Horseshoe Lagoon, Trawool

Environmental Water Management Plan

August 2019

GOULBURN BROKEN CATCHMENT MANAGEMENT AUTHORITY

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Horseshoe Lagoon Environmental Water Management Plan

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Front cover image: Horseshoe Lagoon, December 2018 (Photo: Melanie Tranter, Jacobs)

Executive summary

This plan is prepared to guide the use of environmental water at Horseshoe Lagoon, a wetland on the Goulburn River floodplain near Trawool. Environmental water is a legally recognised amount of water, set aside to meet environmental needs for sites such as Horseshoe Lagoon.

This watering plan is not a holistic management plan for the site as it is limited to issues related to the management of water dependent values and environmental water.

Horseshoe Lagoon is set in a bend of the Goulburn River between Kerrisdale and Trawool, approximately 15 km south east of Seymour. The lagoon is a paleochannel of the Goulburn River and is approximately 2.5 m deep at its deepest point (Australian Ecosystems, 2012). The lagoon is located within the Horseshoe Lagoon Flora and Fauna Reserve, a 46-hectare reserve managed by Parks Victoria, with some lower lying areas surrounding it extending into private land.

Horseshoe Lagoon is of great significance to Taungurung peoples, particularly Taungurung women, as it is central to a creation story of the first women from which they descend. The Taungurung moieties are represented in this story and determined the pattern for marriage between individuals, clans and other tribes. Accordingly, the Taungurung Land and Waters Council have expressed a keen interest in being a part of the ongoing management of the site.

Horseshoe Lagoon has been assessed as being in excellent condition, providing a representative example of wetland types less commonly found on the mid-Goulburn floodplain. The lagoon supports a diversity of native plant and animal species, many of which are of conservation significance. These values have been used to develop management objectives associated with the future use of environmental water at the site.

Management goal: *Provide a watering regime at Horseshoe Lagoon that protects and restores ecosystem functions, and provides vital habitat needed to support the life cycles of water-dependent plants and animals over the longer term.*

Supporting objectives needed to achieve this management goal were developed in collaboration with a range of agency stakeholders, the Taungurung Land and Waters Council and wetland ecologists. These include:

- Protect diversity, recruitment and regeneration of target ecological vegetation classes from the 2012 - 2019 benchmark by 2025
- Ensure the protection of threatened plant species by establishing benchmark condition by 2024 and setting an objective by 2025.
- Protect turtle populations by providing the feeding and breeding habitat needed to support life cycle processes, assessed by the presence of priority species in 50% years to 2025.
- Protect waterbird species diversity, through improved access to feeding and roosting habitat, assessed by the presence of all expected guilds in 50% of years to 2025.
- Protect the diversity of frog species in 80% of years to 2025.

Changes to the flooding patterns in Horseshoe Lagoon have occurred due to regulation of the Goulburn River. Therefore, a wetland watering regime has been derived from the ecological and hydrological objectives, using a seasonally adaptive approach that allows for variability in planned watering actions over time. This means that a watering regime is identified for optimal conditions, as well as maximum and minimum tolerable watering scenarios that may occur in dry or wet years.

The proposed watering regime considers both naturally occurring and managed floods. As such, environmental watering will target the shortfall in desired flooding frequency between naturally occurring events.

The optimum watering regime is to:

> *Provide flooding 8 years in ten, with dry phases in the deepest parts of the lagoon not extending for more than 6 months. Fill wetland to variable depths of up to 2.5m during winter or spring to provide the target EVCs with appropriate watering requirement, allow regeneration and recruitment of vegetation within the wetland body and maintain the duration of flooding for 9 months to provide optimum breeding opportunities for aquatic biota including Black swan.*
>
> *Top up flows may be provided in some years.*

Environmental water will be delivered to the lagoon using a temporary pump to transfer water from the Goulburn River. An estimated 100 to 150 ML of water will be used to fill the lagoon and will be further refined following future deliveries of water to the site.

A range of complementary actions have been identified to assist with other threats to achieving the site management goal. The high priority risks include fox predation on turtle nests, exotic fish damaging vegetation within the lagoon and recreational impacts associated with visitation and camping.

The strategies outlined in this Plan will be reviewed over time and implemented in collaboration with a range of stakeholders including the Goulburn Broken Catchment Management Authority, Parks Victoria, the Taungurung Land and Waters Council, Goulburn Murray Water and the Department of Environment, Land, Water and Planning. Monitoring actions and knowledge gaps that need to be addressed to support this review process are identified in this Plan and will be implemented where funding is available.

Table of contents

ABBREVIATIONS

CAMBA	China Australia Migratory Bird Agreement
CEWO	Commonwealth Environmental Water Office
CMAs	Catchment Management Authorities
DELWP	Department of Environment, Land, Water and Planning
EPBC	*Environment Protection Biodiversity Conservation Act* 1999 (Cth)
EVC	Ecological vegetation class
EWMP	Environmental Water Management Plan
EWR	Environmental Water Reserve
FFG	*Flora and Fauna Guarantee Act* 1988 (Vic)
GB CMA	Goulburn Broken Catchment Management Authority
GMW	Goulburn Murray Water
Ha	Hectare
IWC	Index of Wetland Condition
JAMBA	Japan- Australia Migratory Bird Agreement
ML	Megalitre (one million litres)
ROKAMBA	Republic of Korea Australia Migratory Bird Agreement
TLWC	Taungurung Land and Waters Council
VEWH	Victorian Environmental Water Holder

1. Introduction

1.1 Purpose of this plan

This plan is prepared to guide the use of environmental water at Horseshoe Lagoon, a wetland on the Goulburn River floodplain near Trawool. Environmental water is a legally recognised amount of water, set aside to meet environmental needs for sites such as Horseshoe Lagoon.

This watering plan is not a holistic management plan for the site as it is limited to issues related to the management of water dependent values and environmental water.

1.2 Important note

Horseshoe Lagoon is a site of particularly high cultural significance to Taungurung peoples (section 3.4). The cultural health of Taungurung Country is closely linked to ecological health. This plan contributes to the aspirations of the Taungurung Country Plan by seeking to protect the health of the water dependent environmental values associated with Horseshoe Lagoon.

Representatives of the Taungurung Land and Waters Council (TLWC) have been involved in the development of this plan and opportunities to strengthen this partnership will be explored in its implementation stage (section 10).

1.3 Context

Environmental water management in Victoria is entering a new phase as ongoing water recovery sees significant volumes of water being returned to the environment. The increasing environmental water availability is providing new opportunities to protect, restore and reinstate high value ecosystems throughout northern Victoria. State and Commonwealth environmental watering programs now have the potential to extend beyond those sites that have been watered in the past.

Environmental watering in Victoria has historically been supported by management plans such as this one, that document key information such as the watering requirements of a site, predicted ecological responses and water delivery arrangements. These plans support annual decisions about which sites should receive water and assist managers to evaluate how well those sites respond to the water they receive or what could be done better.

1.4 Environmental water in Victoria

The Victorian Catchment Management Authorities (CMAs), Department of Environment, Land, Water and Planning (DELWP) and the Victorian Environmental Water Holder (VEWH) are working together to develop Environmental Water Management Plans for both current and future environmental watering sites throughout northern Victoria. The primary purpose of the plans is to provide a consistent set of documents that support Seasonal Watering Proposals to be submitted by CMAs to the Victorian Environmental Water Holder annually. The supporting information will include:

- lead management agencies and their management responsibilities
- the water dependent environmental, social and economic values of the site
- the sites environmental conditions and threats
- hydrological and ecological objectives
- opportunities for improved water delivery, efficiency or capacity through structural works or other measures, and
- Scientific knowledge gaps and recommendations for future work.

This document is the Environmental Water Management Plan (EWMP) for Horseshoe Lagoon in the Goulburn Broken Catchment Management region.

1.5 Environmental water sources for Horseshoe Lagoon

Environmental water is held in storage (as a legal entitlement) and can be delivered to wetlands or streams to protect their environmental values and health. The entitlements are held by the Minister for Environment, who delegates management to the Victorian Environmental Water Holder.

Environmental water that may be used at Horseshoe Lagoon includes environmental water held by the Commonwealth Environmental Water Office (CEWO) and the VEWH stored in Lake Eildon. The amount of water available varies from year to year, depending upon volumes in storage and seasonal water allocations.

Further detail on environmental water available for use at Horseshoe Lagoon is provided as Appendix A.

1.6 Links to the Murray-Darling Basin Plan

The Murray–Darling Basin Plan (MDBA, 2012) was developed to manage the Basin as a whole connected system.

The aim of the Murray–Darling Basin Plan is to bring the Basin back to a healthier and sustainable level, while continuing to support farming and other industries for the benefit of the Australian community. At its heart, the Basin Plan sets the amount of water that can be taken from the Basin each year, while leaving enough for our rivers, lakes and wetlands and the plants and animals that depend on them.

Water for the environment is used to improve the health of our rivers, wetlands and floodplains. Managing water for the environment requires recovering, planning and delivering water to protect vital ecosystems.

The Goulburn River is the largest Victorian tributary to the Murray system. As such, the future management of the river and its floodplain makes is an important part of Victoria's contribution to the Murray-Darling Basin Plan. This Environmental Water Management is prepared as part the state's planning activities for the use of water for the environment.

Specifically, it considers the contribution of Horseshoe Lagoon to the broader ecosystem functions and values of the Goulburn River system and how this aligns with the Basin Plan environmental watering objectives and targets as set out in:

- sections 8.04, 8.05, 8.07 and 8.5, as well as
- schedules 7 and 9.

2. Development of this plan

2.1 Consultation

This plan was prepared by Jacobs Australia Pty. Ltd., on behalf of the Goulburn Broken Catchment Management Authority (CMA) with input from the Goulburn Broken CMA wetland technical reference group (TRG). The overall site management goal, ecological and hydrological objectives were developed in conjunction with the TRG and CMA staff at a workshop held at the Goulburn Broken CMA on January 23rd, 2019. The workshop was based around the local history of the lagoon, knowledge of past and present watering regimes, the water requirements to support existing ecological values and the current condition of the swamp. Workshop attendees included:

- members of the TRG: Damien Cook (Australian Ecosystems), Rhonda Butcher (Waters Edge Consulting), Wayne Koster (Arthur Rylah Institute)
- Goulburn Broken CMA: Simon Casanelia and Sue Kosch
- Parks Victoria: Tony Fitzgerald and Kathryn Stanislawski, and
- Taungurung Land and Waters Council: Alejandro Voysest.

The workshop was also informed by a site visit undertaken in early December 2018 by Jacobs, representatives from the Goulburn Broken CMA and Taungurung Clans Aboriginal Corporation.

2.2 Information sources

Information used in the development of this Plan was compiled from various sources including:

- Goulburn Broken Regional River Health Strategy (GBCMA, 2014).
- Mid Goulburn Wetlands Flora and Fauna Surveys (Australian Ecosystems, 2012)
- Flow-related environmental issues associated with the Goulburn River downstream of Lake Eildon (Cottingham, et al., 2003)
- Mid Goulburn River FLOWS study: Final Report (Cottingham, et al., 2014)
- Water requirements of selected Victorian wetland biota: a resource guide (DELWP, 2016)
- A guide to water regime, salinity ranges and bioregional conservation status of Victorian wetland Ecological Vegetation Classes (Frood & Papas, 2016)
- Guidelines for preparing wetland Environmental Water Management Plans v5.0 (DEPI, 2014).

This information was supplemented by discussions with people with an in-depth knowledge of the lagoon area and its environmental values and the management. In addition, a number of state-wide data sets and digital mapping layers were used including the:

- Victorian Biodiversity Atlas Species Survey Records (accessed via NatureKit http://maps.biodiversity.vic.gov.au);
- Bioregional Conservation Status of Ecological Vegetation Classes
- Victorian Wetland Environments and Extent - up to 1994 Victorian Wetland Inventory (Current) 2014 (accessed via MapShare http://mapshare.maps.vic.gov.au/).

2.3 Limitations

The information sources used in the development of this report have a number of limitations. These limitations include the data contained in the Victorian Biodiversity Atlas Species Survey Records 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.

The water regime for Horseshoe Lagoon discussed in this Plan was developed using local knowledge, technical experts, field observations and scientific literature on the water requirements of relevant aquatic flora and fauna where available. 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 intends to be a live document and will be amended as new information becomes available.

A limited budget was available for the preparation of this plan. Therefore, some aspects are not considered in the level of detail provided in other wetland EWMPs.

3. Site overview

3.1 Regional setting

Horseshoe Lagoon is located in the Goulburn Broken catchment area, which comprises the catchments of the Goulburn and Broken Rivers. The catchment covers a total of 2,391,544 hectares or 10.5 % of Victoria's total land area (Figure 1) and generates 11 % of the Murray Darling Basin's water resources (DNRE, 2002).

Figure 1: The Goulburn Broken Catchment; the location of Horseshoe Bend is indicated by a red dot. (Source: GBCMA)

Within the Goulburn Broken Catchment approximately 2,000 natural wetlands have been recorded including numerous wetlands formally recognised for their conservation significance. These include the internationally significant Barmah Forest Ramsar site, ten wetlands of national significance listed in *A*

Directory of Important Wetlands in Australia (EA, 2001) and 111 wetlands of bioregional significance identified for the *National Land and Water Resource Audit* (CoA, 2002). In addition, many of the wetlands support state and nationally threatened plant and animal communities, including birds listed on international agreements and conventions.

Over 60 % of the Goulburn Broken Catchment has been cleared for agriculture purposes (Miles et al., 2010). The Goulburn Broken catchment includes irrigated and dry land agriculture. Drainage, land forming and river regulation have also significantly reduced the number and area of wetland habitats. Therefore, the remnant vegetation and wetlands within the catchment form an important corridor in the catchment.

3.2 Catchment history

Horseshoe Lagoon is set in a bend of the Goulburn River between Kerrisdale and Trawool, approximately 15 km south east of Seymour (Figure 1). The lagoon is a paleochannel of the Goulburn River and is approximately 2.5m deep at its deepest point (Australian Ecosystems, 2012).

It is situated in the Victorian Riverina bioregion, located north of the Great Dividing Range in Victoria. It is characterised by flat to gently undulating landscape on recent unconsolidated sediments with evidence of former stream channels and wide floodplain areas associated with major river systems and prior streams. Alluvium deposits from the Cainozoic period gave rise to the red brown earths and texture contrast soils (Chromosols and Sodosols) which dominate the Riverine Plain.

Annual average rainfall for the region ranges from 360- 672mm per annum. The average annual minimum and maximum temperature range is from 3 to 9 °C and 15 to 21 °C respectively.

Figure 2: Aerial image of Horseshoe Lagoon (source: GBCMA)

Details of the site's environmental values is provided in section 4.

3.3 Land status and management

Horseshoe Lagoon is located within the Horseshoe Lagoon Flora and Fauna Reserve, a 46-hectare reserve managed by Parks Victoria (Figure 3). A public camping area is provided in the reserve to the south of the lagoon. Being one of the few camping areas along the mid Goulburn River, it is a popular with locals and has high utilisation.

Access to the reserve is from Greenslopes Road which passes through private farm land. Land adjacent to the lagoon is used for dryland agriculture. To the west (on the opposing bank of the river) is the Tallarook State Forest, a 5,100 ha mixed species Eucalypt forest reserve (DEPI, 2014).

A range of management agencies are also responsible for ensuring that management of the study area complies with a broad range of legislative requirements, as presented in section 11.

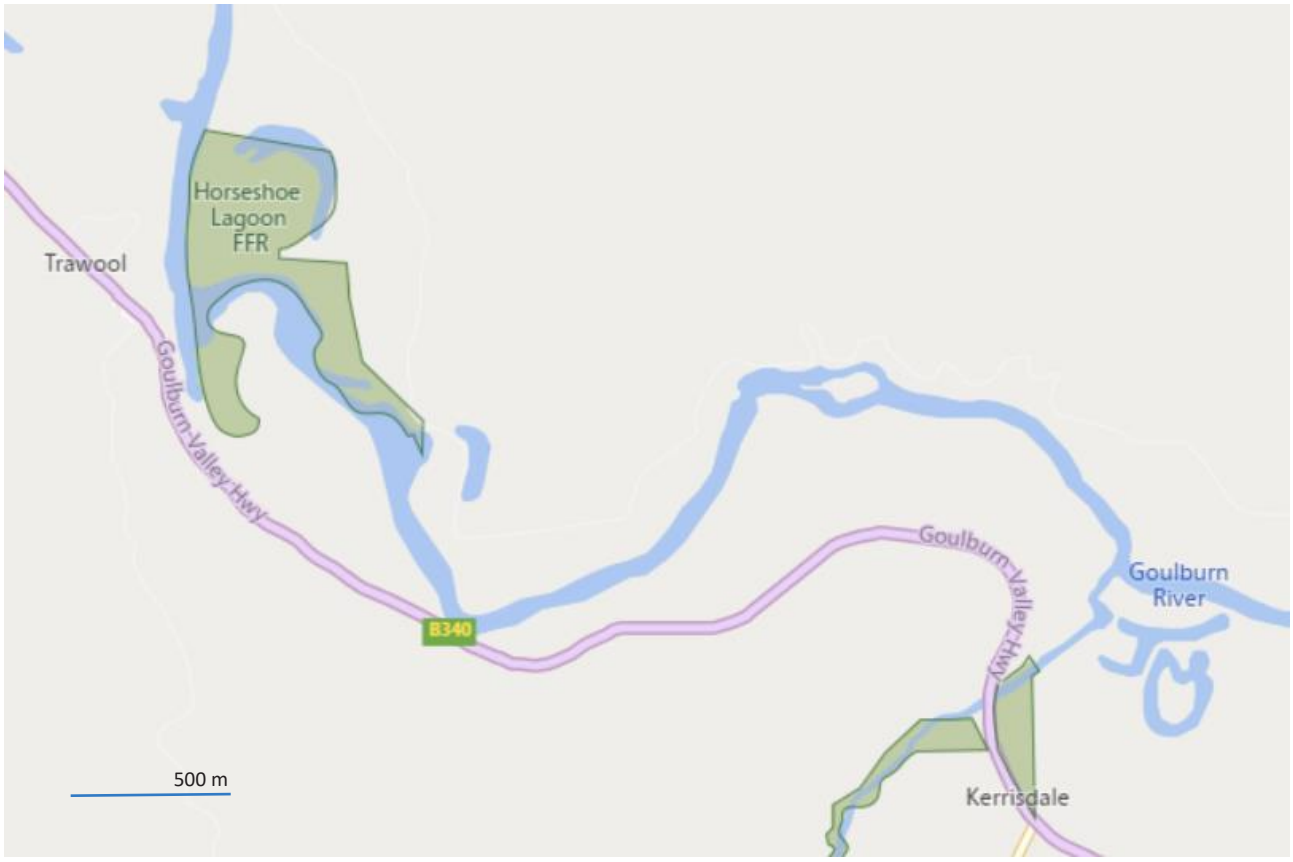

Figure 3: Land tenure in the area surrounding Horseshoe Lagoon (Source: Parkweb, June 2019)

The broader community including adjacent landholders, the Taungurung people, Landcare and recreational users also have an interest and/or role in the management of the planning area. The successful management of the study area therefore relies on effective cooperation and partnership between the government agencies and the broader community.

3.4 Cultural values

The Taungurung Land and Waters Council is the Registered Aboriginal Party for this region. In 2018, the Taungurung people were formally recognised as the traditional owners under the Traditional Owner Settlement Act 2010. Among other things, the agreement recognises the Taungurung people's rights to access Crown land to hunt, fish, camp, and gather natural resources. It also provided financial support for Taungurung Land and Waters Council to partner in natural resource management, such as this Environmental Water Management Plan.

During a site visit in December 2018, representatives from the Taungurung Land and Waters Council told of the significance of Horseshoe Lagoon to their peoples. The lagoon is an important site for the clan, particularly Taungurung women, as it is central to a creation story of the first women from which they descend. The Taungurung moieties, Waang (Crow) and Bundjil (Wedge-tailed eagle), are represented in this story and determined the pattern for marriage between individuals, clans and other tribes.

Other flora and fauna motifs in the creation story include the Black Swan, Brolga, bats, kangaroo, yams and other edible roots. The story also contains imagery of water and mud, representing the types of wetting and drying regimes considered by this management plan.

Figure 4: Taungurung women welcomed and performed a smoke-cleansing before taking the project team to visit the lagoon

Horseshoe Lagoon is classified as a culturally sensitive area under the *Aboriginal Heritage Act 2006* (Vic) as waterways or land within 200m of a waterway. Horseshoe Lagoon and the surrounding floodplain would have provided Taungurung people with a rich and diverse supply of plant and animal resources for food, medicine, shelter, clothing and tools. All Aboriginal sites, places and objects are protected under the *Archaeological and Aboriginal Heritage Act* 2006 (Vic.) and the Aboriginal and Torres Strait Islander *Heritage Protection Act* 1984. Stone tools have been found onsite and flora of cultural significance include bracken, flax and phragmites.

The Taungurung Country Plan (TCAC, 2016) sets out the key aspirations of the Taungurung peoples and provides a map for healing and strengthening Country, Culture and People. The Plan identifies the following priority areas for action:

- Identity, Recognition and Rights, Health and Wellbeing;
- Cultural Heritage;
- Taungurung Traditional Knowledge;

- Caring for Our Country; and
- Economic Independence.

The Plan guides Taungurung Land and Waters Council, partner agencies and stakeholders to implement actions on Taungurung Country.

Taungurung have completed an Aboriginal Waterways Assessment (AWA) of Horseshoe Lagoon. The AWA is a tool developed to assist Traditional Owners in the Murray Darling Basin more effectively participate in water planning and management. Information collected by Taungurung through this process will guide their future involvement in the management of Horseshoe Lagoon.

3.5 Economic values

Wetlands provide both direct and indirect economic values to the Goulburn Broken Catchment (Cork et al., 2001). The direct economic values that Horseshoe Lagoon provides include non-consumptive uses such as tourism and recreation. Indirect economic values that Horseshoe Lagoon provides to the Goulburn Broken Catchment include water filtration, flood protection, water storage, groundwater recharge, nutrient discharge, carbon storage and habitat for threatened flora and fauna species.

3.6 Legislative and policy framework

There is a range of international treaties, conventions and initiatives, as well as national and state legislation, policies and strategies that influence the management of Horseshoe Lagoon. Those of most relevance to this Environmental Water Management Plan are summarised below:

- **International treaties, conventions and initiatives**, such as Japan Australia Migratory Birds Agreement (JAMBA) 1974
- **Commonwealth legislation and policy**, such as the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) and the Framework for Determining Commonwealth Environmental Watering Actions (2009)
- **Victorian legislation**, such as the *Catchment and Land Protection Act* 1994 and the A*boriginal Heritage Act* 2006

- **Victorian policy, codes of practice, charters and strategies**, such as Water for Victoria (DELWP, 2016)
- **Regional plans and strategies**, such as the Goulburn Broken Regional Waterway Strategy 2014- 2022 (GBCMA, 2014) and the Taungurung Country Plan (TCAC, 2016).

Further information on the legislative, policy and planning setting for Horseshoe Lagoon is provided as Appendix B.

4. Water dependent environmental values

4.1 Wetland type

Wetland classification

Wetlands in Victoria are currently classified using a system developed by Corrick and Norman (1980, Appendix C), recently updated in 2014. Using this system, Horseshoe Lagoon is classified as a temporary freshwater swamp under the current Victorian Wetland Inventory layer (Table 1).

Table 1: Summary of site characteristics

Characteristics	Description
Name	Horseshoe Lagoon
Wetland ID	60953
Area (ha)	46 ha reserve; 15 ha wetland at bank full (147 m AHD)
Bioregion	Victorian Riverina
Conservation Status	-
Land Status	Public
Land Manager	Parks Victoria
Surrounding Land Use	Dryland Agriculture
Water Supply	Goulburn River; catchment runoff
1788 Wetland Category	Deep Freshwater Marsh
2014 Wetland Category	Temporary freshwater swamp
Wetland capacity (ML)	115 to 150 ML (section 5.5)
Mean wetland depth at capacity (M)	1 metre (estimated)

Wetland depletion and rarity

The impact of European settlement and development on Victorian wetlands has been severe, with approximately one-third of the state's wetlands being lost since European settlement and many of those remaining at risk of continuing degradation (EA, 2001).

Temporary freshwater swamps, such as Horseshoe Lagoon, are amongst the most impacted wetland types in Victoria, with 70 % of the original area estimated to have been lost (DNRE, 1997). The restoration and protection of these areas is vital to support the life cycle processes for the flora and fauna that rely on them.

Table 2 shows that larger (15 ha) wetlands such as Horseshoe Lagoon are less well represented on the mid Goulburn floodplain, increasing the importance of protecting this site.

Table 2: Wetland type and abundance between Lake Eildon and Seymour (Cottingham, et al., 2003)

Wetland type (1788)	Wetland size class (ha)				Reach total	% of reach total
	1-9	10-25	25-65	>50		
Freshwater meadow	29	5	1	0	35	10
Shallow freshwater meadow	192	21	4	0	217	58
Deep freshwater marsh	38	15	2	0	55	15
Permanent open freshwater	57	2	0	1	60	16
Other	4	1	0	0	5	1

Ecosystem functions

Wetlands are considered ecologically important due to their role in maintaining biological diversity, promoting biochemical transformation and storage and decomposition of organic materials (DSE, 2007b).

Floodplain wetlands like Horseshoe Lagoon perform important functions necessary to maintain the hydrological, physical and ecological health of river systems. These functions include:

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

However, the capacity of floodplain wetlands to perform the ecological functions outlined above will depend on their condition (section 5 – Threats and Condition) and on connectedness back to the river.

The water regimes recommended in this plan will improve the ecosystem functions of Horseshoe Lagoon. Through its implementation, it will contribute to the maintenance ecosystem functions outlined in Schedule 9 of the Basin Plan, specifically criterion 1 – *the ecosystem function creates and supports the maintenance of vital habitats and populations*.

4.2 Fauna

Fauna listings and significance

Horseshoe Lagoon provides habitat for a wide variety of wetland and terrestrial fauna species. To date 76 fauna species have been recorded at the site (Appendix D). These include 69 native bird species (34 of which commonly use wetlands), six mammals and one frog species. Of the water dependent species, six are listed on the Victorian Rare or Threatened Species list, one is listed under the *Victorian Flora and Fauna Guarantee Act* (1988), two are listed under the Bonn Convention, two under the Japan-Australia Migratory Bird Agreement (JAMBA), two under the China Australia Migratory Bird (CAMBA) and one under the Republic of Korea Australia Migratory Bird Agreement (ROKAMBA) (Table 3).

Table 3: Conservation status of water dependent fauna species recorded in the study area

Scientific Name	Common Name	Type	International Agreements	EPBC	FFG	VICADV
Acrocephalus stentoreus	Clamorous Reed Warbler	B	B			
Anas rhynchotis	Australasian Shoveler	B				vu
Ardea modesta	Eastern Great Egret	B	C, J		L	vu
Aythya australis	Hardhead	B				vu
Biziura lobata	Musk Duck	B				vu
Gallinago hardwickii	Latham's Snipe	B	B, C, J, R			nt
Phalacrocorax varius	Pied Cormorant	B				Nt

Legend
Type: Bird (B), Fish (F), Reptile (R)
International: CAMBA (C), JAMBA (J), ROKAMBA (R), Bonn (B)
FFG: Listed as threatened (L)
VROT: Critically Endangered (CEn), Endangered (End), Vulnerable (Vul), Near Threatened (NT), Data Deficient (DD)

Significant fauna

Thirty-four wetland bird species have been recorded at the site, with representatives from functional groups including Ducks, small Grebes and Jacanas; Piscivores; Shorebirds; Large Wading Birds and Herbivores. Adjacent landholder records indicate that Horseshoe Lagoon was previously the site of colonial bird nesting (pers. comm. Sue Kosch, GBCMA, December 2018).

Only one frog species has been recorded at Horseshoe Lagoon – the Common Froglet (*Crinia signifera*), though it has the potential to support additional frog species including the Southern Brown Tree Frog, Spotted Marsh Frog, Pobblebonk, and Plains Froglet.

Three turtle species have been recorded nearby and could utilise Horseshoe Lagoon under the right watering regime; the Eastern Long-necked Turtle (*Chelodina longicollis*), the Broad-shelled Turtle (*Chelodina expansa*), and the Murray Turtle (*Emydura macquarii*). Under a seasonally inundated flow regime, Horseshoe Lagoon could provide feeding and breeding habitat for the Eastern Long-necked Turtle in particular. There are anecdotal records of turtles using the site for nesting on the high bank, with evidence of Broad-shelled Turtles nesting during autumn 2019 (pers. comm. K. Stanislawski, Parks Victoria, 2019).

The Eastern Long-necked Turtle can travel across a relatively large home range including multiple wetlands and terrestrial zones between them. The species prefers ephemeral habitats and can seek out drought refuge of permanent habitat during droughts. The Eastern Long-necked Turtle is a carnivore with aquatic insects making up the majority of their diet (DELWP, 2016).

Broad-shelled turtles have been found to utilise a diverse range of habitats including the main river channel, permanent wetlands, billabongs and anabranches. This species has a much smaller home range than the Eastern Long-necked Turtle and will rarely leave permanent waterbodies except to nest. This species is also a carnivore feeding on decapod crustaceans, small fish and aquatic insects (DELWP, 2016).

4.3 Flora

Vegetation communities

A hierarchical system of classification of vegetation classes has been developed in Victoria to classify vegetation into units that are both ecologically meaningful and useful for vegetation managers. The classification that has been adopted in Victoria is Ecological Vegetation Classes (EVCs), which are defined by a combination of floristics, lifeform, position in the landscape and environments where they are expected to be found. Each EVC includes a collection of floristic communities that occur across a biogeographic range and although differing in species, have similar habitat and ecological processes operating. Approximately 300 EVCs have been described for Victoria.

Horseshoe Lagoon is within the Victorian Riverine Bioregion. EVCs within the wetland include Tall Marsh (EVC #821) and Floodway Pond Herbland (EVC #810). The wetland is surrounded by Floodplain Riparian Woodland (EVC #56) which is in poor to moderate condition (Australian Ecosystems, 2012). Within the Victorian Riverine bioregion Tall Marsh is classified as depleted, Floodway Pond Herbland and Floodplain Riparian Woodland are classified as vulnerable (Table 4).

Table 4: Description and conservation status of water-dependent Ecological Vegetation classes recorded at Horseshoe Lagoon (Australian Ecosystems, 2012).

EVC Number	EVC Name	Description	Bioregional Conservation Status
821	**Tall Marsh**	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.	Depleted
810	**Floodway Pond Herbland**	Low herbland to < 0.3 m tall with occasional emergent life forms, usually with a high content of ephemeral species. Floors of ponds associated with floodway systems. Typically, heavy deeply cracking clay soils. Characteristically smaller wetlands with a more regular flooding and drying cycle in comparison to sites supporting Lake Bed Herbland.	Vulnerable
56	**Floodplain Riparian Woodland**	An open eucalypt woodland or open forest to 20 m tall over a medium to tall shrub layer with a ground layer consisting of amphibious and aquatic herbs and sedges. Occurs along the banks and floodplains of the larger meandering rivers and major creeks, often in conjunction with one or more floodplain wetland communities. Elevation and rainfall are relatively low, and soils are fertile alluviums subject to periodic flooding and inundation.	Vulnerable

Legend (Wierzbowski et al., 2002)
Endangered. Meaning the EVC is on the verge of extinction with 90% or more cleared since European settlement (1750).

Vulnerable. Meaning the EVC is moving towards extinction with 70% or more of these areas having been cleared since European settlement (1750).
Depleted. Meaning the EVC is likely to become threatened if clearing or threatening processes continue and that 50-70% of this EVC has already been cleared since European settlement (1750).

Flora – species listing and significance

A 2012 assessment recorded seventy-nine species of vascular plants, forty-seven (60%) of which were indigenous. A reasonable diversity of emergent grasses, sedges and rushes and wetland herbs that typically colonize the drying mud of riverine wetlands as water levels receded were recorded. However, truly aquatic and semi-aquatic species were poorly represented. This may be due to the timing of the assessment, during drawdown of the wetland (Australian Ecosystems, 2012) (Appendix E).

Five species of rare or threatened plants were recorded during this assessment (Table 5). Of these, four were listed on the on the Victorian Advisory List of rare and threatened (VROT) flora and one, *Amphibromus fluitans* (River Swamp Wallaby-grass), is listed as vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (Australian Ecosystems, 2012).

Table 5: Listed flora species recorded at Horseshoe Lagoon.

Scientific Name	Common Name	EPBC	FFG	VROT
Amphibromus fluitans	River Swamp Wallaby-grass	V	X	
Carex chlorantha	Green-top Sedge			k
Fimbristylis velata	Veiled Fringe-sedge			r
Hypsela tridens	Hypsela			k
Kunzea leptospermoides	Yarra Burgan			k

Legend:
EPBC: Vulnerable (V)
FFG: Listed as threatened (L)
VROT: rare (r), poorly known (k)

Figure 5: Veiled Fringe Sedge (left) and Hypsela (right) at Horseshoe Lagoon February 2012 (Australian Ecosystems, 2012).

Flora – significance

River Swamp Wallaby-grass is an aquatic perennial growing to 120 cm high. It grows mostly in permanent swamps but also lagoons, billabongs, dams and roadside ditches. It requires periodic flooding of habitat to maintain wet conditions and moderately fertile soils with some bare ground; conditions that are caused by seasonally-fluctuating water levels. The main identified threats to River Swamp Wallaby-grass are grazing and trampling by livestock, hydrological changes; and invasion of remnant habitats by exotic grasses and weeds (Department of the Environment, Water, Heritage and the Arts, 2008; Department of the Environment 2019). Notably, Horseshoe Lagoon was the only site where River Swamp Wallaby-grass was detected during the 2012 wetland surveys.

5. Hydrology and system operations

5.1 Water management and delivery

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, 2007b). A wetland's hydrology is determined by surface and groundwater inflows and outflows in addition to rainfall and evapotranspiration (DSE, 2007b). Duration, frequency and seasonality (timing) are the main components of a wetland's hydrological regime.

5.2 Historical water regime

Lake Eildon (originally known as Sugarloaf Reservoir) was constructed between 1915 and 1929 to provide irrigation water in the Goulburn Valley. The dam was modified in 1929 and again in 1935 to increase its storage capacity. However, this was still inadequate to provide the Goulburn Valley with sufficient water during drought. In 1951 the construction of a large dam (now known as Lake Eildon) began. This was completed in 1955 and supplies approximately 60 per cent of water to the Goulburn Murray Irrigation District (Cottingham et al., 2014b).

Prior to European settlement flows in the Goulburn River would have been seasonally variable. The Goulburn would have flooded in the winter and spring. However, this water is now captured by Lake Eildon causing winter and spring flows to be lower than natural. The water stored during winter and spring is now largely released during summer to meet downstream irrigation and consumptive demands. This means that high flows in the mid Goulburn River now occur in summer to autumn. Tributary inflows below Lake Eildon help to provide some natural seasonality below Goulburn Weir (where water is diverted to meet demands) but is substantially reduced in volume from natural conditions (GB CMA, 2007).

Horseshoe Lagoon is located in what is known as Reach 2 of the Goulburn River for environmental water management purposes. Bankfull flows through this reach occur at approximately 11,000 ML/day (Cottingham, et al., 2014b) at which flows low-lying floodplain wetlands, commence to fill. Modelling suggests that higher flows of approximately 20,000 ML/day are required to inundate Horseshoe Lagoon which is situated higher on the floodplain (GBCMA, 2017). Flows of this magnitude would have occurred on an almost annual basis (Table 6) prior to the construction of Lake Eildon.

5.3 Changes to flow management

Under current operating rules, releases from Lake Eildon are capped at 9,500 ML/d to prevent flooding of private property and public infrastructure downstream of the dam, keeping flows well below that needed to fill Horseshoe Lagoon.

As shown in Table 6 the construction and operation of Lake Eildon has had a significant impact on the water regimes in Horseshoe Lagoon, primarily:

- The average recurrence of inflows has reduced from three events per year to less than one
- The percentage of years when inflows occurred has reduced dramatically from 88% to around 33%

Table 6: Comparison of flows before and after the construction of Lake Eildon in Reach 1 of the Goulburn River (source: Cottingham, et al., 2014)

Flow threshold:	11,000 ML/day		20,000 ML/day	
	Natural	Current	Natural	Current
Number of events per year	4	1	3	<1
Percentage of years with events	96%	55%	88%	33%
Median duration (days)	6	6	4	4
Median interval (days)	23	47.5	27	45
Maximum duration (days)	149	152	83	89
Maximum interval (days)	391	524	419	455

The Goulburn River flow regime is further affected by a range of activities within the catchment, including alterations to vegetation, construction of small dams and drainage schemes. Along the floodplain, artificial levees, block banks (Figure 6) and other structures, obstruct flood flows (Cottingham, et al., 2014).

Figure 6: Block bank reducing inflows to a floodrunner immediately upstream of Horseshoe Lagoon (Photo taken by G. Vietz in Cottingham et al., 2014)

5.4 Current water regime

When flooded naturally it is likely that during high flows in the Goulburn River, water enters Horseshoe Lagoon through natural channels at the downstream (point 1 - Figure 7) and upstream (points 2) ends of the lagoon to fill the main section of the lagoon to the north. A road constructed (point 3) may block flows

from entering the low-lying area to the left of the road, except under higher (20,000+ ML/day) Goulburn River flows.

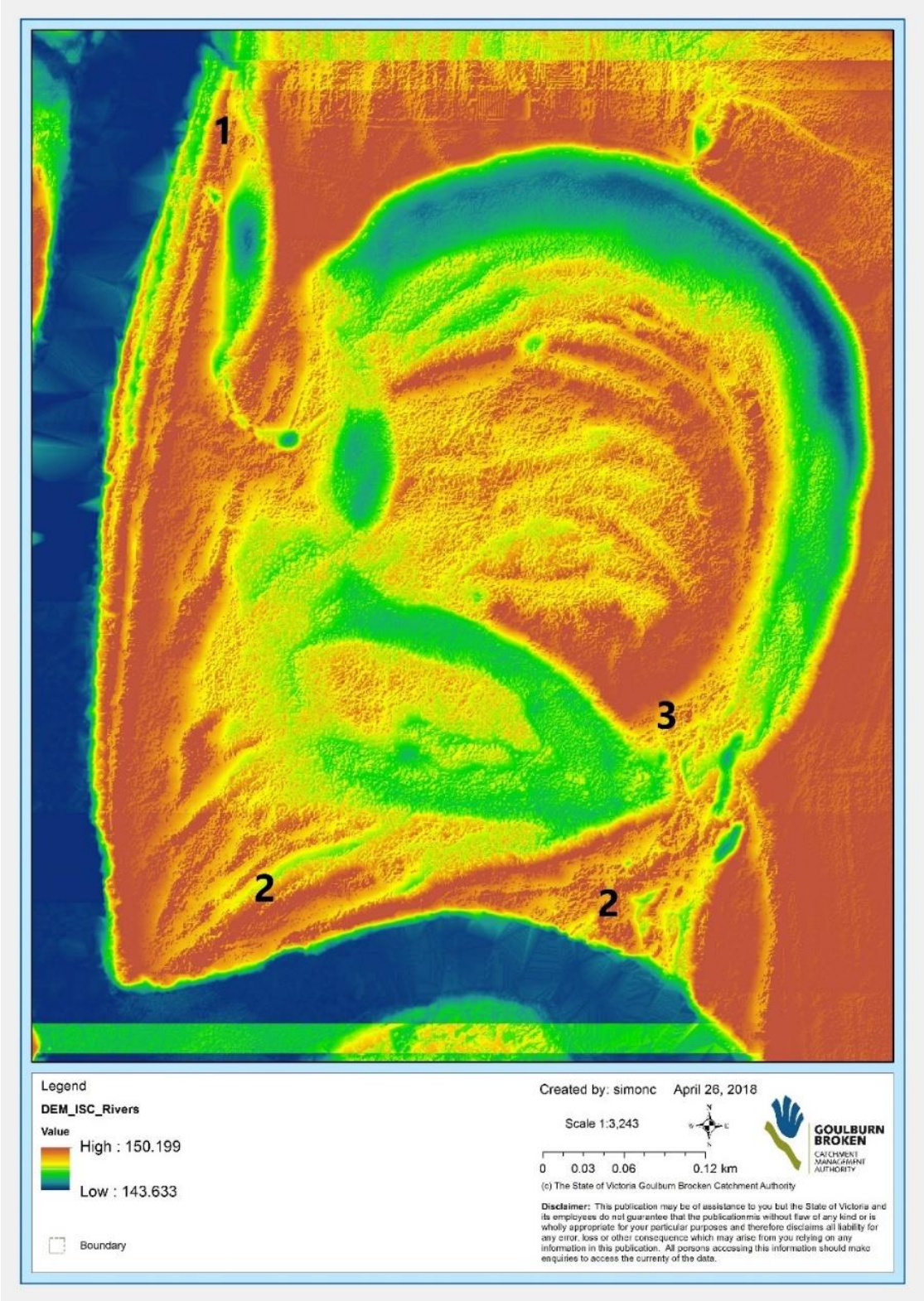

Figure 7: Digital elevation model of Horseshoe Lagoon.

5.5 Wetland volume

Environmental water has not been delivered to Horseshoe Lagoon previously. Using the Digital Elevation Model for the purposes of analysis, it is estimated it would take approximately 115 ML to fill the wetland to a bank level of 147 m AHD (Figure 8). The actual volume will be determined by measuring inflows during the first operating period.

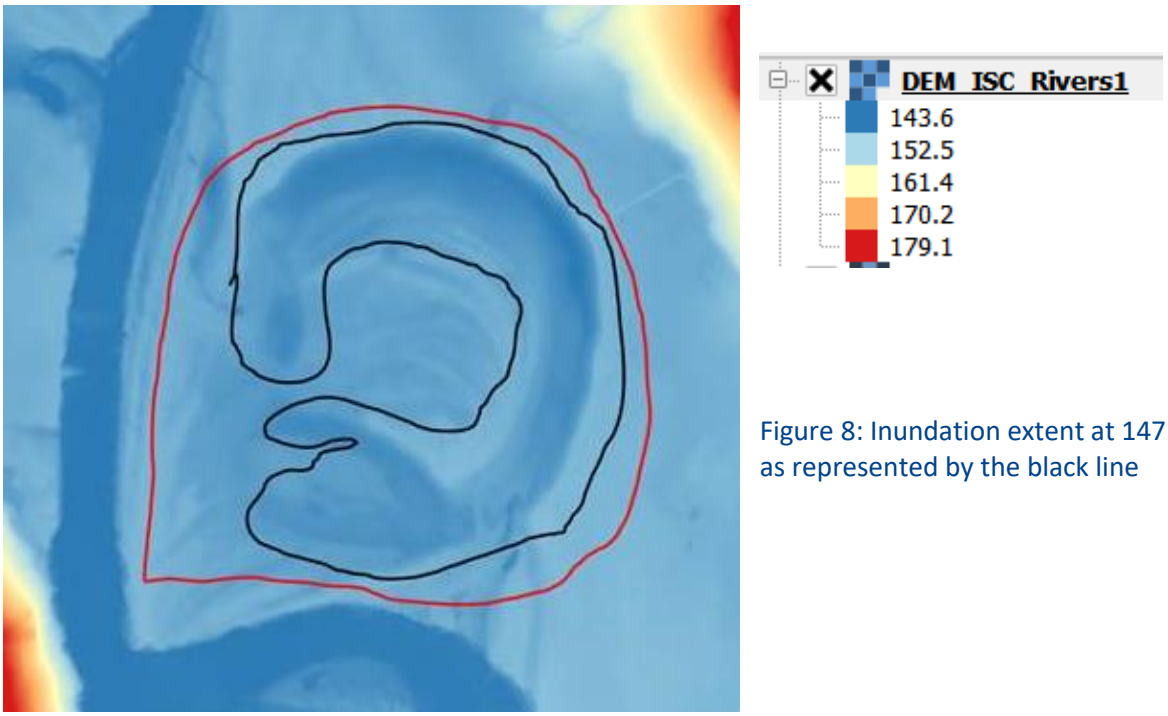

Figure 8: Inundation extent at 147 m AHD, as represented by the black line

As discussed in section 1.5, a range of environmental water sources may be drawn on for use at Horseshoe Lagoon.

6. Threats and condition

6.1 Water dependent threats

The key threats to the values of Horseshoe Lagoon are outlined below. These threats result from activities in the wetland, on adjoining land and in the surrounding catchment. To address these threats and their associated impacts, an integrated approach is required.

Altered water regime

Hydrology is the most important component of wetland ecosystems. It drives the physical and chemical properties of a wetland, and the biota it supports. The natural hydrological regime of Horseshoe Lagoon has been significantly altered by the regulation of the Goulburn River. It is now inundated less frequently and for shorter periods of time than under natural conditions.

Altered physical form

Physical form relates to the area and bathymetry of a wetland. The connection between the north and south areas of the lagoon has been impacted by the construction of a road across the lagoon (Figure 9). Future impacts on the physical form of the wetland are likely to be minimal due to the increased protection provided by its current land reservation status. Change to wetland capacity is unlikely to vary significantly over foreseeable decades.

Figure 9: Road dividing the northern and southern halves of Horseshoe Lagoon.

Poor water quality

Poor water quality including low dissolved oxygen may reduce the habitat available for native aquatic biota, reducing diversity and abundance. Elevated nutrients, particularly phosphorus, can also promote Blue Green Algae blooms that in turn decrease various wetland values. The water quality within Horseshoe Lagoon may be impacted by:

- Nutrient rich run-off from agricultural land entering the wetland
- Exotic fish species such as Carp and Goldfish feeding within the sediment and increasing turbidity.

Exotic flora and fauna

The invasion of native vegetation by pest plants is listed as potentially threatening process under the Schedule 3 of Victoria's *Flora and Fauna Guarantee Act* (1988) and is considered to be one of the major threats to conservation of biological diversity in Victoria (PV, 2003). The growth of pest plants can be sufficiently vigorous to reduce or prevent the regeneration or establishment of native plant species, altering the composition and structure of indigenous communities. Modifications to the composition and structure of indigenous vegetation as a result of pest plant invasion can modify the abundance of indigenous fauna, geomorphological process, hydrological cycles, and the nutrient content of soil and disturbance regimes including fire, grazing and insect activity (PV, 2003).

Thirty-seven environmental weeds have been recorded at Horseshoe Lagoon. The recorded weeds include three CaLP Act listed species - the regionally restricted Spear Thistle (*Cirsium vulgare*), and the regionally controlled Sweet Briar (*Rosa rubiginosa*) and Blackberry (*Rubus anglocandicans*) which is also classified as a Weed of National Significance and a very high threat weed, as designated by DELWP (Advisory List of Environmental Weeds) (Australian Ecosystems, 2012).

Of the wetland plants observed in the study, a further three were listed as very high threat weeds, including, Yorkshire Fog (*Holcus lanatus*), Burr Medic (*Medicago polymorpha*), and Toowoomba Canary Grass (*Phalaris aquatica*). High threat weeds were also recorded, including Sheep's Sorrel (*Acetosella vulgaris*), Great Brome (*Bromus diandrus*), Wimmera Rye-grass (*Lolium rigidum*), and Sweet Briar (*Rosa rubiginosa*). No Vic Alert or National Alert weeds were recorded at Horseshoe Lagoon during a 2012 study.

Pest animals threaten the ecological values of wetlands by predating native species, transmitting diseases, and competing for food and habitat. Pest animals that threaten ecological values at the site include:

- Foxes: fox predation is listed as a threatening process under the EPBC Act (1999) and FFG Act (1988).
- Rabbits: competition and land degradation by rabbits is listed as a threatening process under the EPBC Act (1999) and the FFG Act (1988).
- Carp: Large numbers of carp have been observed during the drying phases of Horseshoe Lagoon during the summer of 2003 (Cottingham, et al., 2003) but not in more recent drying events (pers. comm., S. Casanelia, GBCMA, 2019). Carp, goldfish and gambusia are known to be present in the river adjacent to the lagoon.

Pest management issues will need to be considered during time of environmental water delivery or during natural flooding events to increase the breeding success of turtles and the survival, growth and reproduction of aquatic flora.

6.2 Current condition

The condition of Horseshoe Lagoon was assessed in February 2012 (following floods in the Goulburn River and natural inundation of the wetland) using a method developed by the then Department of Sustainability and Environment called the Index of Wetland Condition (IWC; Appendix F). The IWC defines wetland condition as the state of the biological, physical, and chemical components of the wetland ecosystem and their interactions (DSE, 2007b).

Horseshoe Lagoon recorded an Overall Wetland Condition Score of 9, which – in accordance with the Index of Wetland Condition Methods Manual v.14 – is considered to be a wetland in Excellent condition (Papas and Lyon, 2012) (Australian Ecosystems, 2012). Notably, of the 18 wetland sites surveyed during 2012, only Horseshoe Lagoon was found to be in excellent condition.

Table 7: Index of Wetland Condition Scores at Horseshoe Lagoon (Australian Ecosystems, 2012)

Sub index	Score	Maximum Possible Score	Condition Category
Wetland catchment	20	20	Excellent
Physical form	20	20	Excellent
Hydrology	10	20	Moderate
Water properties	15	20	Good
Soils	19.5	20	Excellent
Biota	19.9	20	Excellent
Overall Wetland Condition	**9**	**10**	**Excellent**

A December 2018 site visit showed Horseshoe Lagoon in a dry phase, with increasing terrestrialisation of the lagoon and River Red Gums establishing in the main channel (Figure 10). Prior to 2017 the site supported horse grazing. Their removal has reduced the grazing pressure on vegetation at the site.

Figure 10: River Red Gums establishing in the main channel of the lagoon (December 2018).

Recent works to improve the condition of the site include:

- Weed control (particularly Blackberry) by Parks Victoria
- Willow control and riparian fencing by the GB CMA.

6.3 Condition trajectory

Ongoing management including the delivery of environmental water, monitoring and complementary works at Horseshoe Lagoon is key to protecting the ecological values at the site. If no intervention occurs, Horseshoe Lagoon will be reliant on natural inflows from the Goulburn River, at a reduced frequency and duration than under natural conditions. With an increasingly dry climate this may occur less frequently than that needed to protect and restore the water dependent vegetation and fauna values of the site.

7. Management objectives and adaptive approaches

7.1 Overall site management objective

The water management goal for Horseshoe Lagoon was developed collaboratively during the development of this EWMP. The overall site objective considers the values of the lagoon and its contribution to the goals of other strategies at a regional, state and basin scale.

Provide a watering regime at Horseshoe Lagoon that protects and restores ecosystem functions, and provides vital habitat needed to support the life cycles of water-dependent plants and animals over the longer term.

7.2 Ecological objectives

Ecological objectives are the desired ecological outcomes of the site. In line with the draft policy Victorian Strategy for Healthy Rivers, Estuaries and Wetlands (VSHREW), the ecological objectives are based on the key values of the site (section 3 – Water Dependent Values).

The ecological objectives are intended to be measurable over time and have been expressed as one of the following trajectories for each key value:

- *Protect* – maintain the current condition of the value while allowing natural processes of regeneration, disturbance and succession to occur.
- *Restore* – improve the condition of the value while allowing natural processes of regeneration, disturbance and succession to occur.

The ecological objectives for Horseshoe Lagoon are based on values that the wetland provides for the mid Goulburn River system, its ability to support species listed under the *Environmental Protection Biodiversity Conservation Act* (1999) and the *Flora and Fauna Guarantee Act* (1988), and its provision of habitat important for the life cycles of waterbirds, frogs and turtles.

The ecological objectives for Horseshoe Lagoon are:

- *Vegetation objective 1* (V1): Protect diversity, recruitment and regeneration of target EVCs from the 2012 - 2019 benchmark by 2025
- *Vegetation objective 2* (V2): Ensure the protection of threatened plant species by establishing benchmark condition by 2024 and setting an objective by 2025.
- *Aquatic biota objective 1* (AB1): Protect turtle populations by providing the feeding and breeding habitat needed to support life cycle processes, assessed by the presence of priority species in 50% years to 2025.
- *Waterbird objective 1* (WB1): Protect waterbird species diversity, through improved access to feeding and roosting habitat, assessed by the presence of all expected guilds in 50% of years to 2025.
- *Aquatic biota objective 2* (AB2): Protect the diversity of frog species in 80% of years to 2025

Further definitions of each of the ecological objectives and their justification for selection is provided in Table 8.

Table 8: Ecological objectives for Horseshoe Lagoon

Objective	Definition	Justification
Water dependent vegetation		
V1: ***Protect diversity, recruitment and regeneration of target EVCs from the 2012 - 2019 benchmark by 2025.***	• Target EVCs represent those vegetation communities expected to be inundated by environmental watering. These include Tall Marsh (821) and Floodway Pond Herbland (810) which is expected to alternate with Aquatic Herbland (653) during the wetted phase. • Diversity' of EVCs is defined within the EVC benchmark and will require further definition	• The vegetation community at Horseshoe Lagoon is in excellent condition therefore the focus of the objective is to protect what is currently there. • A range of years has been adopted as the benchmark. The 2012 surveys followed two consecutive years of flooding. The dry conditions following 2012 are likely to have resulted in some loss of vegetation condition. • Some recovery of River Red Gum health surrounding the high water level is anticipated, representing an additional benefit of watering. No specific objectives or targets have been developed as this represents only a small proportion of the total overstorey at the site.
V2: Ensure the protection of threatened plant species by establishing benchmark condition by 2024 and setting an objective by 2025.	• Threatened plant species include River Swamp Wallaby-grass (*Amphibromus fluitans*), Green-top Sedge (*Carex chlorantha*), Veiled Fringe-sedge (*Fimbristylis velata*), Hypsela (*Hypsela tridens*) and Yarra Burgan (*Kunzea leptospermoides*) • Protection of threatened plant species will be measured in the short term by the presence of these species in plant surveys.	• Limited historical survey data makes it difficult to set meaningful and measurable objectives at Horseshoe Lagoon • The objective, as currently written, guides site managers to build a better understanding before setting benchmarks and objectives for those species • This supports the Basin Plan section 8.05 in relation to the protection and restoration of threatened species.
Aquatic biota		
AB1: Protect turtle populations by providing the feeding and breeding habitat needed to support life cycle processes, assessed by the presence of priority species in 50% years to 2025.	• Turtle populations includes the Eastern long necked (*Chelodina longicollis*), Murray River (*Emydura macquarii*) and Broad-shelled (*Chelodina expansa*) turtles.	• This supports the Basin Plan section 8.05 in relation to the protection and restoration of native aquatic biota. • Objective will be measured by the detection of each species once in every five years, reflecting the anticipated frequency of survey effort.

Objective	Definition	Justification
WB1: Protect waterbird species diversity, through improved access to feeding and roosting habitat, assessed by the presence of all expected guilds in 50% of years to 2025.	• Expected guilds are based on the feeding guild classification by Jaensch, 2002 and need to be assigned	• Jaensch classification approach adopted due to the inclusion of feeding in the objective • Objective aims to protect species diversity to align with wording of Basin Environmental Watering Strategy objective for waterbirds and Basin Plan Schedule 9 (ecosystem functions). • Breeding and numbers has not been included as (i) breeding at the site will be opportunistic and not a focus for management, Horseshoe Lagoon is a relatively small wetland and unlikely to make a significant contribution to waterbird abundance.
AB2: Protect the diversity of frog species in 80% of years to 2025	• Frog species likely to occur, or be supported at Horseshoe Lagoon include Common froglet (*Crinia signifera*), Spotted Marsh Frog, Brown treefrog (*Litoria ewingii*) and Pobblebonk (*Limnodynastes dorsalis*)	• Abundance not included in the objective as monitoring is unlikely to accurately measure this • Only one frog species has been recorded at the site (Common froglet) but this may be due to limited surveys.

7.3 Hydrological objectives

The water requirements of the vegetation communities that will be targeted by environmental watering at Horseshoe Lagoon have been adapted from Frood & Papas (2016) and are presented in Table 9.

Due to the lack of research and literature on the threatened plant species (objective V2) it is difficult to determine a singular watering regime for these species. However, it is known that River Swamp Wallaby-grass is a cool growing species and is likely to benefits from deliveries during the autumn-winter period. Monitoring of these species should occur to better understand their response to water deliveries at Horseshoe Lagoon (Section 10 –Knowledge Gaps and Recommendations).

Specific hydrological objectives have not been developed for waterbirds, frogs and turtles, despite ecological objectives being set for these species. This approach is considered reasonable as:

- **Waterbirds:** The ecological objective for waterbirds focusses on the provision of roosting and feeding habitat. Meeting the water requirements of vegetation is also expected support aquatic food webs and provide roosting habitat for waterbirds. As such, separate hydrological objectives for waterbirds have not been recommended.
- **Eastern long necked turtle:** The water requirements for the Eastern long necked turtle are provided in Appendix F. In summary, Eastern long necked turtles use both permanent and semi-permanent water bodies, migrating between habitat areas if wetlands dry out. Breeding is typically stimulated by season not flooding, although availability of food is important. They may lay up to three clutches of eggs per year between spring and later summer. The water requirements of the vegetation at Horseshoe Lagoon, combined with the presence of deep pool areas, are expected to meet the requirements of the Eastern long necked turtle.
- **Broad-shelled Eastern long necked turtle:** The water requirements for the Eastern long necked turtle and Broad-shelled turtle are provided in Appendix F. The water requirements for the Murray River turtle are similar to those of the Broad-shelled turtle (DELWP, 2016). Eastern long necked turtles use both permanent and semi-permanent water bodies, migrating between habitat areas if wetlands dry out. Breeding is typically stimulated by season not flooding, although availability of food is important.

Table 9: Water requirements of ecological vegetation classes expected to benefit from environmental watering at Horseshoe Lagoon

Ecological objective	Ecological vegetation class	Hydrological Objectives										
		Frequency (years in 10)			Ponding duration (months)			Tolerable dry period (months)			Maximum depth	Timing
		Min	Opt	Max	Min	Opt	Max	Min	Opt	Max		
V1: *Protect diversity, recruitment and regeneration of target EVCs from the 2012 - 2019 benchmark by 2025.*	**Tall Marsh (821)**	6	**8**	10	6	**8**	11	6	**18**	24	<0.4m	autumn to spring
	Aquatic Herbland (653)/ Floodway Pond Herbland (810)	6	**8**	10	6	**18**	36	3	**6**	12	>2m	autumn to spring

7.4 Water requirements for black swan

As discussed above, the water requirements outlined in this EWMP focus on the needs of the vegetation communities expected to occur at Horseshoe Lagoon. Providing the water for these vegetation communities also provides the feeding and roosting habitat used by waterbirds, such as the black swan (*Cygnus atratus*).

The black swan is central to Taungurung's creation story associated with Horseshoe Lagoon[1]. Because of its significance, the water requirements of the black swan are compared against the water regime developed by this EWMP.

Figure 11: Black swan (*Cygnus atratus),* a waterbird species found at Horseshoe Lagoon

An overview of the known water requirements of this species is provided in Table 10 and shows their water needs align well with the water requirements of the key vegetation communities.

Table 10: Water requirements of Black Swan (DELWP, 2016)

Flow component	Black swan, *Cygnus atratus*
Life expectancy	Anecdotally estimated to be 10 years in the wild for Black swan, reaching sexual maturity at 18-36 months old.
Frequency	To maintain breeding populations, Black swan requires a minimum large flood frequency of 1 flood in every 5 years; and small maintenance floods every 1-2 years.

[1] The reference to the Brolga in this story is thought to be associated with other wetlands in the Trawool valley that have more suitable habitat for this species.

Flow component	Black swan, *Cygnus atratus*
Depth	Forages in both open shallow (< 0.5 m) and deep waters (> 1 m), and also on exposed mudflats. The ideal flood depth to enable Black swan to successfully breed is 0.3-2.0 m. Water depth must be sufficient to prevent the brood territory from becoming dry prior to young becoming independent (i.e. minimum 0.3-0.5 m deep).
Duration	Black swan favours large, open permanent wetlands, though it will also use ephemeral wetlands. For Black swan, and for a flood in late-winter or spring to early-summer: • The minimum lag time to commence breeding is less than 1 month; • The ideal lag time to commence breeding is 1 month; • The breeding duration is 7-8 months; • The minimum duration of flooding to enable successful breeding is 7-9 months; and • The ideal flood duration to enable successful breeding is 9 months. Incubation period is 35-48 days. Young swans can fly after the primary feathers have developed, at 150-170 days.
Timing/preferred season	Flooding is the primary stimulus and season a secondary stimulus for breeding in Black swan. Breeding season occurs from winter to spring in Victoria; however, breeding may occur whenever conditions are suitable (e.g. opportunistically throughout the year).
Rate of rise and fall	Not known if important.
Other habitat requirements	Nests are a mound of vegetation constructed in shallow water 0.3-0.6 m deep, and often anchored to aquatic vegetation, such as reeds (Cumbungi, spike-rushes), or on stumps or bases on trees in wooded swamps, on floating debris or on the ground on islands.

7.5 Watering regime

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

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

The proposed watering regime considers both naturally occurring and managed floods. As such, environmental watering will target the shortfall in desired flooding frequency between naturally occurring events.

Variability should be incorporated into planned watering actions over time, better reflecting what happens during natural flooding. Differences from year to year may include changes to the timing of delivery, depth of inundation or the length of the dry phase.

Minimum watering regime

Provide flooding 5 years in ten, with dry phases not extending to more than two consecutive years. Fill wetland to variable depths up to 1.5m during winter or spring to protect target EVCs, provide vital habitat for aquatic biota and to provide foraging and breeding habitat for black swan.

Optimum watering regime

Provide flooding 8 years in ten, with dry phases in the deepest parts of the lagoon not extending for more than 6 months. Fill wetland to variable depths of up to 2.5m during winter or spring to provide the target EVCs with appropriate watering requirement, allow regeneration and recruitment of vegetation within the wetland body and maintain the duration of flooding for 9 months to provide optimum breeding opportunities for aquatic biota including Black swan. Top up flows may be provided in some years.

Maximum watering regime

Provide flooding in each year, allowing for short periods of wetland drying within each ten year cycle. Fill wetland to variable depths of up to 3m during winter or spring to protect target EVCs and restore fringing vegetation communities by pushing water out into higher areas surrounding the lagoon.

Note: the depth, timing and duration of events provided are estimates only and will be further validated during the implementation of the recommended regimes.

8. Potential risks and mitigation measures

Although environmental watering actions are designed to achieve improved ecological outcomes, they also need to consider the potential environmental risks and how they can be managed. Potential environmental risks include things that may limit the achievement of management objectives set for the site or adverse environmental outcomes as a result of environmental watering.

Risk management is part of existing environmental water planning processes including the:

- *Commonwealth Environmental Water Holder's Framework for Determining Commonwealth Environmental Water Use* - that requires environmental watering actions to consider potential environmental risks, including downstream environmental risks, and measure that may be taken to minimise those risks (CEWO, 2013).
- *Victorian Environmental Water Holder's (VEWH) Seasonal Watering Planning process* - which has established an over-arching risk management framework that requires all parties to identify and control foreseeable adverse outcomes.
- *VEWH's Delivery Planning process* – this addresses specific risks associated with each delivery of environmental water including risks to public and private assets.

A summary of potential threats associated with environmental watering activities at Horseshoe Lagoon is provided in Table 11.

Table 11: Priority threats to the cultural and social values of Horseshoe Lagoon

Threat	Impact	Priority	Objective(s) affected	Mitigating action
Fox predation	• Foxes are known to raid turtle and waterbird nests for eggs impacting on the successful completion of breeding cycles	**High** – foxes are known to be present at the site and their impacts are well known	• AB1, WB1	• Work collaboratively with Parks Victoria, Taungurung Land and Waters Council and neighbouring landholders to implement complementary fox control programs.
Exotic fish	• Exotic fish species such as Carp, Gambusia and Goldfish may outcompete native fish species for habitat and food resources or predate on native fish species. Carp and Goldfish may also disturb sediment	**High** – carp are known to enter the lagoon and the impacts are well understood	• V1, V2	• Pumping during cooler months may limit the entry of carp or goldfish into the lagoon. If causing a significant impact, options to screen for fish at the pump intake could be explored. • Implement drying regimes to reduce population numbers.

Threat	Impact	Priority	Objective(s) affected	Mitigating action
	through feeding behaviour increasing turbidity and limiting plant responses			
Recreation impacts	• More frequent water in the lagoon may increase recreational use resulting in campfire escape or impacting on the site's ecological or cultural values (known or unknown).	**High** – the site is a popular camping area. Threat given higher priority due to the potential impact on cultural sites.	• V1, V2	• Work collaboratively with Parks Victoria and Taungurung Land and Waters Council to manage potential visitor impacts • Survey significant cultural sites within the reserve
Exotic plants	• Weeds may displace native species leading to reduced vegetation response, particularly high threats weeds (Yorkshire Fog and Toowoomba Canary Grass) may become dominant in the shallow margins of the lagoon	Moderate – the proposed watering regime is expected to favour native aquatic however high threat weeds are established at the site	• V1, V2	• Work collaboratively with Parks Victoria, Taungurung Land and Waters Council and neighbouring landholders to implement complementary weed control programs.
Inappropriate water regime	• Recommended watering regime does not support the desired vegetation response	Moderate – the natural hydrology of Horseshoe Lagoon is well understood	• V1, V2	• Undertake vegetation monitoring and evaluate observed vegetation responses to adapt and refine the water regime over time.
Poor water quality - blackwater	• Low levels of dissolved oxygen in the water may cause fish deaths, public complaints about odour or create blackwater condition which reduces the ability of light to penetrate limiting plant responses.	Low – key impact on objectives is related to vegetation which will reduce as the wetland dries	• V1, V2	• Implement proposed water regime which may reduce the impact of blackwater over time • Consider the delivery of top up flows to provide a dilution effect
Poor water quality – algal blooms	• Elevated nutrient levels in the lagoon result in algal blooms that may be harmful to aquatic biota	Low – the concentrations of phosphorus in the Goulburn River is low	• AB2	• If threat becomes an increased priority over time, investigate options to reduce nutrient loads in runoff from adjacent land

9. Environmental water delivery infrastructure

9.1 Delivery options

Environmental water can be delivered to Horseshoe Lagoon by pumping from the Goulburn River. A temporary pump could be positioned on the road near the river and water directed to both halves of the wetland via connected pipes and hoses (Figure 12).

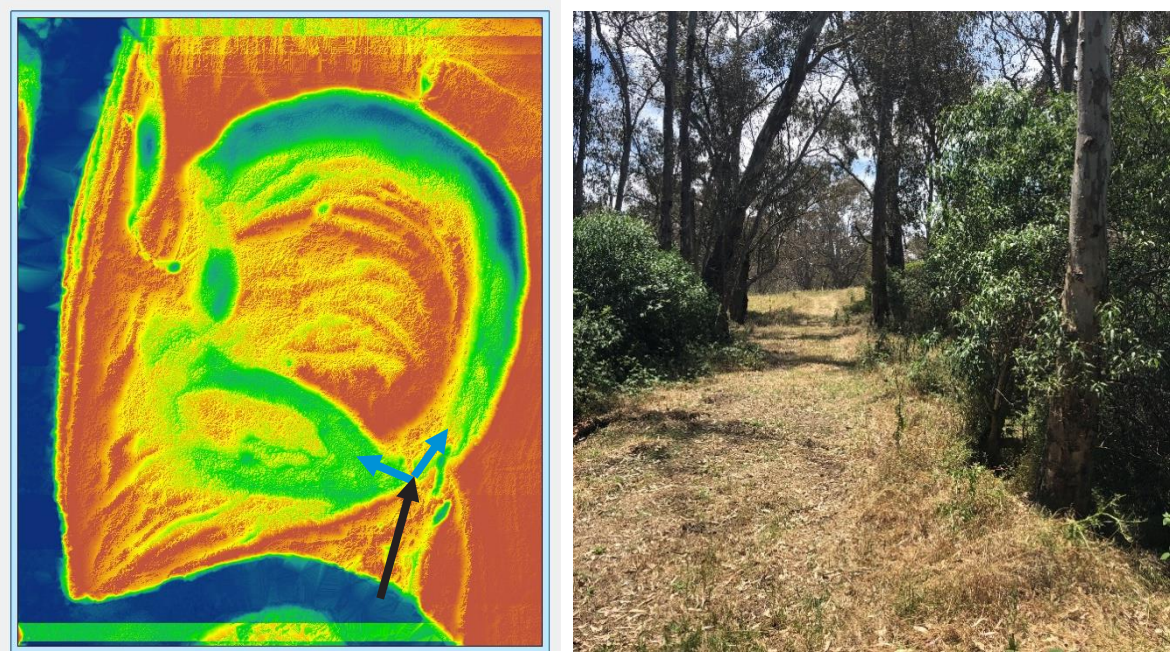

Figure 12: Left hand picture shows a DEM of Horseshoe Lagoon; black arrow shows the proposed location of a temporary pump, blue arrows show the direction of water delivery. Right hand picture shows the site conditions proposed pumping point (December 2018).

Taungurung Land and Waters Council is interested in opportunities to be actively involved in the pumping of water into the lagoon and opportunities to explore this further should be considered.

9.2 Constraints

As discussed in section 5.1, operating rules for the release of water from Lake Eildon are managed to avoid inundation of the floodplain adjacent to the river. This constraint, combined with an obligation to avoid overbank flows when delivering environmental water constrains environmental releases to the river channel. As noted in the previous section, maximising the benefits of environmental water delivery in alluvial systems includes connection of river channels to their floodplains. This contributes to the overall diversity of river-floodplain systems and contributes allochthonous sources of carbon to the river, thus contributing to in-stream productivity.

Opportunities to deliver higher flows in the Goulburn River system are being investigated through the Constraints Management project, an initiative under the Murray-Darling Basin Plan (MDBA 2013). This project is currently only considering flows within operational levels in the mid-Goulburn River and is targeting near bankfull flows in the lower Goulburn River. It is very unlikely that this constraint will be relaxed and that Horseshoe Lagoon will be able to receive deliveries of environmental water targeted at inundating areas of the mid-Goulburn River floodplain in the near future.

Natural inflows are further impacted by a block bank constructed on private land across a floodrunner upstream of Horseshoe Lagoon (Figure 6). The likely impacts of this block bank are to have increased the commence to flow threshold of when the wetland fills during naturally occurring high flow periods and to

fragment and restrict movement of fauna (particularly fish) and transfer of carbon and plant propagules. Opportunities to explore the removal of this embankment could be pursued with the landholder involved.

There is a knowledge gap around the subsurface hydrologic connection between Horseshoe Lagoon and the Goulburn River. Alluvial floodplain wetlands that are located close to rivers often have deep gravel formation as the underlying sediment which can have very high hydraulic conductivity. This means that if water is pumped into the wetland when the river levels are low and the watertable is lower than the base level of the lagoon, water may drain out through the subsurface connection back to the river resulting in an inundation event of very short duration. This may mean that the ecological objectives for Horseshoe Lagoon are not achieved because the duration of flooding is unexpectedly short. Groundwater monitoring during an environmental watering event would help to establish the nature of the subsurface connection and the extent to which this would risk achieving ecological objectives through pumping into the wetland.

9.3 Infrastructure recommendations

Potential works to improve the movement of water within the Horseshoe Lagoon Reserve include possible modifications to the road embankment (Figure 9) which divides the northern and southern sections of the lagoon. Such modifications could include lowering the height of the road crossing or installing a culvert within the road; and would need to consider implications for land management activities within the reserve.

Restoring connectivity between the northern and southern parts of the lagoon is consistent with the aspiration of the Taungurung Traditional Owners, who place high importance of connectivity within and across landscapes.

10. Management actions and recommendations

Table 12 summarises the various knowledge gaps and supporting actions identified within this EWMP. While most of these do not prevent the ability to provide water to the wetland and generate ecological benefits, addressing these would significantly improve the long-term ecological understanding and outcomes at the site.

Each of the recommendations are reference to the relevant section where they are addressed within this plan.

Table 12: Recommended future actions to support environmental watering at Horseshoe Lagoon

Recommendation	Actions	Lead agency
Undertake monitoring to support continual improvement and enable reporting against site based objectives	Develop a monitoring program that supports reporting and evaluation against the management objectives (section 7.2); and includes the following elements: • vegetation monitoring (objectives V1 and V2) • turtle species (objective AB1) • waterbird species presence (objective WB1) • monitoring of frog species (objective AB2).	GB CMA
Improve understanding of the status of threatened plant species at Horseshoe Lagoon	• Undertake targeted surveys of threatened plant species - River Swamp Wallaby-grass, Green-top Sedge, Veiled Fringe-sedge, Hypsela and Yarra Burgan • Benchmark status of current communities and revise objective V2 (section 7.2)	GB CMA
Complementary land management activities	Work collaboratively with Parks Victoria and Taungurung Land and Waters Council to secure funding to assist with: • Eradication of high threat weeds within the reserve including Spear Thistle, Sweet Briar, Blackberry, Yorkshire Fog and Toowoomba Canary Grass (section 6.1, Table 11) • Control fox populations within the reserve and its adjoining land (Table 11) • Assessment of options and implementation of works to assist with managing visitor impacts (Table 11) • Evaluate the feasibility of using cool burns to assist with the control of high threat weeds within the reserve.	Parks Victoria
Explore partnership opportunities with Taungurung Land and Waters Council	• Investigate options to engage Taungurung Land and Waters Council to facilitate the pumping of water into the lagoon (section 9.1).	GB CMA

Recommendation	Actions	Lead agency
Build capacity to develop cultural objectives for the lagoon	• Build on the outcomes of the Aboriginal Waterway Assessment through further surveys of plants and animals of cultural significance at the lagoon • Explore opportunities to secure funding to document these learnings into a cultural management plan for the reserve.	TLWC
Improve connectivity within the lagoon and between the lagoon and river	• Investigate options to improve connectivity within the lagoon (section 9.3) and between the lagoon and river (section 9.2)	GB CMA
Improve understanding of the cultural heritage values of the site	• Undertake a survey of cultural heritage at Horseshoe Lagoon and any opportunities to support these through environmental watering (section 3.4)	TLWC

11. Roles and responsibilities

Management of environmental water involves a number of agencies including the Victorian Environmental Water Holder, the Commonwealth Environmental Water Office, the Murray-Darling Basin Authority and Goulburn Murray Water. Table 13 provides an outline of the agencies and groups involved in environmental water management in the Goulburn River downstream of Lake Eildon.

Table 13: Parties involved in Environmental Water Management.

Party	Involvement
Goulburn Broken Catchment Management Authority (GB CMA)	• Identify regional priorities for environmental water management in the regional waterway strategy. • Assess water regime requirements of priority rivers and wetlands to identify environmental watering needs to meet agreed objectives. Identify opportunities for and implement, environmental works to use environmental water more efficiently. • Propose annual environmental watering actions to the Victorian Environmental Water Holder and implement its environmental watering decisions. • Provide critical input to management of other environmental water (e.g. passing flows management) and report on environmental water management activities undertaken.
Parks Victoria (PV)	• Land Managers. Implement relevant components of Environmental Water Management Plans. • Operate, maintain and replace (as agreed), the infrastructure required for delivery of environmental water, where infrastructure is not part of the GMW irrigation system
Traditional Owners Taungurung Land and Waters Council (TLWC)	• Engaged through the development of the seasonal watering proposal and input to indigenous related issues. • Joint land management activities with Parks Victoria
Goulburn Murray Water (GMW)	• Water Corporation – Storage Manager and Resource Manager • Work with the Victorian Environmental Water Holder and waterway managers in planning for the delivery of environmental water to maximise environmental outcomes. • Operate water supply infrastructure such as dams and irrigation distribution systems to deliver environmental water. • Ensure the provision of passing flows and compliance with management diversion limits in unregulated and groundwater systems.
Victorian Environmental Water Holder (VEWH)	• Make decisions about the most effective use of Water Holdings, including use, trade and carryover. Authorise waterway managers to implement watering decisions. • Liaise with other water holders to ensure coordinated use of all sources of environmental water. • Communicate all environmental watering decisions and outcomes.
Commonwealth Environmental Water Office (CEWO)	• Make decisions about the use of Commonwealth water Holdings, including providing water to the Victorian Environmental Water Holder for use in Victoria. Liaise with the Victorian Environmental Water Holder to ensure co-ordinated use of environmental water in Victoria. • Report on management of Commonwealth water holdings.

Party	Involvement
Department of Environment, Land, Water and Planning (DELWP)	• Manage the water allocation and entitlements framework. • Develop state policy on water resource management and waterway management approved by the Minister for Water and Minister for Environment and Climate change. • Develop state policy for the management of environmental water in regulated and unregulated systems. • Act on behalf of the Minister for Environment and Climate change to maintain oversight of the Victorian Environmental Water Holder and waterway managers in their roles as environmental water managers.
Murray-Darling Basin Authority (MDBA)	• Implementation of the Murray-Darling Basin Plan. The plan sets legal limits on the amount of surface water and groundwater that can be taken from the Basin from July 1 2019 onwards. • Integration of Basin wide resource management and manager of The Living Murray water entitlements.

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Appendix A: Environmental water sources

Victorian River Murray Flora and Fauna Bulk Entitlement – Deployed along the length of the Murray River in Victoria. This has been used in the past to supply water to Barmah Forest and wetlands connected to the supply networks of the Goulburn River and lower Broken Creek Systems.

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

- The Victorian River Murray Flora and Fauna Bulk Entitlement; and
- Future Northern Victorian Irrigation Renewal Project (NVIRP) Environmental Entitlement.

In 1987 an annual allocation of 27,600ML of high security water was committed to flora and fauna conservation in Victorian Murray Wetlands. In 1999, this became a defined entitlement for the environment called the Victorian River Murray Flora and Fauna Bulk Entitlement.

Future Goulburn Murray Water Connections Program (GMW CP) Environmental Water Entitlements - One third of water savings from Stage 1 of the GMW CP project will be used for the environment, some of which will be stored in Lake Eildon. This water will be released into stressed rivers and streams when required. The GMW CP water savings are predicted to provide up to 75GL as a statutory environmental entitlement, which will be used to help improve the health of priority stressed rivers and wetlands in northern Victoria (DSE 2008). The entitlement will have priorities which enable the water to be used at multiple locations as the water travels downstream (provided losses and water quality issues are accounted for); meaning that the water can be called out of storage at desired times to meet specific environmental needs.

The environment's share of water savings will be over and above The Living Murray and Snowy commitments and will primarily target the use of environmental water for priority Victorian wetlands and tributaries.

This will also have flow on benefits when the water enters the River Murray, which can then be reused to meet the needs of the Murray and its floodplains and wetlands, including Kerang Lakes, Barmah Forest, Gunbower Forest, Hattah Lakes, Lindsay-Wallpolla Island and various other sites along the River Murray.

Stage 2 is expected to deliver a further 200 billion litres of water savings a year, which will be shared equally between irrigators and the environment.

Commonwealth Environmental Water Office (CEWO) – The *Water Act 2007* established the Commonwealth Environmental Water Holder to manage the water entitlements that the Commonwealth acquires. These water entitlements will be used to protect or restore environmental assets such as wetlands and streams.

Commonwealth environmental water is available to avoid the critical loss of threatened species. It is also available to avoid irretrievable damage or catastrophic events and to maintain key refuges to allow re-colonisation when conditions improve.

Appendix B: Legislative framework

International Acts, Agreements and Conventions

Japan Australia Migratory Bird Agreement 1974 - Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment.

China Australia Migratory Bird Agreement 1986 - Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment.

These agreements require that the parties protect migratory birds by:

- Limiting the circumstances under which migratory birds are taken or traded;
- Protecting and conserving important habitats;
- Exchanging information; and
- Building cooperative relationships.

Convention of Migratory Species (Bonn Convention) 1979 - The Convention on the Conservation of Migratory Species of Wild Animals (also known as CMS or Bonn Convention) aims to conserve terrestrial, marine and avian migratory species throughout their range. It is an intergovernmental treaty, concluded under the aegis of the United Nations Environment Programme, concerned with the conservation of wildlife and habitats on a global scale. Since the Convention's entry into force, its membership has grown steadily to include 114 (as of 1 October 2010) Parties from Africa, Central and South America, Asia, Europe and Oceania.

Republic of Korea Australia Migratory Bird Agreement 2009 – Agreement between the Government of Australia and the Government of the Republic of Korea on the protection of Migratory birds.

Acts (National)

***Australian Heritage Commission Act* 1975** - An Act to establish an Australian Heritage Commission.

***Aboriginal and Torres Strait Islander Heritage Protection Act* 1984** - An Act to preserve and protect places, areas and objects of significance to Aboriginals, and for related purposes.

***Native Title Act* 1993** – Legislation to protect any native title that has survived 200 years of colonisation.

Environment Protection and Biodiversity Conservation Act 1999 - The Australian Government's central piece of environmental legislation. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places — defined in the Act as matters of national environmental significance.

***Water Act* 2007** - An Act to make provision for the management of the water resources of the Murray-Darling Basin, and to make provision for other matters of national interest in relation to water and water information, and for related purposes.

***Water Amendment Act* 2008** - An Act to amend the Water Act 2007, and for related purposes.

Acts (Victoria)

***Environmental Effects Act* 1978** – Potential environmental impacts of a proposed development are subject to assessment and approval under this Act. A structural works program and any associated environmental impacts would be subject to assessment and approval under this Act.

***Planning and Environment Act* 1987** – Controls the removal or disturbance to native vegetation within Victoria by implementation of a three-step process of avoidance, minimisation and offsetting.

***Flora and Fauna Guarantee Act* 1988** - The key piece of Victorian legislation for the conservation of threatened species and communities and for the management of potentially threatening processes.

***Water Act* 1989 (Victorian)** - The legislation that governs the way water entitlements are issued and allocated in Victoria. It defines water entitlements and establishes the mechanisms for managing Victoria's water resources.

***Catchment and Land Protection Act* 1994** - has an objective of establishing a framework for the integrated and coordinated management of catchments which will;

- maintain and enhance long-term land productivity while also conserving the environment, and
- aim to ensure that the quality of the State's land and water resources and their associated plant and animal life are maintained and enhanced.

The Act established ten Catchment and Land Protection Boards, nine of which have since expanded their roles to become Catchment Management Authorities. The *Catchment and Land Protection Act* (1994) provides for the development of Regional Catchment Strategies which, among other things, must assess the nature, causes, extent and severity of land degradation of the catchments in the region and identify areas for priority attention. Local Planning schemes must have regard for the Regional Catchment Strategies.

***Aboriginal Heritage Act* 2006** - The main purpose of this Act is to provide for the protection of Aboriginal cultural heritage in Victoria. The objectives of this Act are-

a. to recognise, protect and conserve Aboriginal cultural heritage in Victoria in ways that are based on respect for Aboriginal knowledge and cultural and traditional practices;

b. to recognise Aboriginal people as the primary guardians, keepers and knowledge holders of Aboriginal cultural heritage;

c. to accord appropriate status to Aboriginal people with traditional o familial links with Aboriginal cultural heritage in protecting that heritage;

d. to promote the management of Aboriginal cultural heritage as an integral part of land and natural resource management;

e. to promote public awareness and understanding of Aboriginal cultural heritage in Victoria;

f. to establish an Aboriginal cultural heritage register to record Aboriginal cultural heritage;

g. to establish processes for the timely and efficient assessment of activities that have the potential to harm Aboriginal cultural heritage;

h. to promote the use of agreements that provide for the management and protection of Aboriginal cultural heritage;

i. to establish mechanisms that enable the resolution of dispute relating to the protection of Aboriginal cultural heritage;

j. to provide appropriate sanctions and penalties to prevent harm to Aboriginal cultural heritage.

Advisory lists of rare and threatened species in Victoria (DSE) – Three advisory lists are maintained by DSE for use in a range of planning processes and in setting priorities for actions to conserve biodiversity. Unlike other threatened species lists, there are no legal requirements or consequences that flow from inclusion of a species on an advisory list. The advisory list comprises:

- Advisory list of Rare and Threatened Plants in Victoria – 2014
- Advisory list of Threatened Vertebrate Fauna in Victoria – 2013
- Advisory list of Threatened Invertebrate Fauna in Victoria - 2009

Policy and Frameworks (National)

Wetland Policy of the Commonwealth Government of Australia 1997 - On 2 February 1997, the inaugural World Wetlands Day, the Commonwealth Government released the Wetlands Policy of the Commonwealth Government of Australia. The Wetlands Policy aims to promote the conservation, repair, and wise use of wetlands and - within the broader context of environmental management - incorporate the conservation of wetlands into the daily business of the Commonwealth Government.

Framework for Determining Commonwealth Environmental Watering Actions 2009 - The purpose of this paper is to outline a framework for determining Commonwealth environmental watering actions in the Murray-Darling Basin. The framework will be developed and implemented over the period 2009-2011, prior to the development of the Environmental Watering Plan (EWP) by the Murray Darling Basin Authority and be adapted in accordance with the EWP once that is available.

Policy and Frameworks (Victoria)

The State Environment Protection Policy (Waters of Victoria) 2003 - Sets the framework for government agencies, businesses and the community to work together, to protect and rehabilitate Victoria's surface water environments.

Northern Region Sustainable Water Strategy 2009 - The Northern Region Sustainable Water Strategy has been released by the Victorian Government to secure the water future for urban, industrial, agricultural and environmental water users for the next 50 years.

Water for Victoria - A statewide plan setting a new long-term direction for managing Victoria's water resources in the context of climate change and population growth. The plan sets out 69 actions ranging from waterway projects aimed at protecting and restoring waterway health to supporting resilience of farmers with new infrastructure and skills and building understanding of Aboriginal ecological knowledge in water management. The actions in the plan aim to support a healthy environment, a prosperous economy with growing agricultural production and thriving communities.

Policy and Frameworks (Regional)

Goulburn Broken Catchment Regional Catchment Strategy 2013-2019 – A strategy that sets the framework for Natural Resource Management and the context for sub-strategies and action plans within the Goulburn Broken Catchment.

Goulburn Broken CMA Waterway Strategy 2014-2022 – A strategy underpinning the Regional Catchment Strategy that presents an integrated catchment planning framework for waterways in the Goulburn Broken region and is the primary guide for priority setting, maintenance and improvement of waterways.

Biodiversity strategy for Goulburn Broken Catchment 2009 - This Strategy follows implementation of Goulburn Broken CMAs Native Vegetation Management Strategy (developed in 2000) and from the Fringe to mainstream – a Strategic Plan for Integrating Native Biodiversity (developed in 2004). The Strategy provides a regional perspective for implementing Victoria's White Paper for Land and Biodiversity at a time of Climate Change (released December 2009).

Appendix C: Corrick and Norman classification of wetland categories

A system of wetland classification developed by Corrick and Norman (1980) is used to describe wetlands in Victoria. Under this system six naturally occurring wetland types are described based upon water depth, frequency of inundation, salinity and dominant vegetation.

Freshwater meadow

These include shallow (up to 0.3m) and temporary (less than four months duration) surface water, although soils are generally waterlogged throughout winter.

Shallow freshwater marsh

Wetlands that are usually dry by mid-summer and fill again with the onset of winter rains. Soils are waterlogged throughout the year and surface water up to 0.5m deep may be present for as long as eight months.

Deep freshwater marsh

Wetlands that are generally inundated to a depth of 1-2m throughout the year.

Permanent open freshwater

Wetlands that are usually more than 1m deep. They can be natural or artificial. Wetlands are described as permanent if they retain water for longer than 12 months, however they can have periods of drying.

Semi-permanent saline

These wetlands may be inundated to a depth of 2m for as long as eight months each year. Saline wetlands are those in which salinity exceeds 3,000mg/L throughout the whole year.

Permanent saline

These wetlands include coastal wetlands and part of intertidal zones. Saline wetlands are those in which salinity exceeds 3,000mg/L throughout the whole year.

Appendix D: Fauna species list

Table 14: Fauna list of Horseshoe Lagoon (Australian Ecosystems 2012, Victorian Biodiversity Atlas).

Scientific Name	Common name	FFG	VROTS	Treaty	Wetland species
Birds					
Acanthiza lineata	Striated Thornbill				
Acanthiza pusilla	Brown Thornbill				
Acrocephalus stentoreus	Clamorous Reed Warbler			BONNA2H	W
Alcedo azurea	Azure Kingfisher				W
Anas castanea	Chestnut Teal				W
Anas gracilis	Grey Teal				W
Anas rhynchotis	Australasian Shoveler		vu		W
Anas superciliosa	Pacific Black Duck				W
Anhinga novaehollandiae	Darter				W
Ardea modesta	Eastern Great Egret	L	vu	CAMBA, JAMBA	W
Ardea pacifica	White-necked Heron				W
Artamus cyanopterus	Ducky Woodswallow				
Aythya australis	Hardhead		vu		W
Biziura lobata	Musk Duck		vu		W
Cacatua galerita	Sulphur-crested Cockatoo				
Cacatua sanguinea	Little Corella				
Callocephalon fimbriatum	Gang-gang Cockatoo				
Chenonetta jubata	Australian Wood Duck				W
Circus approximans	Swamp Harrier				W
Coracina novaehollandiae	Black-faced Cuckoo-shrike				
Cormobates leucophaea	White-throated Treecreeper				
Corvus mellori	Little Raven				
Cracticus tibicen	Australian Magpie				
Cygnus atratus	Black Swan				
Dacelo novaeguineae	Laughing Kookaburra				
Egretta novaehollandiae	White-faced Heron				W
Elseyornis melanops	Black-fronted Dotterel				W
Eopsaltria australis	Eastern Yellow Robin				
Falcunculus frontatus	Crested Shrike-tit				
Fulica atra	Eurasian Coot				W
Gallinago hardwickii	Latham's Snipe		nt	BONNA2H, CAMBA, JAMBA, ROKAMBA	W

Scientific Name	Common name	FFG	VROTS	Treaty	Wetland species
Gallinula tenebrosa	Dusky Moorhen				W
Gerygone olivacea	White-throated Gerygone				
Grallina cyanoleuca	Magpie-lark				
Haliastur sphenurus	Whistling Kite				
Hirundo neoxena	Welcome Swallow				
Lichenostomus chrysops	Yellow-faced Honeyeater				
Lichenostomus penicillatus	White-plumed Honeyeater				
Malacorhynchus membranaceus	Pink-eared Duck				W
Malurus cyaneus	Superb Fairy-wren				
Melithreptus lunatus	White-naped Honeyeater				
Microcarbo melanoleucos	Little Pied Cormorant				W
Myiagra rubecula	Leaden Flycatcher				
Neochmia temporalis	Red-browed Finch				
ord. *Charadriiformes* fam. *Charadriidae*	Plovers, Dotterels and Lapwings				W
ord. *Podicipediformes* fam. *Podicipedidae*	Grebes				W
Pachycephala pectoralis	Golden Whistler				
Pachycephala rufiventris	Rufous Whistler				
Pardalotus punctatus	Spotted Pardalote				
Pardalotus striatus	Striated Pardalote				
Phalacrocorax carbo	Great Cormorant				W
Phalacrocorax sulcirostris	Little Black Cormorant				W
Phalacrocorax varius	Pied Cormorant		nt		W
Philemon corniculatus	Noisy Friarbird				
Phylidonyris novaehollandiae	New Holland Honeyeater				
Platalea flavipes	Yellow-billed Spoonbill				W
Platycercus elegans	Crimson Rosella				
Platycercus eximius	Eastern Rosella				
Poliocephalus poliocephalus	Hoary-headed Grebe				W
Porphyrio porphyrio	Purple Swamphen				W
Rhipidura albiscapa	Grey Fantail				
Smicrornis brevirostris	Weebill				
Tachybaptus novaehollandiae	Australasian Grebe				W
Tadorna tadornoides	Australian Shelduck				W
Threskiornis molucca	Australian White Ibis				W

Scientific Name	Common name	FFG	VROTS	Treaty	Wetland species
Threskiornis spinicollis	Straw-necked Ibis				W
Todiramphus sanctus	Sacred Kingfisher				W
Vanellus miles	Masked Lapwing				W
Zosterops lateralis	Silvereye				
Mammals					
Ornithorhynchus anatinus	Platypus				
*Oryctolagus cuniculus**	European Rabbit				
Macropus giganteus	Eastern Grey Kangaroo				
Phascolarctos cinereus	Koala				
Trichosurus vulpecula	Common Brushtail Possum				
Vombatus ursinus	Common Wombat				
Amphibians					
Crinia signifera	Common Froglet				

Legend

* Introduced species

L = listed as threatened under the *Flora and Fauna Guarantee Act* (1988)

vu = Listed as vulnerable on the DSE Advisory list of threatened vertebrate fauna (2007)

en = Listed as endangered on the DSE Advisory list of threatened vertebrate fauna (2007)

nt = Listed as near threatened on the DSE Advisory list of threatened vertebrate fauna (2007)

dd = Listed as data deficient on the DSE Advisory list of threatened vertebrate fauna (2007)

cr = Listed as critically endangered on the DSE Advisory list of threatened vertebrate fauna (2007)

w = Water dependent species or Waterbirds

BONNA2H = listed on the Bonn Convention (species is member of a family listed in Appendix 2 of the convention)

CAMBA = Listed on the China- Australia Migratory Bird Agreement 2007

JAMBA = Listed on the Japan- Australia Migratory Bird Agreement

ROKAMBA = Listed on the Republic of Korea- Australia Migratory Bird Agreement

Appendix E: Flora species list

Table 15: Flora list of Horseshoe Lagoon (Australian Ecosystems 2012, Victorian Biodiversity Atlas).

Common name	Scientific Name	Origin	EPBC	FFG	VROTS
Acacia dealbata	Silver Wattle				
Acaena novae-zelandiae	Bidgee-widgee				
Acetosella vulgaris	Sheep's Sorrel	*			
Alternanthera denticulata s.s.	Lesser Joyweed				
Amphibromus fluitans	River Swamp Wallaby-grass		V	X	
Anagallis arvensis	Scarlet Pimpernel	*			
Araujia sericifera	Moth Vine	*			
Austrodanthonia racemosa	Wallaby-grass				
Bromus diandrus	Great Brome	*			
Callistemon sieberi	River Bottlebrush				
Callitriche sonderi	Matted Water-starwort				
Carex appressa	Tall Sedge				
Carex chlorantha	Green-top Sedge				K
Carex tereticaulis	Poong'ort				
Cassinia aculeata subsp. *aculeata*	Common Cassinia				
Centipeda elatinoides	Elatine Sneezeweed				
Centipeda minima subsp. minima s.s.	Spreading Sneezeweed				
Chamaecytisus palmensis	Tree Lucerne	*			
Chenopodium pumilio	Clammy Goosefoot	#			
Cirsium vulgare	Spear Thistle	*			
Conyza bonariensis	Flaxleaf Fleabane	*			
Cyperus eragrostis	Drain Flat-sedge	*			
Cyperus lhotskyanus	Creeping Flat-sedge				
Dactylis glomerata	Cock's Foot				
Distichlis distichophylla	Australian Salt-grass				
Dysphania glomulifera subsp. *glomulifera*	Globular Pigweed				
Echium plantagineum	Paterson's Curse	*			
Elatine gratioloides	Waterwort				
Eleocharis acuta	Common Spike-sedge				
Eucalyptus camaldulensis	River Red-gum				
Fimbristylis velata	Veiled Fringe-sedge				R
Foeniculum vulgare	Fennel	*			
Galium aparine	Cleavers	*			
Geranium sp. 2	Variable Cranes-bill				
Glyceria australis	Austral Sweet-grass				

Common name	Scientific Name	Origin	EPBC	FFG	VROTS
Holcus lanatus	Yorkshire Fog	*			
Hypochaeris radicata	Flatweed	*			
Hypsela tridens	Hypsela				K
Isolepis inundata	Swamp Club-sedge				
Juncus gregiflorus	Green Rush				
Juncus holoschoenus	Joint-leaf Rush				
Juncus ingens	Giant Rush				
Juncus usitatus	Billabong Rush				
Kunzea ericoides s.l.	Burgan				
Kunzea leptospermoides	Yarra Burgan				K
Lachnagrostis filiformis s.s.	Common Blown-grass				
Lactuca serriola	Prickly Lettuce	*			
Landoltia punctate	Thin Duckweed				
Leontodon taraxacoides subsp. *taraxacoides*	Hairy Hawkbit	*			
Lilaeopsis polyantha	Australian Lilaeopsis				
Limosella australis	Austral Mudwort				
Lolium rigidum	Wimmera Rye-grass	*			
Lotus corniculatus	Bird's-foot Trefoil	*			
Ludwigia peploides subsp. *Montevidensis*	Clove-strip				
Lysimachia arvensis	Pimpernel	*			
Lythrum hyssopifolia	Small Loosestrife				
Medicago polymorpha	Burr Medic	*			
Melicytus dentatus	Tree Violet				
Melicytus dentatus s.l.	Tree Violet				
Microlaena stipoides var. *stipoides*	Weeping Grass				
Modiola caroliniana	Red-flowered Mallow	*			
Muellerina eucalyptoides	Creeping Mistletoe				
Myriophyllum crispatum	Upright Water-milfoil				
Oxalis exilis	Shady Wood-sorrel				
Paspalum dilatatum	Paspalum	*			
Paspalum distichum	Water Couch	*			
Persicaria lapathifolia	Pale Knotweed				
Persicaria prostrate	Creeping Knotweed				
Phalaris aquatica	Toowoomba Canary-grass	*			
Phragmites australis	Common Reed				
Plantago lanceolata	Ribwort	*			
Poa labillardierei	Common Tussock-grass				

Common name	Scientific Name	Origin	EPBC	FFG	VROTS
Polygonum aviculare s.l.	Prostrate Knotweed	*			
Pseudognaphalium luteoalbum	Jersey Cudweed				
Pseudoraphis spinescens	Spiny Mud-grass				
Pterideum esculentum	Austral Bracken				
Ranunculus spp.	Buttercup				
Rorippa palustris	Marsh Yellow-cress	*			
Rosa rubiginosa	Sweet Briar	*			
Rubus fruticosus spp. agg.	Blackberry	*			
Rumex brownie	Slender Dock				
Rumex conglomeratus	Clustered Dock	*			
Rumex crispus	Curled Dock	*			
Senecio hispidulus	Hill Fireweed				
Solanum laciniatum	Kangaroo Apple				
Solanum nigrum	Black Nightshade	*			
Sonchus asper s.s.	Rough Sow-thistle	*			
Sonchus oleraceus	Common Sow-thistle	*			
Stellaria caespitose	Matted Starwort				
Trifolium repens var. *repens*	White Clover	*			
Trifolium subterranean	Subterranean clover	*			
Triglochin procera s.s.	Common Water-ribbons				
Ulex europaeus	Gorse	*			
Urtica incise	Stinging Nettle				
Verbena bonariensis s.l.	Purple-top Verbena	*			

Legend:

E =Listed as Endangered under the *Environmental Protection Biodiversity Act* (1999)
L = Listed as threatened under the *Flora and Fauna Guarantee Act* (1988)
e = Endangered in Victoria in DSE Advisory list of rare and threatened plants in Victoria (2005)
k = Poorly known in Victoria in DSE Advisory list of rare and threatened plants in Victoria (2005)
v = Vulnerable in Victoria in DSE Advisory list of rare and threatened plants in Victoria (2005)
r = Rare in Victoria in DSE Advisory list of rare and threatened plants in Victoria (2005)
w = Wetland species,
p = Planted,
# = Native to Victoria but grows outside natural range

Appendix F: Water requirements of Eastern long-necked turtle and Broad-shelled turtle (Source: DELWP, 2016)

Flow component	Eastern long-necked turtle, *Chelodina longicollis*	Broad-shelled turtle, *Chelodina expansa*
Stimulus	Lays clutches of 6 to 23 eggs between spring and late summer; may lay up to 3 clutches per year (Kennett et al. 2009). Season/temperature more likely to stimulate breeding than flooding, although food availability resulting from watering is important.	Lays clutches of between 5 and 28 eggs (Bower and Hodges 2014). Embryos can enter a diapause cued by low temperatures which enable them to overwinter in the nest. Consequently, the eggs can have incubation times that can vary considerably from 192 to 522 days.
Frequency	Frequency less important than access to permanent and semi-permanent water bodies. Can migrate between habitats if wetlands dry out (Kennett et al. 2009).	Frequency less important than access to permanent water bodies.
Depth	The species utilises a broad range of habitats including ephemeral wetlands, rivers pools, backwaters and dams. Greatest abundance occurs in shallow ephemeral wetlands in the absence of other turtle species (Kennett et al. 2009). Migrates to new habitat when current localities dry.	Abundance is only weakly correlated with water depth and distance from the river.
Duration	Prefers semi-permanent water in the absence of other turtle species. Can undergo estivation of up to 480 days to survive dry periods.	Prefers permanent water bodies, even in disturbed state (Bower and Hodges 2014).
Timing/preferred season	Spring to late summer breeding season.	Nesting occurs predominantly through autumn and winter and occasionally in spring.
Rate of rise and fall	Preference not known.	Preference not known.
Dry period	Annual; individuals can survive by estivation for up to 480 days.	Variable, so long as permanency is retained.
Other habitat requirements	The Eastern long-necked turtle is a floodplain specialist, preferentially occupying ephemeral habitats and retreating to permanent habitat in times of drought (Kennett and Georges 1990, Singh et al. unpub. data). This species is well adapted to overland migration (Chessman 1984a), utilising terrestrial corridors for both migration and aestivation (dormancy), with home ranges typically encompassing 2-3 wetlands (Roe and Georges 2007). Eastern long-necked turtles are opportunistic carnivores and their diet primarily consists of aquatic insects (Chessman 1984b, Georges et al. 1986).	The Broad-shelled turtle has been captured in a wide range of habitats including main rivers and their permanent wetlands, backwaters, anabranches and swamps (Chessman 1988, Howard et al. 2013a, Howard et al. 2013b). This species rarely leaves the water except to nest (Thompson 1993), and is an obligate carnivore eating decapod crustaceans, small fish and aquatic bugs (Chessman 1983).

Appendix F: Water requirements of Common froglet (Source: DELWP, 2016)

Flow component	Common eastern froglet, *Crinia signifera*
Stimulus	Breeding occurs during cooler temperatures, but also following rainfall and may occur at different times of the year (Wassens 2011). Therefore, it is likely that season/temperature is a primary stimulus and flooding or rainfall a secondary stimulus.
Frequency	In the Southwestern Slopes and Riverina Bioregions of New South Wales, and in 2010, Wassens et al (2013) found that the closely-related Plains froglet or Eastern sign-bearing froglet (*Crinia parainsignifera*) was capable of undergoing two breeding events after responding to winter-rains, including: • Early and late-stage tadpoles in March–May; • Drying of the wetland in mid-May; and • Refilling in late May; and • Egg masses, early-stage and mid-stage tadpoles. Wassens (2011) and Wassens et al. (2013) suggested that this flexibility and rapid breeding time may increase the resilience of this species to changes in seasonality of rainfall and wetland hydrology than more water dependent species.
Depth	Lower numbers of Common eastern froglets were heard calling in dry years, compared to wet years at Barmah Forest (McGinness et al. 2014). McGinness et al. (2014) also recorded a positive relationship between wetting frequency (i.e. the number of times the site was recorded as 'wet' proportional to the number of times a site was surveyed between 2000 and 2006) and number of calling male Common eastern froglets. Mac Nally et al. (2009) found in central Victoria, as did McGinness et al. (2014) at Barmah Forest, that Common eastern froglets significantly declined in abundance during the pro-longed millennium drought (2000-2009). River regulation has also reduced overbank flooding and subsequent availability of floodwaters during spring, resulting in reduced breeding in spring-breeding frog species, including Common eastern froglets.
Duration	Anstis (2013) found that females laid an average of 216 eggs (range 125-394 eggs). Mortality of eggs may be high as eggs are often deposited in ephemeral pools that may dry up. However, these frogs are frequent breeders. Hatching occurs 7-10 days after eggs are laid (Anstis 2013). Tadpole development times are variable and the duration of larval life may take from 6 weeks at 15°C, to 3 months, depending upon environmental conditions (Rogers 2011; Anstis 2013). Tadpole development times are species-specific and reflect the hydro periods of wetlands the species occupies (Wassens et al. 2013). Species with rapid tadpole development times (including Common eastern froglet) generally have a higher breeding success rate in temporary wetlands, compared with species with tadpoles that have long development times (Wassen et al. 2013). Wetlands should retain pooled water for a minimum period of 6 weeks if flooded in spring or summer, and a minimum of 3 months if flooded in winter to enable froglets to complete their breeding cycle (Wassens 2011).
Timing/preferred season	Common eastern froglet prefers cooler temperatures for breeding, and typically breeds through winter, autumn and spring, but may breed at any time depending on habitat and temperature (Rogers 2011; Anstis 2013). Male calling has recorded in all seasons and metamorphs have been recorded in spring (September and October), summer (December to February) and autumn (April) (Rogers 2011; Anstis 2013). At Barmah Forest, tadpoles or metamorphs have been recorded in September, October, November, December and February (McGinness et al. 2014). Male Common eastern froglets were also heard calling in greatest number in September than in any other month, though they were also commonly heard in October.
Rate of rise and fall	Wetlands should retain pooled water for a minimum period of 6 weeks if flooded in spring or summer, and a minimum of 3 months if flooded in winter to enable froglets to complete their breeding cycle (Wassens 2011). Floodwaters could recede at a slow, moderate or fast rate as long as the minimum flooding periods of 6 weeks and 3 months are met in spring/summer and winter, respectively (Rogers 2011).
Inter-flood dry period	Wassens (2011) noted that during the 2009 winter watering of in the Lower Lowbidgee floodplain (Lower Murrumbidgee Catchment), the Plains froglet was common in wetlands that had been dry since 2006. This species was also shown to be capable of a breeding event prior to mid-May drying of a wetland, and a second event following refilling of the wetland in late May. Rapid breeding enables opportunistic use of recently flooded (and formerly dry) areas.
Other habitat requirements	Common eastern froglet is a highly adaptable species that can occupy a diversity of permanent and semi-permanent wetlands, including rain-filled depressions, ditches, oxbow lagoons, creeks and rivers, farm dams, irrigation channels, flooded grasslands and urban ponds (Hazell et al. 2004; Mac Nally et al. 2009, 2014; Wassens 2011; Anstis 2013; McGinness et al. 2014). Common eastern froglets prefer to breed in wetlands supporting diverse aquatic vegetation or submerged grasses (Wassens 2011; McGinness et al. 2014). In Greater Melbourne, Hamer et al. (2012) found that at 81 wetland cells within 30 stormwater treatment wetlands, Common eastern froglet abundance increased with the size of the waterbody, and higher numbers were recorded at ponds with a shallow gradient. Hamer et al. (2012) suggested that shallow shores provide habitat with emergent vegetation for the Common eastern froglet to call from and deposit eggs. Eggs are laid in water and are usually attached to submerged grass stems, twigs, leaves, woody debris or substrate (Wassens 2011; Anstis 2013). Tadpoles are bottom-dwellers and generalist detritivores and herbivores and feed on biofilms, detritus and microscopic algae, and shelter under leaf litter, vegetation and among rocks (Wassens 2011; Anstis 2013). Froglets shelter away from drainage lines/wetlands under rocks, logs and leaf litter; may also shelter under pebbles in dry creek beds.

Appendix G: Index of wetland condition method

Table 16 below shows what is assessed for each of the six subindices and how they are scored

Table 16: IWC subindices and measures.

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

Adapted from DSE letter 29 April 2010

Scoring method

Each subindex is given a score between 0 and 20 based on the assessment of a number of measures. Weightings are then applied to the scores as shown in Table 17. The maximum possible total score for a wetland is 38.4, which for ease of reporting, is scaled to 10 by dividing the total score by 38.4 and multiplying by 10. The score is then rounded to the nearest whole number.

Table 17: Weights of each subindex

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

Five wetland condition categories have been assigned to the subindex scores (Table 18) and total IWC scores (Table 19), to be consistent with the number of categories used in other condition indices such as the Victorian Index of Stream Condition. Biota score categories were determined by expert opinion and differ to those of the other subindices.

Table 18: Wetland condition categories assigned to subindex scores.

Wetland condition category	Very poor	Poor	Moderate	Good	Excellent	Insufficient data
Biota sub-index score range	0 - 8	9 - 13	14 - 16	17 - 18	19 - 20	NA
IWC sub-index score range (except biota):	0 - 4	5 - 8	9 - 12	13 - 16	16 - 20	NA

Table 19: Wetland condition categories assigned to total IWC scores

Wetland condition category	Very poor	Poor	Moderate	Good	Excellent	Insufficient data
IWC total score range	0 - 2	3 – 4	5 - 6	7 - 8	9 - 10	NA

This information has been drawn from - Version 9 of the Index of Wetland Condition - Methods Manual was prepared by Phil Papas, Janet Holmes and Shanaugh Lyon of the Department of Sustainability and Environment January 2010.