smicrornis brevirostris*	B	17
Southern Whiteface	*Aphelocephala leucopsis*	B	3
Yellow Thornbill	*Acanthiza nana*	B	3
Chestnut-rumped Thornbill	*Acanthiza uropygialis*	B	8
Buff-rumped Thornbill	*Acanthiza reguloides*	B	1
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	B	3
Rufous Songlark	*Cincloramphus mathewsi*	B	1

Common Name	Scientific Name	Type	Records
Little Grassbird	*Megalurus gramineus*	B	3
Clamorous Reed Warbler	*Acrocephalus stentoreus*	B	20
Superb Fairy-wren	*Malurus cyaneus*	B	12
Variegated Fairy-wren	*Malurus lamberti*	B	9
White-breasted Woodswallow	*Artamus leucorynchus*	B	4
Masked Woodswallow	*Artamus personatus*	B	3
White-browed Woodswallow	*Artamus superciliosus*	B	4
Dusky Woodswallow	*Artamus cyanopterus*	B	12
White-browed Treecreeper	*Climacteris affinis*	B	3
Mistletoebird	*Dicaeum hirundinaceum*	B	8
Spotted Pardalote	*Pardalotus punctatus*	B	1
Silvereye	*Zosterops lateralis*	B	1
Brown-headed Honeyeater	*Melithreptus brevirostris*	B	1
Striped Honeyeater	*Plectorhyncha lanceolata*	B	1
White-fronted Honeyeater	*Phylidonyris albifrons*	B	1
Painted Honeyeater	*Grantiella picta*	B	1
White-plumed Honeyeater	*Lichenostomus penicillatus*	B	27
Noisy Miner	*Manorina melanocephala*	B	29
Yellow-throated Miner	*Manorina flavigula*	B	1
Red Wattlebird	*Anthochaera carunculata*	B	5
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*	B	3
Blue-faced Honeyeater	*Entomyzon cyanotis*	B	7
Noisy Friarbird	*Philemon corniculatus*	B	1
Little Friarbird	*Philemon citreogularis*	B	15
Zebra Finch	*Taeniopygia guttata*	B	3
Apostlebird	*Struthidea cinerea*	B	2
Little Crow	*Corvus bennetti*	B	1
White-winged Chough	*Corcorax melanorhamphos*	B	8
Grey Butcherbird	*Cracticus torquatus*	B	2
Australian Magpie	*Gymnorhina tibicen*	B	26
Australian Raven	*Corvus coronoides*	B	17
Rock Dove	*Columba livia*	B	11
Striated Pardalote	*Pardalotus striatus*	B	13
Common Brushtail Possum	*Trichosurus vulpecula*	M	2
Western Grey Kangaroo	*Macropus fuliginosus*	M	1
Inland Broad-nosed Bat	*Scotorepens balstoni*	M	1
Water Rat	*Hydromys chrysogaster*	M	2
Tree Dtella	*Gehyra variegata*	R	1
Bynoe's Gecko	*Heteronotia binoei*	R	1
Beaked Gecko	*Rhynchoedura ornata*	R	
Lace Monitor	*Varanus varius*	R	1
Dwarf Burrowing Skink	*Lerista timida*	R	1

Common Name	Scientific Name	Type	Records
Boulenger's Skink	*Morethia boulengeri*	R	6
Mueller's Skink	*Lerista muelleri*	R	1
Western Blue-tongued lizard	*Tiliqua occipitatis*	R	
Stumpy-tailed Lizard	*Tiliqua rugosa*	R	1
Lined Earless Dragon	*Tympanocryptis lineata lineata*	R	
Yellow-faced Whip Snake	*Demansia psammophis*	R	1
Tiger Snake	*Notechis scutatus*	R	4
Eastern Brown Snake	*Pseudonaja textilis*	R	1
Curl Snake	*Suta suta*	R	1
Broad-shelled Turtle	*Chelodina expansa*	R	10
Commong Long-necked Turtle	*Chelodina longicollis*	R	4
Murray River Turtle	*Emydura macquarji*	R	21
Southern Bullfrog (ssp. unknown)	*Limnodynastes dumerilii*	A	2
Barking Marsh Frog	*Limnodynastes fletcheri*	A	4
Spotted Marsh Frog (race unknown)	*Limnodynastes tasmaniensis*	A	11
Plains Froglet	*Crinia parinsignifera*	A	7
Peron's Tree Frog	*Litoria peronii*	A	4
Growling Grass Frog	*Litoria raniformis*	A	3
Yellow Rosella	*Platycercus elegans flaveolus*	B	8
Brown Treecreeper (south-eastern ssp.)	*Climacteris picumnus victoriae*	B	20
Carpet Python	*Morelia spilota metcalfei*	R	1
Silver Perch	*Bidyanus bidyanus*	F	1
Crimson-spotted Rainbowfish	*Melanotaenia fluviatilis*	F	
Freshwater Catfish	*Tandanus tandanus*	F	5
Black-winged Stilt	*Himantopus himantopus*	B	2

Legend

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

Fauna – Exotic

Common Name	Scientific Name	Type	Records
Common Starling	*Sturnus vulgaris*	B	4
House Sparrow	*Passer domesticus*	B	3
Common Blackbird	*Turdus merula*	B	2
Northern Mallard	*Anas platyrhynchos*	B	1
European Goldfinch	*Carduelis carduelis*	B	1
European Rabbit	*Oryctolagus cuniculus*	M	1
European Hare	*Lepus europeaus*	M	2

Common Name	Scientific Name	Type	Records
Redfin	*Perca fluviatilis*	F	1
Goldfish	*Carassius auratus*	F	1
Eastern Gambusia	*Gambusia holbrooki*	F	1
Red Fox	*Vulpes vulpes*	M	1

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

APPENDIX 2.

ECOLOGICAL VEGETATION CLASSES (EVCS)

EVC no.	EVC name	Bioregional Conservation Status Robinvale Plains Bioregion	Description
106	Grassy Riverine Forest	Depleted	Occurs on the floodplain of major rivers, in a slightly elevated position where floods are infrequent, on deposited silts and sands, forming fertile alluvial soils. River Red Gum forest to 25 m tall with a groundlayer dominated by tussock-forming graminoids. Occasional tall shrubs present.
813	Intermittent Swampy Woodland	Depleted	Eucalypt woodland to 15 m tall with a variously shrubby and rhizomatous sedgy - turf grass understorey, at best development dominated by flood stimulated species in association with flora tolerant of inundation. Flooding is unreliable but extensive when it happens. Occupies low elevation areas on river terraces (mostly at the rear of point-bar deposits or adjacent to major floodways) and lacustrine verges (where sometimes localised to narrow transitional bands). Soils often have a shallow sand layer over heavy and frequently slightly brackish soils.
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 Lignumshrubs. Occupies heavy soil plains along Murray River, low-lying areas on higher-level (but still potentially flood-prone) terraces.
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.

EVC no.	EVC name	Bioregional Conservation Status Robinvale Plains Bioregion	Description
819	Spike-sedge Wetland	Vulnerable	Low sedgy vegetation of species-poor seasonal or intermittent wetlands, dominated by spike-sedges. Typically treeless, but sometimes thickets of saplings or scattered more mature specimens of Eucalyptus camaldulensis. Mostly confined to a narrow ring around the upper margins of floodway ponds. Soils are typically heavy clays (eg mottled yellow-grey clay, grey loamy clay), occasionally silty near the surface. In some riverine sites, annual inundation is not reliable and the rhizomic rootstocks of Eleocharis acuta appear capable of surviving at least occasional periods of longer dormancy.
821	Tall Marsh	Depleted	Wetland dominated by tall emergent graminoids (rushes, sedges, reeds), typically in thick species-poor swards. Competitive exclusion in core wetland habitat - of optimum growing conditions for species tolerant of sustained shallow inundation. Occupies wetlands usually associated with anabranch creeks. Soils are almost permanently moist. Dominant species are tolerant of relatively deep and sustained inundation, but not total immersion for any sustained period.
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.
104	Lignum Swamp	Vulnerable	A relatively heterogenous group of species-poor wetlands dominated by robust and often dense lignum. Scattered in lower rainfall areas of north and west, including rain-shadow areas on basalt.
102	Low Chenopod Shrubland	Depleted	Sparse, low non-eucalypt woodland to 12m tall of the arid zone with a tall open chenopod shrub-dominated understorey to a treeless, tall chenopod shrubland to 3m 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 occasional emergent.
97	Semi-arid Woodland	Vulnerable	Non-eucalypt woodland or open forest to 12m 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.

EVC no.	EVC name	Bioregional Conservation Status Robinvale Plains Bioregion	Description
98	Semi-arid Chenopod Woodland	Vulnerable	Sparse, low non-eucalypt woodland to 12m tall of the arid zone with a tall open chenopod shrub-dominated understorey to a treeless, tall chenopod shrubland to 3m 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.

Source: DSE, 2013

APPENDIX 3.

PSYCHE BEND LAGOON AND WOORLONG WETLAND EWMP UPDATED ENVIRONMENTAL OBJECTIVES, FURTHER INFORMATION (FROM BUTCHER ET AL 2020)

Psyche Bend Lagoon and Woorlong Wetland EWMP – Information describing rationale behind updated environmental objectives and targets (from Butcher et al 2020)

SMARTness and rationalisation

Site-specific environmental objectives for the Psyche Bend Lagoon and Woorlong Wetland EWMP (Mallee CMA 2016d).

EWMP objectives
PW1: Self-sustaining population of Murray Hardyhead following translocation - (Psyche)
PW2: Extensive beds of *Ruppia* spp. in wetland - (Psyche)
PW3: Provide shallow water habitat and exposure of mudflats to support foraging and resting of small waders – (Psyche and Woorlong)
PW4: Healthy and productive Lignum and chenopod communities – (Woorlong)
PW5: Provide seasonal aquatic that supports a diverse range of small fish and frogs – (Woorlong)
PW6: Reduce the area of Woorlong wetland dominated by reed (Phragmites and Cumbungi) communities – (Woorlong)
PW7: Maintain high levels of aquatic productivity - (Psyche and Woorlong)

Assessment of SMARTness of current Psyche Bend Lagoon and Woorlong Wetland EWMP objectives. Scoring: 1 is criterion met, 0 is criterion not met, and 0.5 is partially met

	Specific		Measurable			Achievable		Relevant		Timely	
Objective	Magnitude clearly specified	Location and scale detailed	Indicators available or easily developed	Can be analysed using accepted statistical practices	Capacity to collect data exists	Under river operating constraints and current climate variability	Considered feasible by knowledgeable stakeholders	Matters driven by environmental watering and/or works and measures	Linked to BP objectives	Absolute date or time period specified	Considers likely lags in response
PW1	0	0.5	1	1	1	0.5	0.5	0.5	1	0	0
PW2	0	0.5	0.5	0.5	1	0.5	0.5	0.5	0.5	0	0
PW3	0	0	1	1	1	0.5	1	1	1	0	0
PW4	0	0.5	1	1	1	0.5	1	1	0.5	0	0
PW5	0	0	0	0	0	0	0	0	0	0	0
PW6	0	1	1	1	1	0.5	1	0.5	1	0	0
PW7	0	0	0.5	0.5	1	0.5	0	0.5	1	0	0

Rationalised environmental objectives for the Psyche Bend Lagoon and Woorlong Wetland EWMP (Mallee CMA 2016d).

Objective	Issue	Outcome
PW1	No longer considered viable by MCMA	Deleted
PW2	Ruppia species not listed in EWMP – need this information to advise on water regime for target setting.	As *R. megacarpa* is a perennial species whereas *R. polycarpa* is an annual – it is possible that *megacarpa* is the species at this wetland. Also ALA records suggest *R. megacarpa* is more common in the region, but this is obviously dependent on sampling and reporting to ALA – species present needs to be determined particularly as salinity tolerance will differ among halophytes.
PW3	Originally identified as not being viable by MCMA, but later included – may need to be reviewed further. Objective for waders added.	Objective may end up being deleted in the future as there is uncertainty around viability of achieving outcomes.
PW4	Objective has multiple outcomes - Consider simplifying.	Rationalised to align with LTWP objectives with the assumption that if condition is improved this incorporates productivity.
PW5	Split objective – one for small bodied fish and one for frogs	Need species list for the frogs
PW6	No problem with having an objective dealing with these species, just needs to be SMART	Not linked to Basin Plan.
PW7	Not considered viable at the asset by MCMA. Productivity objectives were included in EWMPs as a fundamental ecological function; however this is not a specific value of the site and water is not delivered solely for productivity outcomes at this wetland; it will be an outcome achieved by the delivery of water for the other objectives at the asset.	Deleted

Mapping to Basin Plan

Basin Plan Schedule 8 and 9 criteria.

Schedule 8 criteria met	Schedule 9 criteria met
From DELWP (2015a)	
4: EPBC act, FFG Act, DSE Listed **5:** Recognised as a significant conservation area	**1:** Supports the creation and maintenance of vital habitats and populations **2:** water quality - ecosystem processes supports the transportation and dilution of nutrients, organic matter and sediment; supports the dilution of carbon and nutrients from the floodplain to the river system **4:** lateral connectivity - (between floodplains, anabranches and wetlands)
Updated assessment	
3(b): Prevents declines in native biota **4(a):** EPBC listed spp and communities	**1(e):** Vital habitat - preventing decline of native biota

Mapping Psyche Bend Lagoon and Woorlong Wetland EWMP objectives to Basin Plan EWP objectives, Schedule 7 targets, BWS QEEO, and LTWP Vic Murray objective.

EWMP objectives	Relevant Basin Plan EWP objective	Relevant Schedule 7 target	Relevant BWS QEEO	LTWP objective
PW1: Self-sustaining population of Murray Hardyhead following translocation - (Psyche)	8.05,3(a)	Condition of priority asset - supports listed species and communities Condition of priority asset - prevention of decline in native biota	B4.1	LTWPVM16
PW2: Extensive beds of Ruppia spp. in wetland - (Psyche)	8.05,3(b)	Extent and contiguousness of native water dependent vegetation Condition of priority asset - prevention of decline in native biota	B2.11	LTWPVM4
PW3: Provide shallow water habitat and exposure of mudflats to support foraging and resting of small waders – (Psyche and Woorlong)	8.05,3(b)	Condition of priority asset - prevention of decline in native biota Condition of priority asset - vital habitat - feeding, breeding, nursery	None specified	None specified
PW4: Healthy and productive Lignum and chenopod communities – (Woorlong)	8.05,3(b) 8.06,6(b)	Condition of priority asset - prevention of decline in native biota Diversity of native water dependent vegetation Condition of water-dependent vegetation Condition of priority ecosystem functions - creation of vital habitat - habitat for prevention of decline in native species	B2.10	LTWPVM8
PW5: Provide seasonal aquatic habitat that supports a diverse range of small fish and frogs – (Woorlong)	8.05,3(b) - SBF	Condition of priority asset - prevention of decline in native biota Recruitment and populations of native fish	B4.5	LTWPVM15
	8.05,3(b) – Frogs 8.05,3(a)	Condition of priority asset - prevention of decline in native biota Condition of priority asset – supports EPBC listed species Recruitment and populations of other native water-dependent biota	None specified	LTWPVM19 LTWPVM20
PW6: Reduce the area of Woorlong wetland dominated by reed (Phragmites and Cumbungi) communities – (Woorlong)	Not applicable	Not applicable	None specified	None specified
PW7: Maintain high levels of aquatic productivity - (Psyche and Woorlong)	8.06,7	Condition of priority ecosystem functions – connectivity – off-stream productivity	None specified	None specified

Updated objectives for Psyche Bend Lagoon and Woorlong Wetland

Current objective	PW1: Self-sustaining population of Murray Hardyhead following translocation - (Psyche)
Comments	Deleted

Current objective	PW2: Extensive beds of Ruppia spp. in wetland - (Psyche)
Comments	Need to establish baseline of species present and salinity tolerance thresholds for *Ruppia* species present. Likely to be both polycarpa and megacarpa as multiple species are mentioned in the EWMP.
EWP objective(s)	8.05,3(b)
Schedule 7 targets	Condition of priority asset - prevention of decline in native biota
PEA/PEF criteria met	PEA 3(b) Prevents declines in native biota
BWS QEEO	B2.11
LTWP objective	LTWPVM4 Improve the extent of aquatic vegetation
LTWP target	None specified
2020 Objective:	By 2030, maintain populations and extent of saline aquatic vegetation at Psyche Bend Lagoon, Psyche Woorlong including benthic herblands with *Ruppia* beds containing both *R. polycarpa* and *R. megacarpa*.
2020 Targets:	By 2030, vigorous populations of saline aquatic vegetation at Psyche Bend Lagoon, Psyche Woorlong: - improve cover of *Ruppia* to ≥30% and at least 10 live (green) shoots per core at 80% of sites assessed - measured by taking sediment 5 core samples (75mmx4cm deep) at transects of dry zone above waterline, waterline, 30cm and 60cm depths - up to five random transects per site minimum of 200m apart To achieve this specific water regime and salinity levels will need to be established – i.e. once a baseline is established these targets may be modified. Sampling method modified from Paton et al. (2018). Suggested salinity threshold of 30ppt should support growth/germination and condition of both species (see Sim et al. 2006). Flowering is likely to require 3 months at <15ppt salinity (Sim et al. 2006). These thresholds need to be confirmed for this wetland system.

Current objective	PW3: Provide shallow water habitat and exposure of mudflats to support foraging and resting of small waders – (Psyche and Woorlong)
Comments	Focus is on feeding guild - foraging
EWP objective(s)	8.05,3(b)
Schedule 7 targets	Condition of priority asset - vital habitat - feeding, breeding, nursery
PEA/PEF criteria met	PEA 3(a) iii Vital habitat - feeding, breeding, nursery sites PEF 1 (c) Vital habitat - feeding, breeding, nursery sites
BWS QEEO	B3.1 That the number and type of water bird species present in the Basin will not fall below current observations
LTWP objective	LTWPVM13: Improve feeding areas for waterbirds LTWPVM12: Improve habitat for waterbirds
LTWP target	Appropriate water regime to support feeding and habitat areas for guilds of waterbirds delivered at 50% of sites, 8 years in 10
2020 Objective:	By 2030, maintain representative populations of the shallow-water feeding guild of waterbirds (F2, after Jaensch 2002) at Pysche and Woorlong by maintaining shallow-water habitats.
2020 Targets:	By 2030, 80% of representative F2 species recorded at Pysche and Woorlong, in 8 years out of any 10-year period where conditions are suitable. • Representative F2 species of small waders includes: Masked Lapwing (*Vanellus miles*), Red-necked Avocet (*Recurvirostra novaehollandiae*) Red-capped Plover (*Charadrius ruficapillus*), Black-fronted Dotterel (*Elseyornis melanops*), Red-kneed Dotterel (*Erythrogonys cinctus*), Black-winged Stilt (*Himantopus himantopus*), and Sharp-tailed Sandpiper (*Calidris acuminata*) • Feeding habitat defined as shallow feeding areas (<0.5 m depth and or drying mud) with intermittent inundation of densely vegetated shrublands.

Current objective	PW4: Healthy and productive Lignum and chenopod communities – (Woorlong)
Comments	Rationalised to align with LTWP objectives with the assumption that if condition is improved this incorporates productivity.
EWP objective(s)	8.05,3(b) 8.06,6(b)
Schedule 7 targets	Condition of priority asset - prevention of decline in native biota Diversity of native water dependent vegetation Condition of water-dependent vegetation Condition of priority ecosystem functions - creation of vital habitat - habitat for prevention of decline in native species
PEA/PEF criteria met	PEA 3(b) Prevents declines in native biota PEF 1(e) Vital habitat - preventing decline of native biota
BWS QEEO	B2.10 Maintain extent of Lignum along the Murray River from the junction with the Wakool River to downstream of Lock 3, including Chowilla and Hattah Lakes
LTWP objective	LTWPVM8: Improve the condition of shrub and lignum dominated EVCs
LTWP target	A positive trend in the condition score of Shrub and Lignum dominated EVC benchmarks at 50% of sites over the 10 year period to 2025
2020 Objective:	By 2030, improve condition and maintain extent from baseline levels of Lignum (*Duma florulenta*) to sustain communities and processes reliant on Lignum communities at Woorlong Wetland, Psyche Woorlong
2020 Targets:	By 2030, condition in standardised transects that span the floodplain elevation gradient and existing spatial distribution, ≥70% of Lignum plants in good condition with a Lignum Condition Score (LCI) ≥4.

Current objective	PW5: Provide seasonal aquatic that supports a diverse range of small fish and frogs – (Woorlong)
Comments	Objective split to cover frogs and fish separately
EWP objective(s)	8.05,3(b)
Schedule 7 targets	Condition of priority asset - prevention of decline in native biota
PEA/PEF criteria met	PEA 3(b) Prevents declines in native biota
BEWS QEEO	B4.5 Improved community structure of key native fish species
LTWP objective	LTWPMV15 Maintain abundance of small-bodied native fish in wetlands
LTWP target	No negative trend in the abundance of small-bodied wetland specialist native fish in 2025
2020 Objective PW5a:	By 2030, protect and restore biodiversity by maintaining representative populations of small bodied native fish at Woorlong, Psyche Woorlong including Unspecked Hardyhead (*Craterocephalus stercusmuscarum fulvus*), Western Carp Gudgeon (*Hypseleotris klunzingeri*) and Flat-headed Gudgeon (*Philypnodon grandiceps*)
2020 Targets PW%a:	By 2030, maintain self-sustaining populations of Unspecked Hardyhead (*Craterocephalus stercusmuscarum fulvus*), Western Carp Gudgeon (*Hypseleotris klunzingeri*) and Flat-headed Gudgeon (*Philypnodon grandiceps*) at Woorlong, Psyche Woorlong, measured as: • Adults or YoY for each species recorded in 8 out of 10 years
Comments	Need species confirmed
EWP objective(s)	8.05,3(b) 8.05,3(a)
Schedule 7 targets	Condition of priority asset - prevention of decline in native biota Condition of priority asset – supports EPBC listed species Recruitment and populations of other native water-dependent biota

PEA/PEF criteria met	PEA 3(b) Prevents declines in native biota PEA 4 (a) EPBC listed spp and communities PEF 1(e) Vital habitat - preventing decline of native biota
BEWS QEEO	None specified
LTWP objective	LTWPVM19 Improve habitat for frog communities LTWPVM20 Maintain species richness of frog communities
LTWP target	Maintain the number of native frog species recorded in 80% of years to 2025
2020 Objective PW5b:	By 2030, protect and restore biodiversity by maintaining representative populations of frogs at the Psyche Bend Lagoon and Woorlong Wetland asset.
2020 Targets PW5b:	By 2030, maintain self-sustaining populations of frogs at the Psyche Bend Lagoon and Woorlong Wetland asset: • Barking marsh frog (*Limnodynastes fletcheri*), Plains froglet (*Crinia parainsignifera*), Southern bullfrog (*Limnodynastes dumerilii*), and Spotted marsh frog (*Limnodynastes tasmaniensis*) - Need to confirm frog species at the site

Current objective	**PW6: Reduce the area of Woorlong wetland dominated by reed (Phragmites and Cumbungi) communities – (Woorlong)**
Comments	Not covered under the Basin Plan – but can still have an objective relating to their control.
EWP objective(s)	Not applicable as they are problematic natives – Basin plan only refers to alien
Schedule 7 targets	Not applicable
PEA/PEF criteria met	Not applicable
BWS QEEO	Not applicable
LTWP objective	None specified
LTWP target	None specified
2020 Objective:	By 2030, reduce the extent of invasive emergent macrophytes (Typha *Typha domingensis* and Common reed *Phragmites australis*) to prevent the decline of native vegetation at the Woorlong Wetlands, Psyche Woorlong
2020 Targets:	By 2030, reduce the spatial extent of Typha *Typha domingensis* and Common reed *Phragmites australis* in Woorlong wetlands, Psyche Woorlong by 25%

Current objective	**PW7: Maintain high levels of aquatic productivity - (Psyche and Woorlong)**
Comments	Deleted

APPENDIX 4.
COMMUNITY CONSULTATION 2023 SUMMARY

Four of forty-seven respondents (8.51%) chose Psyche Woorlong as the most important area to them, however only two respondents completed the Psyche Woorlong survey. Of the six wetlands shown in the survey map, respondents visited Psyche Bend Lagoon (1/2), Woorlong wetlands (2/2) and Power Station Wetland (1/2). Both respondents nominated Woorlong Wetlands as the most important or meaningful to them at the site, and both respondents scored values only for Woorlong Wetland. Both respondents were residents, and one described themselves as a recreational user of Psyche Woorlong. One user visited daily, while the other visited the site once or twice per year. Visits occurred in all seasons.

Both respondents use the site for walking and running. Additional uses included socialising (1/2) and nature appreciation (1/2). No new water-dependent values were identified for the site (above those already known from the existing EWMP and other literature).

At Woorlong Wetlands the unique landscape features and natural beauty, recreational opportunities, exercise trails and work/education opportunities were unanimously extremely important to participants (score 5/5). Commercial or business opportunities were of mixed importance to respondents (scores of 1/5 and 4/5).

Neither participant completed 'importance' surveys for Wonega Avenue drain or for Psyche Bend lagoon.

Both respondents were in the 45-54 year age category.

Survey respondents were asked to rank the importance of known values at visited wetlands. These rankings are summarised in **Table 25**.

Table 25 - Community Values Rankings - Woorlong Wetlands (two completed surveys)

Community Value	*Value Ranking*
Unique landscape features and natural beauty	Unique landscape features and natural beauty were of extremely high importance to survey respondents (score 5/5). One of two survey respondents use Woorlong Wetlands for Nature Appreciation.
Recreational opportunities (e.g. birdwatching, fishing)	Recreational opportunities were of extremely high importance to both of survey respondents (score 5/5).
Exercise (trails for walking, running, cycling)	Both survey respondents considered the exercise values of Kings Billabong to be of extremely high importance (score 5/5). Both respondents use Woorlong wetlands for running/walking.
Work or Education opportunities	Work or education opportunities were of extremely high importance to both respondents (score 5/5).
Socialising	One of two survey respondents used Woorlong Wetlands for socialising
Commercial or business opportunities	Commercial or business opportunities were of mixed importance to respondents (score 2.5/5) with one considering these opportunities as of high importance, while the second respondent scored such opportunities as not important at all.

mallee
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