Walshes Bend Environmental Water Management Plan

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CONTENTS

Executive summary

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

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

Walshes Bend is located on the Murray River floodplain approximately two kilometres north east of the township of Tol Tol and two kilometres southeast of the township of Robinvale and covers approximately 582 hectares. A small section of Walshes Bend along the southern border is privately owned; the rest of the site is Murray River Reserve and is managed by Parks Victoria.

Within the 582 hectares of the Walshes Bend a mosaic of flood dependent habitats exist, including seasonal wetlands, woodlands and floodplain channels. Walshes Bend has the potential to support diverse aquatic fauna, including small-bodied native fish, juvenile large-bodied fish, frogs and turtles. The River Red Gum (*Eucalyptus camaldulensis)* and Lignum (*Muehlenbeckia florulenta*) woodlands can provide significant habitat for waterbird nesting and feeding, whilst existing mature trees support Regent Parrot (*Polytelis anthopeplus monarchoides)*, White-bellied Sea-eagle (*Haliaeetus leucogaster)*, Brown Tree-creeper (*Climacteris picumnus victoriae)* and Carpet Python (*Morelia spilota metcalfei)*.

The long term management goal of the Walshes Bend EWMP is to provide a water regime which reflects natural water level variability and seasonality, which will maintain and promote the mosaic of habitats that protect and restore the key species, ecological communities and functions of the ecosystem within the Walshes Bend EWMP target area. The target area of 37.16ha is defined as:

- areas that are currently permanently inundated by the stable weir level including Knights Creek;
- areas that may benefit from maninpulation of the Euston Weir upto 48.2 m AHD including wetland #7428679683; and wetland #7428653680.

To achieve this, ecological and hydrological objectives were defined to provide an appropriate environmental watering regime. The ecological objectives are based on the values that the Walshes Bend EWMP target area is likely to support. They are:

WB1: By 2030, improve condition and maintain extent from baseline levels of River Red Gum (*Eucalyptus camaldulensis*), and Black Box (*E. largiflorens*) and to sustain communities and processes reliant on such communities at the Walshes Bend asset.

WB2: By 2030, improve vital habitat at the Walshes Bend asset by increasing the diversity of aquatic macrophytes present across a range of Water Regime Indicators
WB5: By 2030, protect and restore recruitment of small-bodied native fish at the Walshes Bend asset, including Australian Smelt (*Retropinna semoni*), Unspecked Hardyhead (*Craterocephalus stercusmuscarum fulvus*), Murray-Darling Rainbowfish (*Melanotaenia fluviatilis*), Flat-headed Gudgeon (*Philypnodon grandiceps*) and Carp Gudgeon (*Hypseleotris* spp).

A recommended weir pool regime has been recommended for Euston Weir. This is presented in the table below and is complementary to recommendations made in the Lock 15 EWMP (Ecological Associates 2015).

Month	Optimum variation from normal weir pool operating level of Lock 15 (m)
Jan	0.0
Feb	0.0
March	0.0
April	-0.2
May	-0.3*
June	-0.3*
July	0.0
August	+0.25
September	+0.6
October	+0.6
November	+0.4
December	0.0

In addition to the objectives that can be met through manipulation of the Euston Weir, specific objectives relating to wetland #7428653680 are included and require a water regime managed through minimisation of irrigation drainage water and operation of an upgraded regulator.

The optimal water regime for wetland #7428653680 is to:

- Inundate the wetland four to five times in ten years with a maximum interval of two years between events;
- Maintain the wetland to <1 metre depth for five months to maintain the health of River Red Gum and Lignum communities; and
- Ensure that irrigation drainage flows are ceased during the drying period to ensure that Lignum is not continuously flooded.

In addition to actions relating to environmental water management, this EWMP recommends investigation into improved irrigation drainage water management, to improve water quality and provide for a more appropriate water regime for wetland #7428653680.

Acknowledgements

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

Introduction

This Environmental Water Management Plan (EWMP) has been prepared by the Mallee CMA to establish the long-term management goals for Walshes Bend.

The key purposes of the EWMP are to:

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

1. Site overview

1.1. Site Location

The Mallee CMA region is located in the north-west of Victoria covering approximately 39,000 square kilometres with an estimated regional population of 65,000. Major towns include Mildura, Birchip, Sea Lake, Ouyen, Robinvale, Red Cliffs and Merbein. The area is semi-arid, with an annual rainfall of around 250mm. The average daily temperature at Mildura ranges from 32°C in summer to 15°C in winter (Mallee CMA, 2006). The Mallee CMA region is the largest catchment in the state given its extent is almost one fifth of Victoria. This catchment runs along the Murray River from Nyah to the South Australia border (Mallee CMA, 2014).

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

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

This EWMP has been developed for a Sub-Unit of the Waterway Management Unit of Bumbang. It includes Walshes Bend and Knights Bend and will be referred to as Walshes Bend for the purpose of this EWMP.

1.2. Catchment Setting

Walshes Bend is located on the Murray River floodplain approximately two kilometres north east of the township of Tol Tol and two kilometres southeast of the township of Robinvale, Victoria. Walshes Bend covers around 582 hectares. A small section along the southern border is privately owned; the rest of the site is Murray River Reserve and is managed by Parks Victoria. A site map of Walshes Bend is shown in Figure 1.

The main aquatic features of Walshes Bend are Knights Creek, a channel that cuts off the Knights Bend meander loop, two wetlands mapped as deep freshwater marsh #7428653680 (29.49 ha) and #742871684 (1.57 ha) and one wetland mapped as permanent open water #7428679683 (6.11 ha).

Knights Creek is permanently inundated under the influence of Lock 15. Wetland #7428653680 is affected by possible water quality issues and seepage from adjacent irrigation drains.

High terraces at Walshes Bend support Blackbox woodland and shrubland, while low terraces and wetlands support River Red Gum woodland and forest. Floodplain channels intersect Walshes Bend and could provide important habitat.

Walshes Bend is located in the Robinvale Plains bioregion within the Mallee CMA region approximately 80 kilometres south east of Mildura. The Robinvale Plains bioregion is characterised by a narrow gorge confined by the cliffs along the Murray River, which is entrenched within older up-faulted Cainozoic sedimentary rock. Alluvium deposits from the Cainozoic period gave rise to the red brown earths, cracking clays and texture contrast soils that support Riverine Grassy Forest and Riverine Grassy Chenopod Woodland ecosystems (DSE, n.d.).

The mean annual rainfall at the nearby Robinvale meterological station is 305 milimetres per year (Bureau of Meteorology, 2015). Walshes Bend is located approximately 22 kilometres (or 10 kilometres via the Bumbang cut) upstream of the Euston Weir, also known as Lock 15. Water levels in the adjacent Murray River, Knights Creek and groundwater are all influenced by the weir.

Walshes Bend is surrounded by land used for irrigated horticulture in the Robinvale irrigation District Section B. An excavated drainage channel bisects the floodplain, transporting runoff from Robinvale Irrigation District Section B to the Murray River.

Figure 1 – Walshes Bend Waterway Management Sub-Unit

1.3. Conceptualisation of the Site

A conceptual model of the Walshes Bend target area (Figure 2) has been developed which describes the interaction between the ecological processes and water dependant values of Walshes Bend. Note that the figure has been developed to represent key processes and values and is not intended to represent a literal cross section of Walshes Bend.

1. Vegetation communities form a mosaic of Riverine Forest, Woodland and Swampy Woodland. Clear delineation of sills and flows paths is difficult at some wetlands in Walshes Bend.
2. Regulation of the Murray River, water extraction for irrigation use and in-stream structures such as weirs and dams reduce the frequency and duration of flooding events.
3. Euston Weir creates a stable water environment at 47.6m AHD. The influence of the weir directs a relatively fresh (5,000 EC) groundwater lens away from the river. Prolonged drawdown of the Euston Weir would reinstate saline groundwater (35,000 EC) flow towards the Murray River.
4. River Red Gum recruitment is high on the low floodplain terraces, assisted by high fresh groundwater levels.
5. Knights Creek is retained at a stable water level, with low water velocities and algal-dominated biofilms predominating. These are less productive than bacteria-dominated biofilms, with reduced nutrient available for species of aquatic grazers such as small bodied fish, juvenile large bodied fish and macroinvertebrates.
6. Stable water levels and reduced flooding has led to contraction and reduced diversity of littoral and riparian vegetation communities. This has resulted in a reduction in habitat extent and structural complexity for aquatic and terrestrial fauna.
7. Key understorey species of Grassy Riverine Forest (EVC #106) and Intermittent Swampy Woodland (EVC #813) are missing or sparse due to reduced flooding duration and frequency.
8. A reduction in flood magnitude has reduced the frequency of inundation of higher terraces, resulting in reduced vegetation health and complexity in the Black Box Woodland. Prolonged dry conditions reduce floodplain productivity leading to reduced organic matter inputs into the riverine food chain.
9. Opportunities to raise the Euston Weir level would inundate areas of Floodway Pond Herbland (EVC #810), entraining nutrients and organic matter, supporting aquatic herbs and emergent sedges and providing feeding and breeding habitat for small fish and frogs.
10. An irrigation drainage channel from nearby farmland to the Murray River bisects the floodplain, altering flow paths (Wetland #7428653680).
11. Leakage from the drainage channel causes freshwater to pond in the Lignum Swampy Woodland, impeding the drying phase required by this EVC. Prolonged flooding can result in loss of vigour and eventually death for Lignum, Black Box and River Red Gum.
12. Mature, living River Red Gums may provide nesting hollows for White-bellied Sea Eagle, Murray Darling Carpet Python and Regent Parrots.
13. Woody debris in Knights Creek (and on the floodplain during flood events) provide protection from predators for small bodied and juvenile fish.
14. Mosquitofish are present in Knights Creek and the drainage channel and may directly compete with and predate on small native fish.
15. Breeding opportunities for colonial waterbirds such as Ibis and Egrets are greatly reduced by reduced flooding frequency, extent and duration. With an appropriate water regime waterbirds will utilise areas of shallow water, mudflats and the littoral zone in backwaters, creeks and wetlands found in the target area. These would include small waders, shoreline foragers and waterfowl.

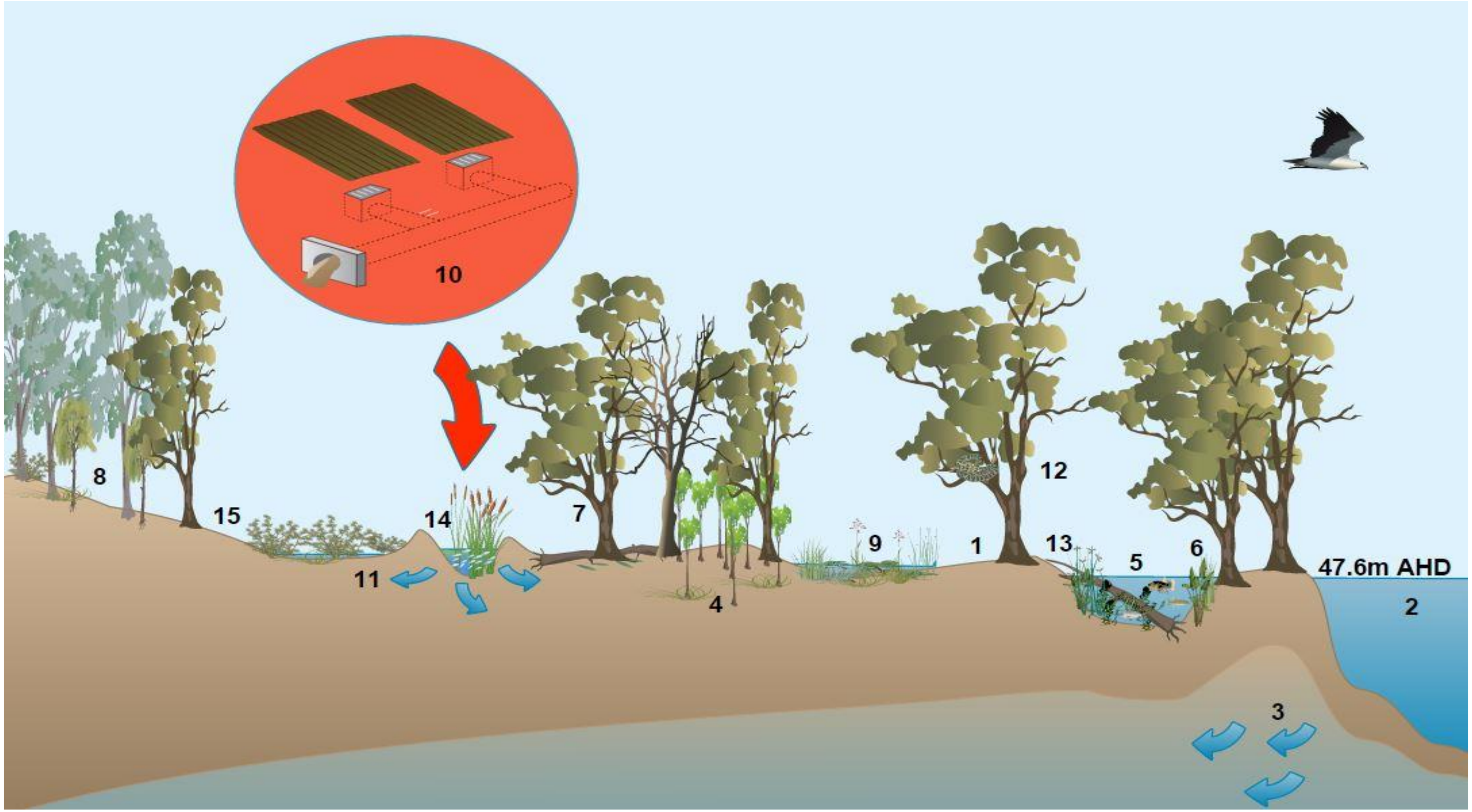

Figure 2 - Conceptualisation of Walshes Bend

1.4. Land Status and Management

Land tenure at Walshes Bend is shown in Figure 3. The majority of the site is located within Murray River Reserve or Ecologically Managed Minor Area Park and is managed by Parks Victoria. A small section along the southern border is privately owned; the Robinvale Pump Station, managed by the Lower Murray Water Authority, is located in the north western section.

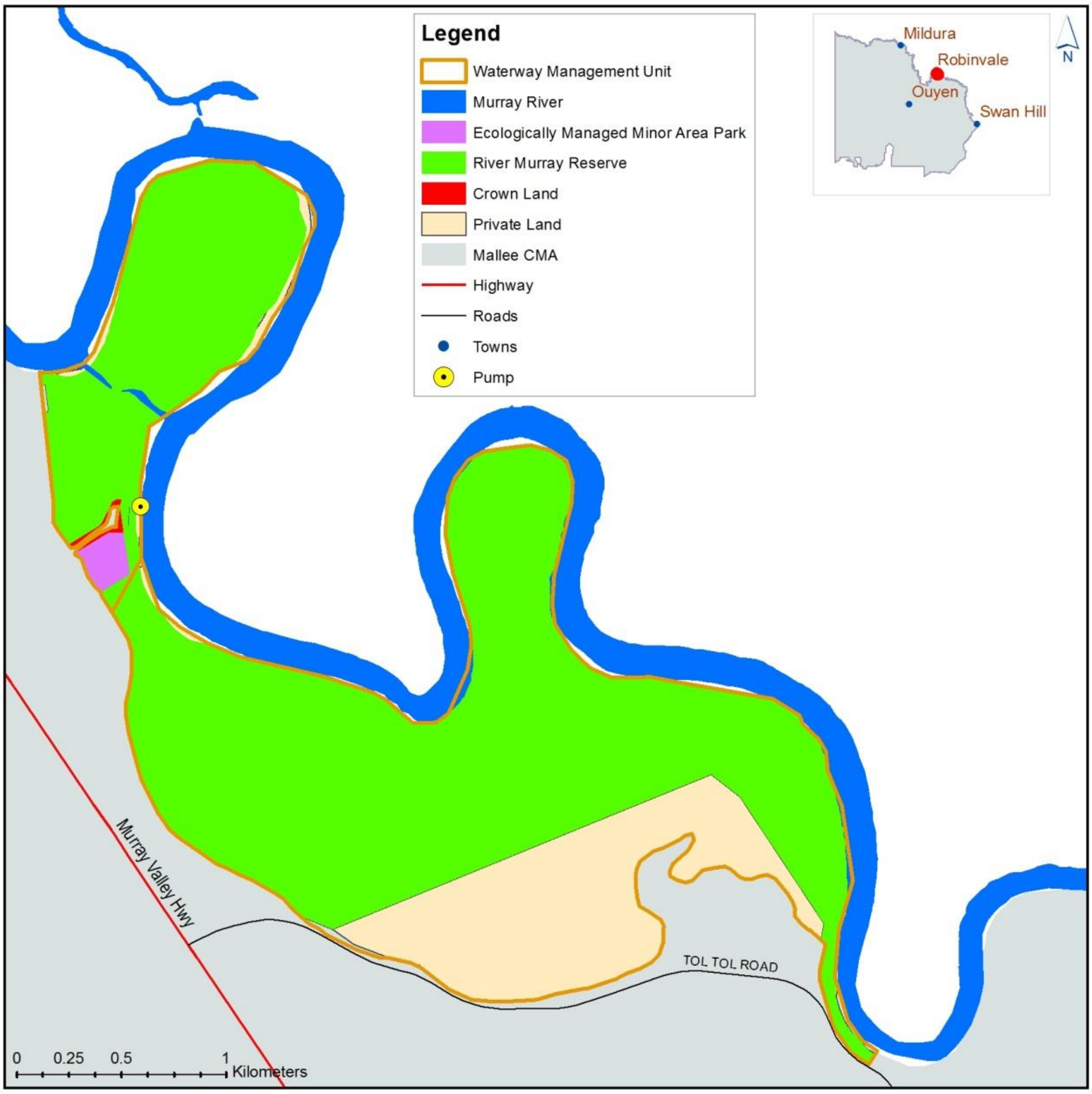

Figure 3 – Land management boundaries of Walshes Bend

1.5. Stakeholders for Walshes Bend EWMP

Stakeholders associated with or interested in environmental water management outcomes for the Walshes Bend are listed in Table 1

Table 1 - Walshes Bend Environmental Water Management Stakeholders

Group	Role
Parks Victoria	Land Manager
Mallee Catchment Management Authority (MCMA)	Regional waterway and environmental management
Department of Environment, Land, Water and Planning	State level environmental water management planning, land manager, threatened species manager
Victorian Environmental Water Holder	Manager of Victoria's environmental water entitlements
State Water (NSW)	Water management Lock 15 operators
Lower Murray Water (Vic)	Rural drainage provider
Aboriginal Communities	Indigenous Representation
Murray Darling Basin Authority (MDBA)	Murray River operations
Landowners	Landowners
Recreational users	Land user
General community	Land user

1.6. Wetland Characteristics

Within the 582 hectares of Walshes Bend a mosaic of flood dependent habitats exist, including ephemeral wetlands, lignum swamps and floodplain terraces. A total of 37 hectares of wetlands is mapped at the site, including six hectares categorised as Permanent Open Water and 31 hectares as Deep Freshwater Marsh. Although two wetlands at the site are classified as Permanent Open Freshwater, both were dry during a field visit to the site in February 2015 and it is likely that they are ephemeral, wetting and drying in response to seasonal and annual flow and rainfall conditions.

Knights Creek provides areas of slow flowing habitat incorporating deep pools and shallow benches. The influence of the Euston Weir (Lock 15) has led to the permanent inundation of Knights Creek and the creation of an island within the former meander loop. Previously, the banks of the creek would have been intermittently inundated during flood (Ecological Associates, 2006).

When wetted, floodways and effluents support slow flowing habitats while lignum swamps and wetlands provide still water. Large woody debris is available for shelter and perches across the different habitat types.

The location of individual wetlands within Walshes Bend and their categorisation is shown in Figure 4. The wetlands within Walshes Bend are unnamed, and will be referred to using their unique identification number from the "Victorian Wetland Environments and Extent - up to 2013" (WETLAND_CURRENT) GIS layer; an update of the 1994 wetland layer "Victorian Wetland Environments and Extent - up to 1994" (WETLAND_1994).

Walshes Bend is predominately vegetated by River Red Gum woodland and forest on lower terraces and Black Box (*Eucalpytus largiflorens*) woodlands and Lignum shrublands on higher floodplain areas. Watering frequency and duration have been significantly altered due to Murray River regulation and improved irrigation practices (Ecological Associates, 2006), with impacts to vegetation health, extent and age class diversity.

Approximately 22 hectares of wetlands at the site were previously used for irrigation water disposal (Ecological Associates, 2006), wetland #7428653680 continues to be impacted by seepage from irrigation drains.

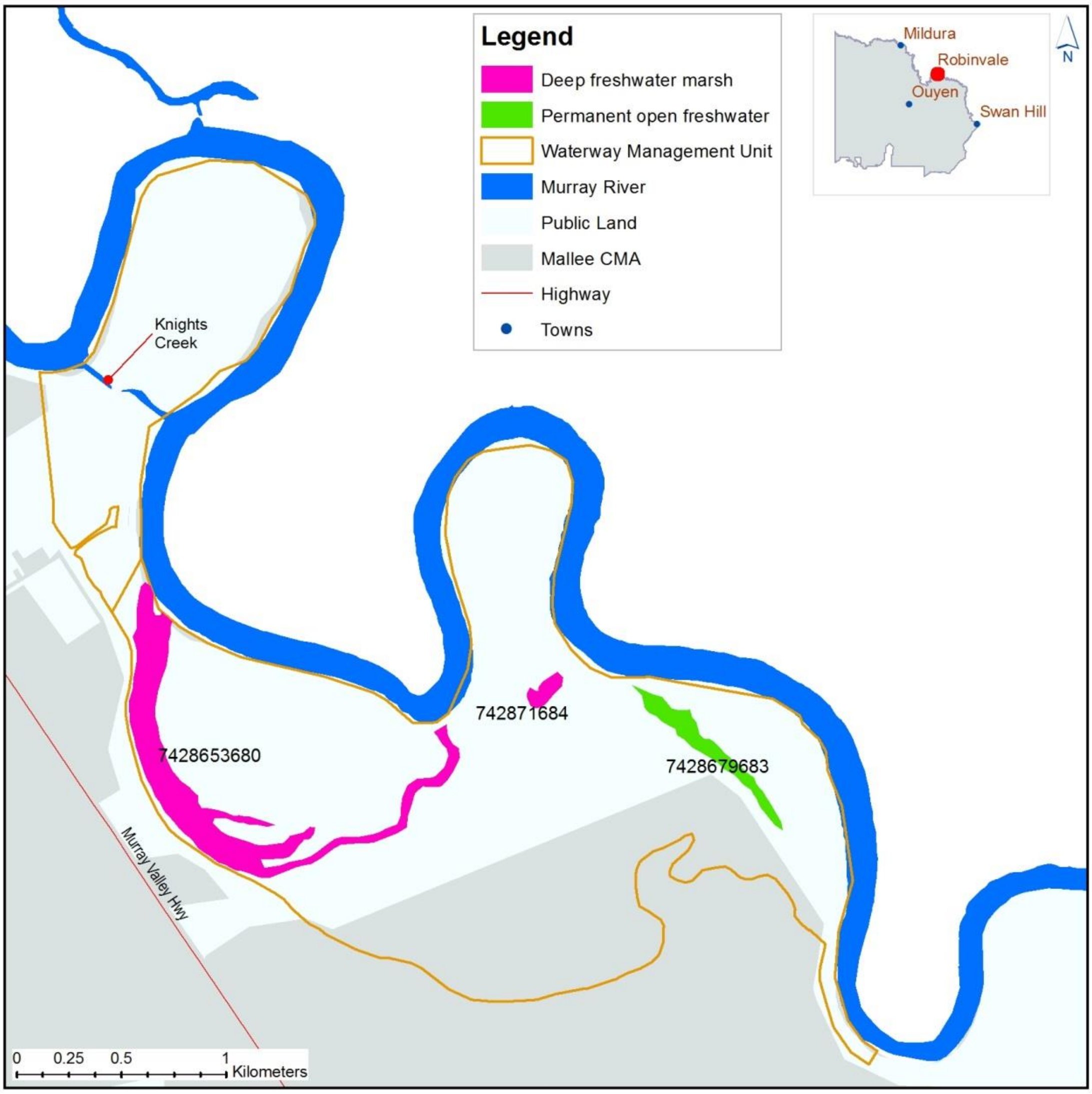

Figure 4 - Wetlands and waterways within Walshes Bend ("Victorian Wetland Environments and Extent - up to 2013" GIS layer)

As well as the mapped wetlands (from the WETLAND_CURRENT layer) a number of other flood dependent areas are found at the site. These include low lying floodplain terraces and ephemeral channels.

A brief overview of the main characteristics of wetlands at Walshes Bend is given in Table 2.

Table 2 - Summary of Walshes Bend wetland characteristics

Characteristics	Description
Name	Walshes Bend
Individual wetlands within Walshes Bend (numbers follow Corrick numbering system)	#7428653680 #7428679683 #742871684
Area (ha)	Total area of WMU is 581.54 ha Total area of wetlands is 37.16 ha. #7428653680 (29.49 ha) #7428679683 (6.11 ha) #742871684 (1.57 ha)
Bioregion	Robinvale Plains
Bioregional conservation status of EVCs in Walshes Bend	Vulnerable, Depleted and Least Concern
Land Status	Natural Features Reserve (Murray River Reserve) Ecologically Managed Minor Area Public land - Robinvale Pump Station Private land
Land Manager	Parks Victoria Lower Murray Water Authority Private landholder
Surrounding Land Use	Irrigated Agriculture (Robinvale Irrigation District Section B) Residential
Water Supply	Murray River Wetland #7428653680 also receives drainage water leakage from an irrigation channel.
1788 Wetland Category	#7428653680 (Deep Freshwater Marsh) #7428679683 (Permanent Open Freshwater) #742871684 (Deep Freshwater Marsh)
1994 Wetland Category and sub-category	#7428653680 (Deep Marsh, subcategory Reed) #7428679683 (Open Water, subcategory Red Gum) #742871684 (Deep Marsh, subcategory Red Gum)
Wetland Volume (ML)	Not known
Mean wetland depth at Capacity (m)	Not known

1.7. Management Scale

The whole of Walshes Bend has a water requirement as a floodplain complex however the focus for this plan is restricted to a target area within Walshes Bend that can benefit from the following environmental watering activities:

- manipulation of the Euston Weir;
- improved retention of high flows or pumped environmental water through additional or updated infrastructure; and
- introduction of a drying regime through better management of irrigation drainage water flowing through the site.

Implementation of these activities at this site is relatively low cost and likely to be widely supported. Existing programs are in place which may assist implementation of the first and third activities.

This EWMP is designed to benefit the target area, defined as:

- areas that are currently permanently inundated at the stable weir level of 47.6m AHD including Knights Creek (Figure 5)
- areas that may benefit from maninpulation of the Euston Weir up to 48.2 metres including wetland #7428679683 (Figure 6); and
- wetland #7428653680 (Figure 5 and Figure 6).

The target area does not include wetland #742871684. Ecological Associates (2006) identified that extensive infrastructure would be required to develop a defined channel between the Murray River and the wetland, and that the area able to be inundated would be insignificant given the surrounding topography.

Initial estimates of the area likely to be inunundated via manipulation of Euston Weir have been made using LiDAR data. However, modelling of weir manipulation is required to confirm the target area. Field truthing following weir manipulation trials will also improve knowledge in this area.

Figure 5 - Areas of Walshes Bend inundated at stable weir level 47.6m AHD (*Full supply level is shown in black*). Inundation area estimated using LiDAR provided by Mallee CMA.

Figure 6 - Areas of Walshes Bend inundated at stable weir level 48.2m AHD *(+0.6m above full supply level is shown in black*). Inundation area estimated using LiDAR provided by Mallee CMA.

1.8. Environmental Water Sources

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

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

Environmental water for Walshes Bend may be sourced from the water entitlements and their agencies listed in the table.

Table 3 - Summary of environmental water sources available to Walshes Bend*.

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

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

1.9. Related Agreements, Policy, Plans and Activities

The following policies, plans and activities are directly relevant to the environmental management of Walshes Bend.

Mallee Regional Waterway Strategy

The Mallee Regional Waterway Strategy (Mallee CMA, 2014) includes the Bumbang Floodplain Management Unit, which contains Walshes Bend. The Waterway Strategy prioritises the development of the EWMP for Walshes and Knights Bends.

Investigation of water management options for the Murray River – Nyah to Robinvale

In 2006, the Mallee CMA engaged consultants Ecological Associates to investigate water management options for the floodplain of the Murray River from Nyah to Robinvale (Ecological Associates, 2006). This investigation prioritised options to increase the frequency and duration of floodplain inundation for each FMU. The investigation also looked at the scope of manipulating river levels to benefit ecosystems through operation of the Euston Weir.

In this report Ecological Associates investigated and recommended further regulation of wetland #7428653680. Whilst the Ecological Associates report identified a high sill (48.5m

AHD), LiDAR imagery indicates that parts of this wetland can be inundated at lower levels requiring the lowering of sills, as discussed earlier in the Site Overview, Management Scale section.

Construction of a regulating structure could retain water in an area of up to 29.5 hectares. This would need further investigation.

Regulating this wetland would allow water captured during weir manipulation to be retained and would also allow the retention of water following natural flow peaks.

Environmental Water Management Plan for Lock 15 (Draft, 2015)

An EWMP for the River Murray and its floodplain in the Lock 15 weir pool (EA, 2015) has been completed. The region includes areas in both NSW and Victoria. This EWMP was prepared to guide environmental water management for the entire reach, with the aim that weir pool manipulation is complimentary to other floodplain areas within the Lock 15 influence.

Lock 15 Weir Maninpulation Trials

The NSW Office of Water are working with stakeholders to undertake weir level manipulation in late 2015 in order to meet environmental objectives identified through EWMPs including the Draft Lock 15 EWMP, Walshes Bend EWMP and the Bumbang Island EWMP.

On-ground works and management activities

During 2007 – 2008, Parks Victoria in partnership with Mallee CMA undertook pest plant and animal monitoring and control measures. Track rationalisation, and directional signage was also undertaken to manage visitor access.

Lower Murray Water

During 2014 Lower Murray Water undertook cumbungi removal and herbicide spraying activities on wetland #7428653680 for drainage water management (F. Merdoch pers. Comm. March 2015)

Other

Walshes Bend is situated on the Victorian floodplain of the Murray River which is the subject of investigation in many guises. These include salinity management plans, flow studies and Land Conservation Council reviews.

2. Hydrology and System Operations

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

2.1. Hydrology, Water Management and Delivery

Regulation for water diversion of the Murray River has reduced the frequency and duration of peaks in river flow which activate anabranches, fill wetlands and inundate floodplain areas. However, for some floodplain and wetland areas, the influence of structures has increased the period of inundation and created more stable water regimes that can have negative impacts on floodplain and wetland ecology (Ecological Associates, 2013).

The water regime of Walshes Bend is heavily influenced by the Euston Weir (Lock 15) pool. The current flow thresholds select the pool level and are not based on the natural wetlands sills; many are currently located below the water surface (Ecological Associates, 2006).

Pre regulation hydrology

Under natural conditions the river levels exhibited a strong seasonal cycle in water levels with the median autumn level four metres lower than the median level in spring (Figure 7). The river levels showed high inter-annual variability with the 5th and 95th percentiles in spring ranging over 8 m (Ecological Associates, 2015).

Current hydrology

Under current development (Figure 8) and operating practices the weir has raised the river to 47.6 m AHD, a level similar to the median annual peak, i.e. the spring seasonal level. Variation in river levels has been largely eliminated from the low-flow seasons of summer and autumn. In winter and spring median river levels are maintained close to the target pool level, but rare, high flows continue to provide elevated water levels.

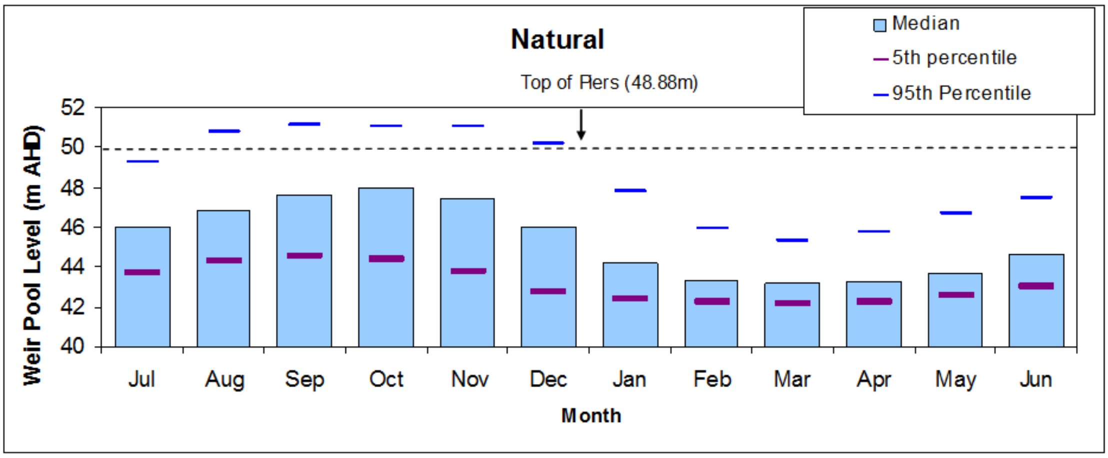

Figure 7 - Distribution of monthly water levels downstream of Lock 15 under Natural modelled conditions (Ecological Associates, 2015) using data relating river level and discharge.

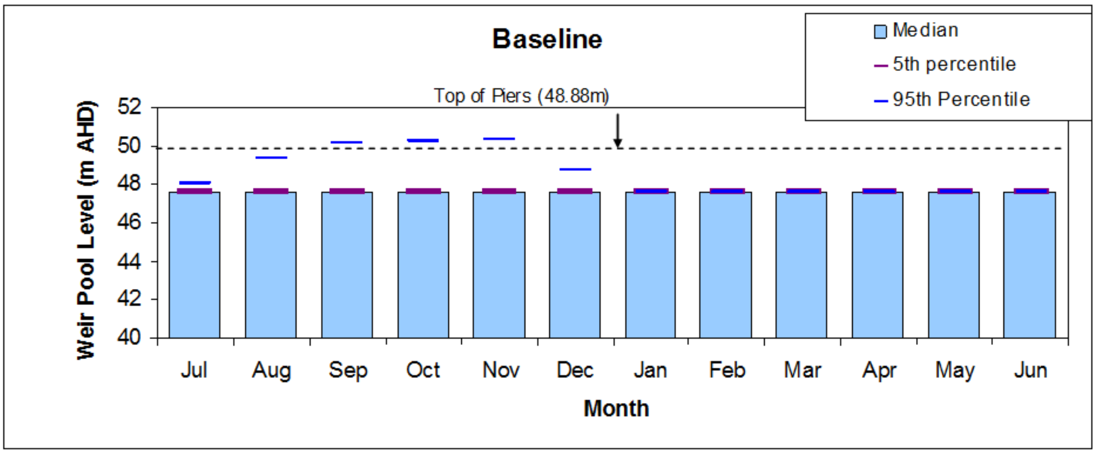

Figure 8 - Distribution of monthly water levels downstream of Lock 15 under current (Baseline) modelled conditions (Ecological Associates, 2015) using data relating river level and discharge.

Euston Weir was originally installed around 1938 to maintain a water level sufficient for navigation. The weir has subsequently been used to maintain sufficient water level for Sunraysia irrigation diversion. Water is pumped from the weir pool to supply the Robinvale Irrigation District in Victoria, private diverters in NSW and urban water supplies (SKM, 2009). During the irrigation season, the weir pool level is held fairly steady at 47.6m AHD. The weir pool can be varied to regulate flows between Hume Dam and the South Australian Border (Ecological Associates, 2006).

The effect of the Euston Weir is most marked at the weir wall at very low flows, when the water surface is elevated by 5.86 metres compared to downstream. This impact decreases with increasing discharge and with distance upstream. The Euston Weir is drowned out at 48,425 ML/d (Ecological Associates, 2006) and has no further impact on the frequency of wetland inundation. At 50,000 ML/d the Lock operator must remove the boards to meet safety and operational requirements (P. Cocks pers. comm. August 2014).

Mean annual flows at Euston have been reduced by 49% from natural levels, although seasonality of mean monthly flows is unaltered (Maheshwari, Walker and McMahon, 1993; Ecological Associates, 2006) as shown in Figure 9 and Figure 10.

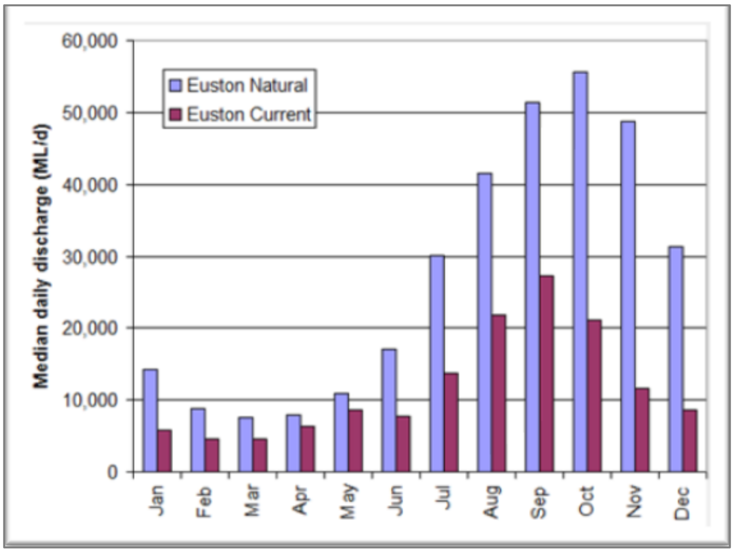

Figure 9 - Distribution of median flows for each month in the Murray River through Euston Weir for natural and current (benchmark) conditions (Ecological Associates, 2006).

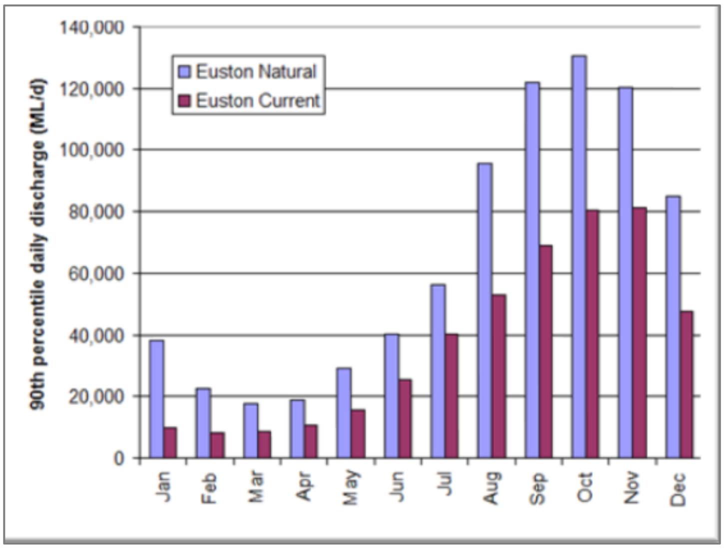

Figure 10 - Distribution of 90th percentile flows for each month in the Murray River through Euston Weir for natural and current (benchmark) conditions (Ecological Associates, 2006).

The hydrology of the Murray River at Euston under natural and current conditions was analysed by Fluvial Systems (2014) (Figure 11, Figure 12 and Figure 13).

For flows greater than 20,000 ML/d, event frequency has reduced significantly under regulated conditions. Current event frequency is in the order of 50% to 70% less than pre-regulation frequency, even for flows exceeding 170,000 ML/d.

The duration of spells is also lower for intermediate events: spells are approximately 50% shorter for events 20,000 to 60,000 ML/d. However for high flows, greater than 90,000 ML/d, the duration of spells under natural and benchmark scenarios is similar.

The river is in a low-flow state for a greater proportion of time under current conditions as it is managed to deliver water to downstream consumers efficiently. The river fluctuates frequently over the 10,000 ML/d flow threshold. Under natural conditions these events were less frequent, 93 events per 100 years, but longer due to the higher and more sustained flow peaks.

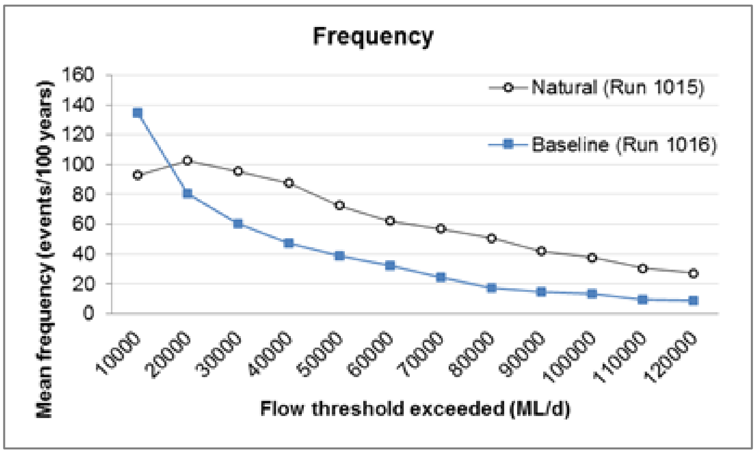

Figure 11 - Downstream Euston Weir spell event frequency for baseline (current) and natural conditions over a 114 year modelled period (Gippel, 2014).

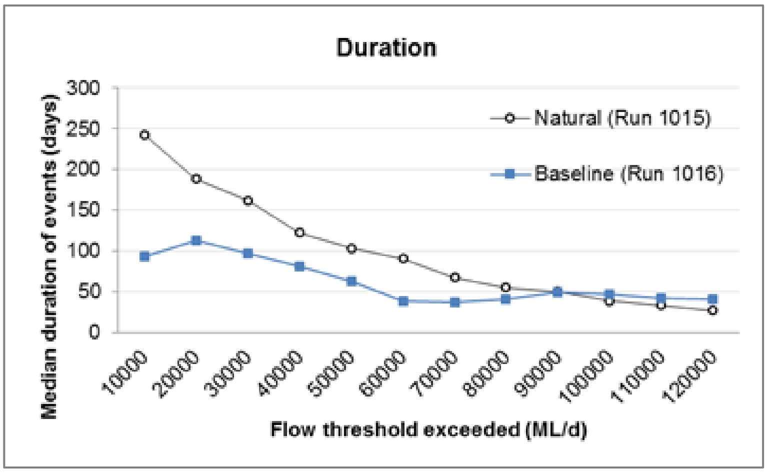

Figure 12 – Downstream Euston Weir spell event median duration for baseline (current) and natural conditions over a 114 year modelled period (Gippel, 2014).

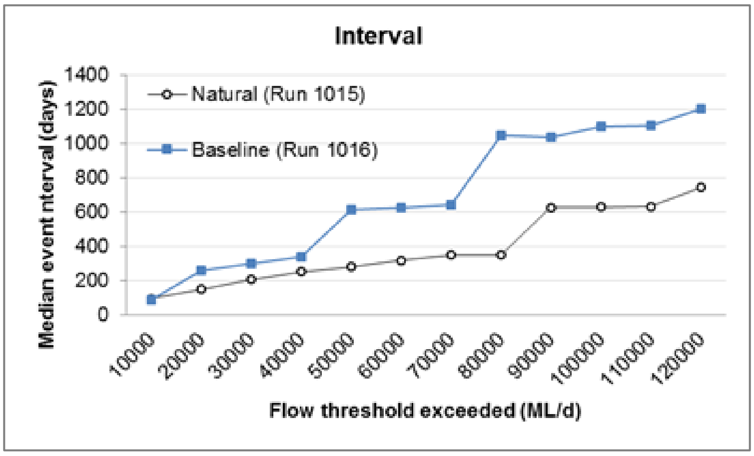

Figure 13 - Downstream Euston Weir spell event median interval for baseline (current) and natural conditions over a 114 year modelled period (Gippel, 2014).

Ground Water

The Euston Weir also impacts on the local groundwater condition around Walshes Bend. The weir creates a freshwater lens, having raised the groundwater up to 3 metres, with the groundwater levels at or near the river level (Ecological Associates, 2006). Groundwater salinity near the Euston weir pool is consistently fresher than the surrounding dryland landscape and often less than 5,000 EC (Ecological Associates, 2006). Recharge from the river can create a flushed zone of low salinity, shallow groundwater that promotes dense and healthy vegetation at the fringes of the river, wetlands and creeks. However at sites distant from the river banks, the elevation of the water table can expose naturally saline groundwater to evaporation leading to highly saline soils, saline groundwater discharge and poor vegetation health (Sharley and Huggan, 1995) (Ecological Associates, 2006). A low weir level will promote groundwater discharge from the bank and may accelerate salt discharge to the river. Elevated weir levels may increase the extent of the flushes and intensify salination in isolated floodplain areas (Ecological Associates, 2013).

Ecological Associates (2013) suggest that by storing water and reducing variability in river levels, weirs, such as Lock 15 have significant ecological impacts including:

- loss of flowing-water habitat;
- permanent inundation of the river channel, backwaters and wetlands;
- increased sedimentation in weir pools, backwaters and wetlands;
- increased erosion in tail water zones;
- contraction of riparian and littoral vegetation communities;
- reduction in water-level triggers for fish spawning; and
- raising groundwater tables leading to floodplain salinisation.

Irrigation Drainage

In addition to river regulation through irrigation diversions and the Euston Weir, the local hydrology of the site is also impacted by irrigation drainage. Wetland #7428653680 was historically (until the 1980s) used for irrigation drainage and was permanently inundated over an area of 18ha. The connection to the river was regulated to release drainage water to the river and a stop-log regulator was installed to control outflows. The regulator only controlled levels in the lowest parts of the wetland and could not retain water to significant depths (Ecological Associates, 2006).

Currently, the four main drains that run into Walshes Bend; irrigation drainage from two of these are collected in an excavated drainage channel which collects the water and flows from east to west along the southern boundary of the site, before flowing through wetland #7428653680 and into the Murray River (Figure 16). The channel has recently been mechanically cleared of Cumbungi (*Typha* spp.) and other macrophytes and has also had a buffer sprayed with herbicide (Figure 14). There is evidence of poor water quality (high nutrient levels) in the channel with significant amounts of algal growth, and invasive weeds associated with the location of earth works. It is likely that the drainage channel continuously leaks providing a permanent 'drip-feed' to wetland #7428653680. During a field investigation (February 2015) the wetland was relatively dry with water confined to the drainage channel; (Figure 14) and connectivity with the Murray River was evident (Figure 15), however, it is assumed that the drainage water would contribute to provide inflows and subsurface moisture depending on the season, as drainage flows were significant even during very dry seasonal conditions.

Figure 14 - Irrigation drainage channel running through wetland #7428653680, showing algae, weed control and excavation works near drain confluence with the Murray River.

Figure 15 - Irrigation drainage channel running through wetland #7428653680, showing connection with the Murray River

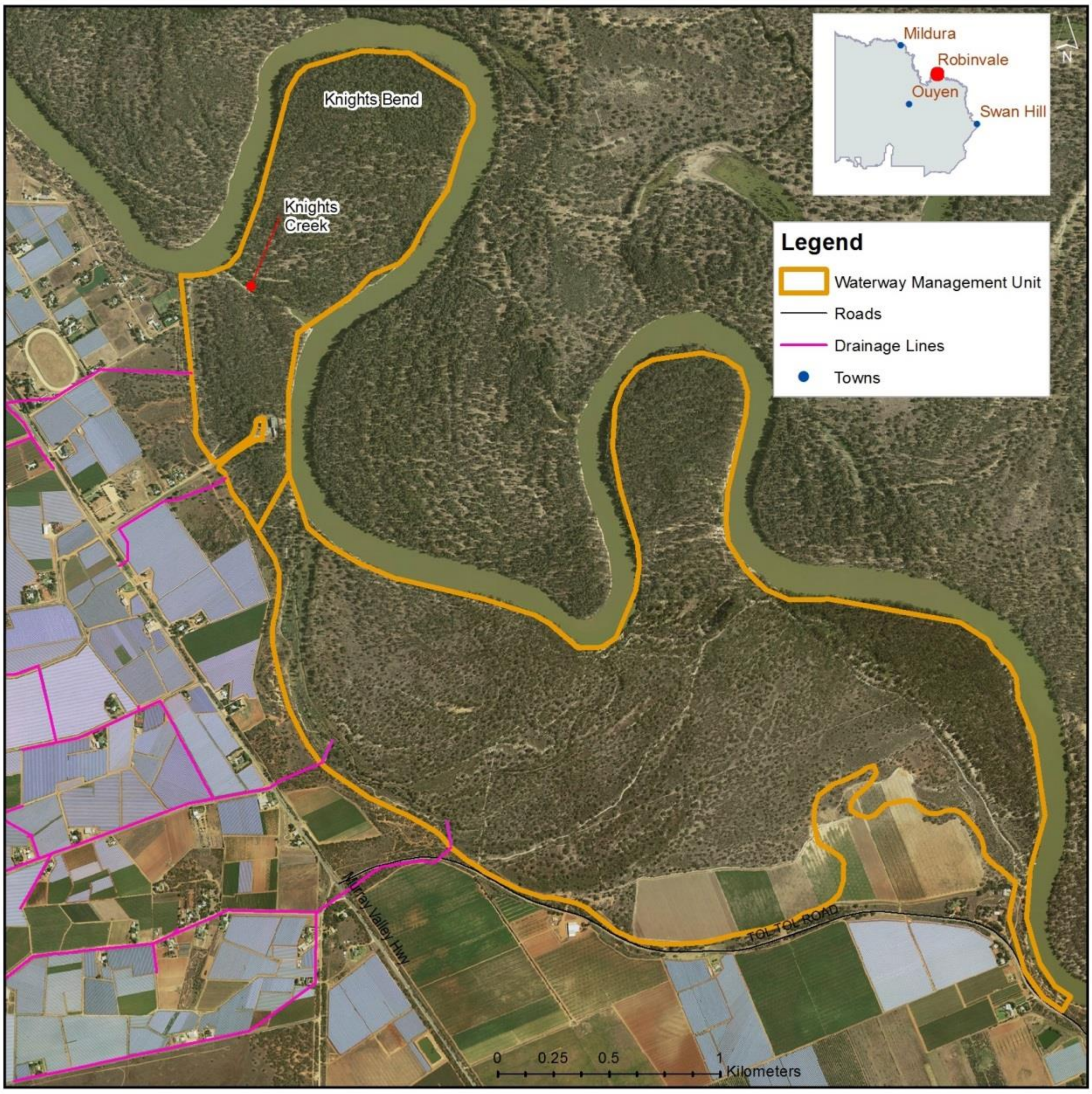

Figure 16 - Irrigation drains running into Walshes Bend from the Robinvale Irrigation District Section B. Earthern channels shown in pink.

2.2. Environmental Watering

Environmental watering has not specifically occurred at this site in the past.

Between 22 July and 29 August 2014, the NSW Office of Water undertook a weir manipulation trial, raising the weir gradually to 47.9m AHD (P. Cocks pers. comm., September 2014). The trial was not specifically aimed at environmental watering but had the potential to provide ecological outcomes. The purpose of the trial was to test recent upgrade works and to assist with works downstream of Lock 15 by holding back some water (P. Cocks pers. comm., September 2014).

During 2010 and 2012, three significant flow events occurred in the Murray River, providing flows over 40,000ML/day (P. Kelly pers. comm. October 2014). These higher flows would have inundated wetland #7428679683 as it has a commence to flow rate of 40,000 ML/day.

The NSW Office of Water has further weir maninpulation trials, aimed at meeting specific ecological objectives for sites within the influence of the Euston Weir pool, planned for late in 2015. This will potentially benefit the Walshes Bend target area.

3. Water Dependent Values

3.1. Environmental Values

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

Listings and Significance

The availability of flora and fauna data for Walshes Bend is deficient due to limited field surveys. While data from the Victorian Biodiversity Atlas has been referenced, the EWMP has been developed around the EVCs mapped for the study area and the likely ecological links associated with these EVCs. Relationships outlined in the *Investigation of Water Management Options for the Murray River – Nyah to Robinvale* report (Ecological Associates, 2006) in the discussion of woodland and wetland habitats were also used, as well as information from nearby sites. It is recommended that flora and fauna surveys are undertaken at the site to confirm some of the assumptions used in the development of this EWMP.

Listed Fauna

Of special interest are the water dependent species listed in legislation, agreements or conventions, as shown in Table 4 and Table 5. Extensive flora and fauna surveys have not been undertaken at the site and the availability of species data is limited. Despite only limited listed fauna being identified in Victorian Biodiversity Atlas (VBA) records, it is fair to assume that a number of listed species could occur due to the availability of habitat and nearby sightings. Appendix 1 lists the fauna species identified through the VBA. Regent Parrots and a White-bellied Sea-eagle were sighted during a site visit for this EWMP in February 2015.

Table 4 - Listed fauna recorded at Walshes Bend

Common name	Scientific name	Type	EPBC status	FFG status	DELWP Advisory List
Regent Parrot	*Polytelis anthopeplus monarchoides*	B	VU	L	V
Brown Treecreeper	*Climacteris picumnus victoriae*	B	NL	NL	NT
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	B	VU	L	VU

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

Table 5 - Listed species potentially found at Walshes Bend

Common name	Scientific name	Type	EPBC status	FFG status	Advisory List
Carpet Python	*Morelia spilota metcalfei*	R	NL	L	EN
Freshwater Catfish	*Tandanus tandanus*	F	NL	L	EN
Golden Perch	*Macquaria ambigua*	F	NL	NL	NT
Murray-Darling Rainbowfish	*Melanotaenia fluviatilis*	F	NL	L	VU
Murray Cod	*Muccullochella peelii*	F	VU	L	VU
Silver Perch	*Bidyanus bidyanus*	F	CR	L	VU
Growling Grass Frog	*Litoria ranformis*	A	VU	L	VU

Legend
Type: Invertebrate, Fish, Amphibian, Reptile, Bird, Mammal
EPBC Act status: EXtinct, CRitically endangered, ENdangered, VUlnerable, Conservation Dependent, Not Listed
FFG Act status: Listed as threatened, Nominated, Delisted, Never Listed, Ineligible for listing

DELWP Advisory status: presumed EXtinct, Regionally Extinct, Extinct in the Wild, CRitically endangered, ENdangered, Vulnerable, Rare, Near Threatened, Data Deficient, Poorly Known, Not Listed

Fish

In 2004, the Mallee CMA commissioned a study (Ho et al., 2004) to determine the distribution of aquatic vertebrates within the Mallee Region. The study aimed to provide information able to be used across the region, when site specific data, such is the case with Walshes Bend, is not available. Two sites within this study, Margooyia Lagoon and Belsar Island, are relevant to Walshes Bend. Margooyia Lagoon is located approximately 800 metres from Walshes Bend and is also regulated by Lock 15 and the Murray River. Belsar Island forms the upstream section of the Lock 15 weir pool. Therefore it is likely that the fish, turtles and frog species found at these sites may also be supported at the Walshes Bend target area. Comparison of vegetation communities and habitat availability between these site would need to be determined.

McCarthy, et al. (2007) undertook an aquatic fauna survey at the Euston Lakes and Washpen Creek, which are located on the Murray floodplain a few kilometres from Walshes Bend (on the NSW side). They found nine species of fish; three species were exotic and six native. Freshwater Catfish (*Tandanus tandanus),* which are listed under the FFG Act and endangered under the DELWP Advisory List were amongst those found and were the most abundant large bodied fish in the Euston Lakes.

The presence of Freshwater Catfish in the Euston Lakes is of regional significance (SKM, 2009). This species has experienced significant decline in abundance and distribution throughout its southern range (SKM, 2009). Freshwater Catfish require still or slow flowing water and habitat with aquatic vegetation (Treadwell & Hardwick, 2003). Inundation of secondary channels provide extra habitat for Freshwater Catfish during floods, and the connection of the channels and the floodplain provides increased habitat complexity (Balcombe, et al., 2006). These secondary channels and floodplain habitat features are found within the target area. Fallen logs and smaller woody habitat (which is plentiful on the floodplain and within Knights Creek) can provide significant habitat diversity, protection from predators and enhanced food supplies for the Catfish (Rogers & Ralph, 2010), small-bodied and juvenile fish.

Knights Creek and the wetlands and floodplain channels of Walshes Bend provide excellent habitat for many species of small-bodied native fish. The complexity and diversity of habitat means that an abundance of food and protection from predators is provided. Many native fish species such as Murray-Darling Rainbowfish prefer slow-flowing waters and wetlands where submerged macrophytes are abundant along with other riparian cover, including smaller woody habitat (Allen, Midgley, & Allen, 2003). Small-bodied fish will move onto the floodplain and between wetland areas with increased inundation and connectivity of flood channels (Bice, et al., 2014) and (Lyon, Stuart, Ramsey, & Mahoney, 2010). Manipulating the weir pool level will provide these movement opportunities at the site. The presence of Mosquitofish (*Gambusia spp.*) in Knight's Creek and the drainage channel may negatively impact small native fish through direct competition and predation.

Waterbirds

Waterbird diversity and abundance are influenced by wetland habitat diversity, with different species and feeding guilds using different habitats for breeding and foraging (Haig, Mehlman and Oring, 1998). Water depth in particular influences waterbird diversity due to the specific feeding behaviours of different species (Bancroft, Gawlick and Rutchey, 2002). Managing wetlands to provide diverse habitats such as variable water depth, mud flats, inundated vegetation and areas of deep water increases the likelihood of waterbird diversity (Taft, Colwell, Isola, & Safran, 2002).

Due to limited distribution data, recommendations within this EWMP will be directed toward providing the habitat through a watering regime appropriate to provide key habitat needs of the waterbird guilds listed in Table 6. This is based on the habitat types available at the site.

Table 6 - Waterbird functional feeding groups (Roshier, Robertson, & Kingsford, 2002) and their resource use

Waterbird Group	Food Resource	Habitat Use	Breeding Strategy
Dabbling and Diving Ducks (e.g. Chestnut teal, Pink-eared duck, Freckled duck)	Generalists; plankton, small invertebrates, plant material	Shallow Water (Dabblers)	Solitary
Grazing Waterfowl (e.g. Shellduck, Wood Duck)	Plant material, seeds, invertebrates	Shallow Water, littoral zone	Colonial or solitary
Fish Eaters (e.g. Pelican, Cormorants, Grebes, Darter, Egret, Heron, Tern)	Fish	Open and deep water	Colonial
Small Waders (e.g. Stilt, Plovers, Dotterels)	Small invertebrates, seeds	Littoral zone, mudflats	Solitary
Large Waders (e.g. Ibis)	Macroinvertebrates, fish, amphibians	Littoral zone	Colonial or solitary
Shoreline Foragers (e.g. Lapwings, Hens)	Plant material, seeds, invertebrates,	Littoral zone, mudflats	Solitary or small groups

Providing appropriate water requirements to support the vegetation communities will support habitat for birds that have adapted to the required flooding and drying cycle (Scott, 1997). With an appropriate water regime waterbirds will utilise areas of shallow water, mudflats and the littoral zone in floodplain channels, creeks and wetlands found in the Walshes Bend target area.

Other birds

In addition to the waterbirds a number of other significant bird species are indirectly water dependent. These include the White-bellied Sea-Eagle and the Regent Parrot, who both rely on the habitat provided by River Red Gums. White-bellied Sea-Eagles nest near water, in tall live or dead trees. River Red Gum are commonly used as nest trees (Emison & Bilney, 1982) (Figure 17).

The eastern Regent Parrot breeds almost entirely in River Red Gum forest and woodland. Nest trees are typically large, mature, healthy River Red Gums or Black Box with many hollows, usually close to water. These trees are a minimum of 160 years old (Baker-Gabb & Hurley, 2011). The eastern Regent Parrot Recovery Plan (Baker-Gabb & Hurley, 2011) identifies this area as a likely breeding site for the species (the Murray River between Red Cliffs and Piangil).

Figure 17 – Mature River Red Gum providing nesting habitat for species including Regent Parrot at Walshes Bend

Frogs

Frog survey data associated with the nearby Euston Lakes found nine species present (SKM, 2009). Of these the Growling Grass Frog (*Litoria raniformis)* is listed under the EPBC Act as vulnerable and the FFG Act as threatened. The Growling Grass Frog is usually found in or around permanent or ephemeral Black Box/Lignum/Nitre Goosefoot swamps, Lignum/Typha swamps and River Red Gum Swamps; or billabongs along river valleys, these habitats are all found at Walshes Bend. Breeding is triggered by flooding or a significant rise in water levels in late winter/ spring (SKM, 2009). It is possible that this site could support Growling Grass Frog populations.

Table 7 - Frog species potentially found at Walshes Bend based on their presence at nearby sites.

Scientific name	Common name
Eastern Sign-bearing Froglet	*Crinia parinsignifera*
Eastern Banjo Frog	*Limnodynastes dumerili*
Barking Marsh Frog	*Limnodynastes fletcheri*
Spotted Marsh Frog	*Limnodynastes tasmaniensis*
Peron's Tree Frog	*Litoria peroni*
Growling Grass Frog	*Litoria raniformis*
Eastern Common Froglet	*Crinia signifera*
Mallee Spadefoot Toad	*Neobatrachus sudelli*
Common Spadefoot Toad	*Neobatrachus pictus*

Carpet python

Carpet Python are also indirectly water dependent; relying on habitat provided by River Red Gum forests and associated Black Box woodlands along major watercourses. Hollow-bearing trees and logs, or large rock outcrops, plus thick litter or shrub cover, are essential to the existence of Inland Carpet Pythons (Department of Sustainability and Environment, 2003). The Carpet Python therefore rely on suitable habitat which may be protected or improved through this EWMP.

Vegetation Communities

Thirteen Ecological Vegetation Classes (EVC's) occur at Walshes Bend. Four of these are listed as vulnerable within the Robinvale Plains bioregion: Lignum Swamp (#104), Semi-arid Chenopod Woodland (#98), Semi-arid Parilla Woodland (#828) and Semi-arid Woodland (#97). Of these, Lignum Swamp is the only water dependent EVC. The bioregional conservation status of all water-dependent EVCs at the site is shown in Table 8.

Table 8 - Bioregional conservation status of water dependent EVCs at Walshes Bend

EVC no.	EVC name	Bioregional Conservation Status Robinvale Plains Bioregion (to be confirmed)
104	Lignum Swamp	Vulnerable
823	Lignum Swampy Woodland	Depleted
810	Floodway Pond Herbland	Depleted
818	Shrubby Riverine Woodland	Least Concern
813	Intermittent Swampy Woodland	Depleted
103	Riverine Chenopod Woodland	Depleted
295	Riverine Grassy Woodland	Depleted
106	Grassy Riverine Forest	Depleted
811	Grassy Riverine Forest / Floodway Pond Herbland Complex	Depleted
821	Tall Marsh	Depleted

Elevation changes across the floodplain are minimal, and vegetation communities form a mosaic of Riverine Forest, Woodland and Swampy Woodland.

Shallow flood prone areas of River Red Gum dominated woodland and forest contain the Grassy Riverine Forest/Floodway and Pond Herbland EVC Complex (Figure 18). Under the appropriate intermittent flooding regime these areas will support aquatic herbs and emergent sedges that are characteristic of drying mud within wetlands as well forbs and grasses characteristic of Grassy Riverine Forest (Frood, 2012).

Figure 18 - Grassy Riverine Forest/Floodway Pond Herbland Complex at Walshes Bend

Low floodplain terraces support forest and woodland EVCs dominated by River Red Gums such as Grassy Riverine Forest (#106), Riverine Grassy Woodland (#295) and Intermittent Swampy Woodland (#813). River Red Gum recruitment is high on the low-lying floodplain terraces, in response to the high fresh groundwater level created by the weir pool. At higher elevations however, the EVCs lack, or have reduced cover of, key understorey species, which are dependent on flooding (Ecological Associates, 2006).

River Red Gums provide extensive habitat for a range of fauna, and waterbirds use these trees for nesting. However, trees in poor condition contribute little to the function and productivity of the ecosystem and the quality of woodland habitat is greatly reduced (Roberts and Marston, 2011). River Red Gums also deposit organic woody debris to wetlands which provide structural habitat features for wetland fauna such as perching sites for waterbirds and snags for fish (Ecological Associates, 2007b). Ideal flooding for River Red Gum recruitment is late spring to early summer (Johns and et al., 2009), while ideal flood timing for River Red Gum maintenance and survival is winter to spring following the natural flooding pattern (Dalton, 1990; Rogers and Ralph, 2011).

Slightly higher terraces that receive less flooding support EVCs dominated by Black Box such as Shrubby Riverine Woodland (#818) and Riverine Chenopod Woodland (#103). Black Box provides essential habitat and foraging opportunities for a range of species including mammals and reptiles and supports a high proportion of ground foraging and hollow-nesting birds. Black Box can tolerate a range of moisture and salinity conditions (Roberts and Marston, 2011), however recruitment and establishment is linked to the elevated and continued soil moisture associated with flood events. Under extended periods of dry conditions Black Box is likely to decline and eventualy die (Ecological Associates, 2007a).

Lignum dominated EVCs are present in shallow floodplain depressions that are intermittently inundated (Roberts and Marston, 2011). These range from the treeless Lignum Swamp (#104) to a mix of Lignum and Eucalypt or Acacia Woodland (Lignum Swampy Woodland #823 and Intermittent Swampy Woodland #813). When flooded these areas can provide nesting habitat for platform building birds as well as productive fish habitat (Ecological Associates, 2006). Tangled Lignum has particular ecological value as waterbird breeding habitat (Rogers and Ralph, 2011) making it especially significant at this site. Wetland birds that breed over water, such as Egrets, use flooded Lignum shrublands (Ecological Associates, 2007a) for resting and the Hardhead Duck uses Lignum for nesting (Rogers and Ralph, 2011).

In elevated positions where flooding and groundwater influences are minimal or absent there are small areas of non-Eucalypt woodland, open forest or chenopod shrubland. These EVCs, Semi-arid Woodland (#97), Semi-arid Parilla Woodland (#828) and Semi-arid Chenopod Woodland (#98), have a sparse canopy cover of some or all of Belah (*Casuarina pauper*), Buloke (*Allocasuarina luehmannii*) and Slender Cypress-Pine (*Callitris gracilis* ssp. *murrayensis*) and a mixed understorey of shrubs and grasses.

Figure 19 displays the location and extent of each EVC mapped as part of Walshes Bend. For a full list of EVCs at the site and the characteristics of each see Appendix 2.

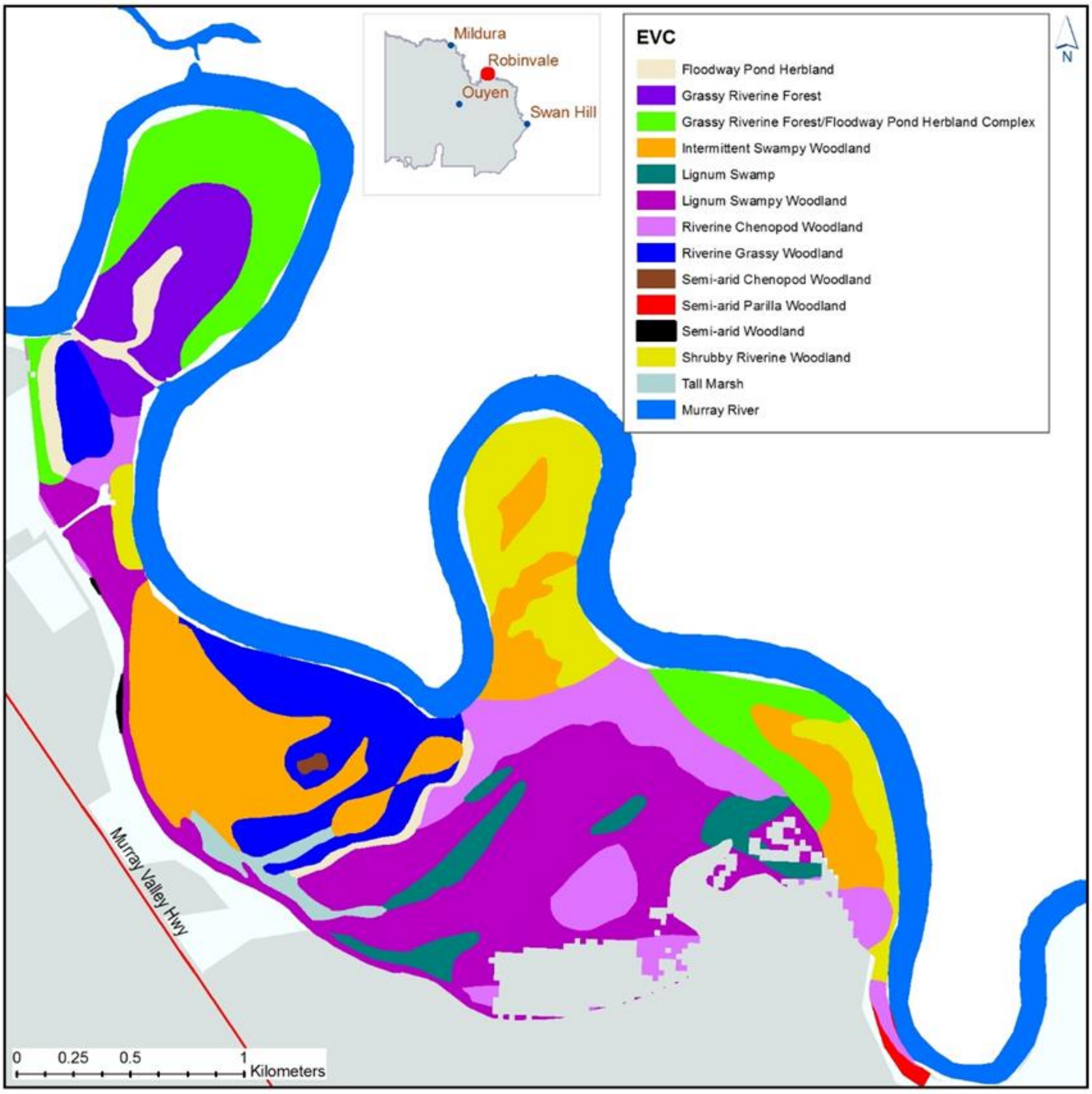

Figure 19 – EVCs at Walshes Bend

Flora

A number of listed flora species have been found at Walshes Bend and are displayed in Table 9. EVCs at the site are dominated by River Red Gum, Black Box and Tangled Lignum and management will be targeted towards these umbrella species and their water regime requirements. A full list of all flora recorded at Walshes Bend can be found in Appendix 3.

Table 9 - Significant flora species found at or in close proximity to Walshes Bend (from VBA February 2015)

Common Name	Scientific Name	Victorian Advisory List
Umbrella Wattle	*Acacia oswaldii*	Vulnerable
Twin-leaf Bedstraw	*Asperula gemella*	Rare
Frosted Goosefoot	*Chenopodium desertorum* subsp. *desertorum*	Rare
Desert Jasmine	*Jasminum didymum subsp. lineare*	Vulnerable
Doubah	*Marsdenia australis*	Vulnerable
Crimson Tails	*Ptilotus sessilifolius*	Poorly known
Twiggy Sida	*Sida intricata*	Vulnerable
Scurfy Germander	*Teucrium albicaule*	Poorly known

3.2. Wetland Depletion and Rarity

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

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

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

It has been possible to determine the depletion of wetland types across the state using the primary category only, based on a comparison of wetland extent between the 1788 and 1994 wetland layers.

Comparison between the wetland layers has demonstrated the impact of European settlement and development on Victorian wetlands. This has been severe, with approximately one-third of the state's wetlands being lost since European settlement; many of those remaining are threatened by continuing degradation from salinity, drainage and agricultural practices (ANCA, 1996).

Walshe's Bend contains three wetlands listed in the "Victorian Wetland Environments and Extent - up to 2013" GIS layer. They have been classified using the Corrick-Norman wetlands classification system as Deep Freshwater Marsh and Permanent Open Freshwater (Figure 4).

Based on a comparison of the 1788 and 1994 geospatial wetland layers, Deep Freshwater Marshes are the most depleted (-70% change) type of wetland in Victoria, second most (-45% change) in the Mallee CMA region and second most (-37% change) in the Robinvale Plains Bioregion. This makes the two Deep Freshwater Marshes in the Walshes Bend target area significant in the region.

Permanent Open Freshwater wetlands in Victoria decreased by six percent in area between 1788 and 1994. In the Mallee area these wetlands have increased by five per cent, potentially due to the ponding of water in reservoirs, dams and weirs, and have decreased in the Robinvale region by one percent (Mallee CMA, 2006) (Table 10).

The 1994 layer was updated in 2013 based on interpretation of aerial photographs taken between 2007 and 2011 and supplemented with existing geospatial datasets such as vegetation mapping and topography (DEPI, 2014). This recent update has shown the shrinkage of the two Deep Freshwater Marsh wetlands at the Walshes Bend target area from a total of 35.83 hectares to 31.1 hectares; the shrinkage of the Permanent Open Freshwater wetland from 8.36 to 6.1 hectares; and the loss of one 8.24 hectare Shallow Freshwater Marsh wetland (already reduced from a modelled extent of 13.21 hectares in 1788).

Table 10 - Changes in area of the wetlands in the target area by Corrick classification Source: DEPI Biodiversity interactive maps, Mallee Wetland Strategy.

Corrick Category	No of Wetlands in target area	Total area (ha)	Percentage change in wetland area from 1788 to 1994			Percentage change in wetland area from 1994 to 2013
			Change in area in Victoria	Change in area In Mallee CMA	Change in Robinvale Plains Bioregion	Change at Walshes Bend
Deep Freshwater Marsh	2	31.05	-70	-45	-37	-13%
Permanent Open Freshwater	1	6.11	-6	+5	-1	-27%

3.3. Ecosystem Functions

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

Three key broad ecosystem functions have been identified for the Walshes Bend EWMP. Each function is interlinked and must be supported in order for the ecosystem to flourish. The functions are briefly described below.

Connections across floodplains, adjacent wetlands and billabongs (lateral)

Water levels that engage flood channels, wetlands and floodplain surfaces will promote nutrient and carbon cycling and return organic material to the river for further processing (Robertson, Bacon, & Heagney, 2001).

The movement of species of fish, invertebrates and amphibians is driven by floodplain and wetland connectivity. Gudgeon and other small-bodied native fish will move onto the floodplain and between wetland areas with increased inundation and connectivity of flood channels (Bice, et al., 2014) and (Lyon, Stuart, Ramsey, & Mahoney, 2010).

The waterbird groups also access a variety of habitat types which only become available following inundation. Many species will nest only in trees or shrubs, such as Lignum, surrounded by floodwaters.

Diversity of habitat for feeding, breeding and nursery

Seasonal fluctuations in the water levels increase the availability of specific habitat niches for feeding, breeding and nursery areas. The higher water levels proposed in spring and summer will provide a source of food, refuge from predators and nesting sites and materials (Kingsford & Norman, 2002). Receding water levels through autumn will expose mudflats required by small waders (Roshier, Robertson, & Kingsford, 2002).

Inundation of the wetlands and woodlands will provide roosting and nesting habitat for species such as Darter (Vestjens, 1975) and Cormorant (Loyn, Lumsden, & Ward, 2002), while the increase in macrophyte diversity and abundance will increase habitat values for shoreline foragers such as Purple Swamphens (*Porphyrio porphyria)* and small-bodied fish such as Murray-Darling Rainbowfish and Gudgeon spp. (Allen, Midgley, & Allen, 2003).

Current water conditions are favoring fish species with no specific flow-related spawning requirements (SKM, 2009). Higher river levels from early spring to early summer followed by lower river levels in late summer and autumn will enhance the fish community and meet the requirements of the species present. For example spawning of Golden Perch is associated with high flow events and backwater inundation (Balcombe, et al., 2006).

Submerged and emergent macrophytes provide juvenile large-bodied fish with shelter from predators and abundant prey.

Transportation and dilution of nutrients and organic matter and increase in macroinvertebrate productivity and biofilm diversity

Wetland inundation and flooding of the Floodway Pond Herbland channels and low level terraces will transport nutrients and carbon into the water column, which will become available for consumption by bacteria, algae, macrophytes and macroinvertebrates. Terrestrial invertebrate species of the orders Coleoptera and Isoptera have been found in the diet of Freshwater Catfish after flooding, presumably due to their increased availability following disturbance and removal from the floodplain following inundation (Davis, 1977).

Low creek levels and drying of wetlands, particularly during summer and autumn, expose sediments and facilitate decomposition and processing of organic matter. The microbial decay of plant material is an important route for energy and nutrients to enter the riverine food chain (Young, 2001).

Fluctuations in water levels allowing exposure of substrates such as large wood and plant stems through an annual drying cycle allow for a mosaic of biofilm species that offer a range of food resources for macroinvertebrates and fish (SKM, 2009).

3.4. Social Values

Cultural Values

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

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

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

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

Cultural Heritage

Walshes Bend is of significant cultural value to Indigenous and non-Indigenous people, with the area popular for fishing, camping and hunting, and as a meeting place.

In regard to Indigenous cultural values, some cultural sites have been documented through various archaeological investigations, but the true extent of the number and types of sites present is still unknown.

Surveyed sites within the Mallee region include middens, earth features, scarred trees, oven mounds,surface scatters, stone quarries and places of burial. Aboriginal people had a strong connection to the area and made use of the natural resources within the forest for bush medicine, basket weaving and other cultural activities. Significant aboriginal burial sites are found on Knights Bend and are currently protected from visitor impacts by the permanent inundation of Knights Creek.

The recorded cultural heritage sites show the area was an important meeting place for Aboriginal people, with water and food sources making it possible to survive in this landscape.

Aboriginal people continue to have a connection to this country. The *Ladjiladji* and *Dadidadi* are indigenous groups that have a vested interes in this area; however, other groups/community members may have an interest in this area. The land council, and other Aboriginal community members continue to value this country through traditional laws and customs.

Recreation

Adjacent to Walshes Bend the Murray River is particularly wide, which encourages many waterfront activities including fishing, camping, waterskiing, swimming, camping, bird watching and bush walking.

Basic four wheel drive tracks are located through the Walshes Bend but there are no other visitor facilities. Some fencing to control visitor access and signage is erected at the site.

Economic Values

The Euston Weir provides water for diversions to the Robinvale Irrigation District, parts of the Sunraysia Irrigation District, and private diverters in NSW as well as providing urban water to Robinvale and Euston (Gippel and Blackhan, 2002). Around the Robinvale area irrigated horticulture produces table grapes, wine grapes, olives, carrots, broccoli, asparagus, apples, avocados, pumpkins and citrus fruits along with pistachios and almonds. It is estimated that agricultural in the Robinvale area generates over $140 million and supports over 700 jobs in the region (Robinvale Euston Visitors Centre, 2014).

Walshes Bend is adjacent to the Robinvale Irrigation District Section B, and receives drainage water from this area.

3.5. Significance

The site is permanently protected within the Murray River Reserve, meaning that many threatening processes, primarily landuse driven, impacting Murray River wetlands elsewhere, do not impact this site. Walshes Bend has the potential to support diverse aquatic fauna, including small-bodied native fish, juvenile large-bodied fish, frogs and turtles. The River Red Gum and Lignum Woodlands can provide significant habitat for waterbird nesting and feeding, whilst existing mature trees support Regent Parrot, White-bellied Sea-eagle, Brown Tree-creeper and Carpet Python. The environmental, social and economic values outlined indicate the significance of this site. While these values do not constitute Walshes Bend being a unique or pristine site, the riparian and floodplain communities of the Murray River are important to the functioning of the river system and its sustainability.

4. Ecological Condition and Threats

4.1. Current Condition

Index of Wetland Condition assessments have not been undertaken for wetlands within the target area. The condition information described below is based on brief field observations and limited existing literature. It should be considered high priority to undertake a more comprehensive condition assessment.

Across Walshes Bend the vegetation appears relatively healthy, with very little evidence of any die back of mature trees and shurbs. There is plentiful leaf litter and structural habitat. Wetland #7428679683 is shown in Figure 20. All wetlands within the target area were dry at the time of the field inspections (February, 2015) and had no connection to the Murray River.

Figure 20 - Wetland #7428679683 Grassy Riverine Forest/Floodway Pond Herbland Complex

Knights Creek is a channel that cuts off the meander loop which is Knights Bend. Prior to the construction of the Lock 15 it would have occasionally been breached during high flows, but it is now permanently inundated with stable water levels. Knights Creek contains extensive structural habitat, including submerged macrophytes and large wood. However, bank vegetation is absent for much of the creek length. There would also be a lack of biofilm diversity on the structural habitat due to the stable water levels. Knights Creek is shown in Figure 21.

Figure 21 - Knights Creek

Wetland #7428653680 was historically used for irrigation drainage disposal, including permanent inundation of 18 hectares. This practice has ceased due to increased irrigation efficiency, although an excavated drainage channel is likely to consistently leak irrigation drainage water into the wetland. The Intermittent Swampy Woodland and Lignum Swamp Woodland (Figure 22) would benefit from a drying period. Evidence of poor water quality (high nutrients) from the drainage channel, including excessive algal growth was seen during field inspections (Figure 23). High nutrient levels may impact vegetation condition within the wetland.

Figure 22 - Wetland #7428653680 Lignum Swampy Woodland and Intermittent Swampy Woodland

Figure 23 - The irrigation drainage channel contains significant amounts of algae and has been cleared of reeds and other fringing vegetation

Shallow fresh groundwater, associated with the backwater effect of the Euston Weir has promoted dense growth by River Red Gums (Figure 24) and forest vegetation associations (Ecological Associates, 2006). Higher terraces support Black Box and Lignum woodland and shrublands. Most wetlands within Walshes Bend are located above the normal operating level of the Euston Weir pool and are rarely inundated.

Figure 24 - Dense growth of River Red Gum woodland

4.2. Condition Trajectory

If the current water regime at the site continues, significant ecological losses may occur. Whilst fresh groundwater associated with the Euston Weir pool may be supporting deep rooted vegetation on the lower terraces, including Riverine Forest areas, lack of inundation on a regular basis will continue to result in a lack of complex understorey in these areas. Inundation is also required for maintenance and recruitment of the dominant vegetation species, River Red Gum, Black Box and Lignum.

While large healthy River Red Gums are present at the site, a more appropriate water regime is required to ensure their health and maintain habitat for significant species such as Regent Parrot and Carpet Python.

Rainfall events may trigger germination for Black Box, however rainfall may not be adequate to support subsequent seedling establishment and large scale flood events appear to be required to provide the soil moisture necessary for widespread germination and establishment of Black Box (Johns and et al., 2009; Trelour, 1959).

Overwatering and ponding can be detrimental to Lignum, and the water regime must include a drying period. It is anticipated that the continuous flow of irrigation drainage water may limit Lignum health and productivity in the long term.

Stable water levels within Knights Creek will continue to favour algal dominated biofilms and overall productivity will continue to decline, limiting the ability of the Creek to support small and large bodied fish, frogs and turtles.

Continued inputs of relatively high volumes of poor water quality from the irrigation drainage will also lead to a decline in productivity within wetland #7428653680, with the potential for algal blooms to occur within the wetland. Conditions within the wetland would then be sub optimal for resident and visiting fish, frogs and waterbirds.

Overall the site retains some significant values and vegetation health is relatively good. It is important to ensure that the essential ecosystem functions are supported in years with high to average rainfall and flow, to enable ecosystem resilience during periods of successive dry years, such as during drought. Improvements to the water regime as outlined in this EWMP, will build this resilience.

4.3. Water Related Threats

Altered water regime

Hydrology is the most important component of wetland ecosystems. It drives the physical and chemical properties of wetlands, waterways and floodplains and the biota they support. As described in the Hydrology and Systems Operations section, the natural hydrological regime of Walshes Bend has been altered by regulation of the Murray River, leading to reduced frequency and duration of wetland flooding. In addition to this Lock 15 provides largely stable water levels through Knights Creek and also provides a shallow lense of fresh groundwater under Walshes Bend.

Poor Water Quality

Run-off containing high nutrient loads or pollutants entering the target area from surrounding agricultural land is potentially a problem. The irrigation drain, running along the west boundary of the site (Figure), has significant amounts of algae, and is lacking vegetation to slow flows and filter nutrients. It was estimated that the drain was flowing at 1-2 ML/day during field inspections.

Pest Plants and Animals

It is likely that *Gambusia* are a relatively dominant species in the irrigation drainage channel on the southern boundary of Walshes Bend. Small fish suspected to be *Gambusia* were also abundant in Knights Creek during field investigations.

Mechanical removal of vegetation from the irrigation drain was associated with the introduction of a number of weed species at the site, including Noogoora Burr (*Xanthium* spp.), a Regionally Controlled species in the Mallee region. Vehicle and machinery hygiene, such as cleaning the undercarriage and tyres of work vehicles prior to entering the site, should be a key consideration before future maintenance works of the drains are carried out at Walshes Bend.

5. Management Objectives

5.1. Management Goal

The long-term management goal for Bumbang Island is:

To provide a water regime which reflects natural water level variability and seaonaility, maintains and enhances the mosaic of habitats that will protect and restore the key species, ecological communities and functions of the ecosystem within the EWMP target area.

5.2. Environmental Objectives

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

During 2020, the environmental objectives (formally ecological objectives) undertook a refinement process with the intent of improving the specificity and measurability of the objectives through the development of targets, and to improve line of sight to the Basin Plan. While the process attempted to maintain the intent and integrity of the original objectives, it provided an opportunity to reassess the suitability of these objectives for the asset. The rationalisation, assessment of SMARTness, mapping to Basin Plan and update of each objective for Walshes Bend can be found in Section 5.27.1 of Butcher et al. (2020).

Alignment to Murray-Darling Basin Plan

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

Mapping of Environmental objectives to high level planning documents

As well as alignment with Basin Plan, the objectives have alignment with Basin-wide environmental Watering Strategy objectives and State level Long-term Watering Plan objectives. Table 11 maps the current EWMP objectives against these objectives to provide a line of sight.

Table 11 Mapping updated Walshes Bend EWMP objectives to Basin Plan Environmental Watering Plan (EWP) objectives, Basin Plan Schedule 7 targets, Basin wide Environmental Watering strategy (BWS) quantified environmental expected outcomes (QEEO) (MDBA 2019), and Long-term Watering Plan (LTWP) Victorian Murray objective (DELWP 2015).

EWMP objectives	Basin Plan EWP objective	Relevant Schedule 7 target	Relevant BWS QEEO	LTWP objective
WB1	8.05,3(b) 8.06,6(b)	Condition of priority asset - prevention of decline in native biota Condition of water-dependent vegetation Diversity of native water dependent vegetation	B2.2 B2.8	LTWPVM5 LTWPVM6
WB2	8.05,3(b) 8.06,6(b)	Condition of priority asset - prevention of decline in native biota Diversity of native water dependent vegetation Condition of priority ecosystem functions - creation of vital habitat - habitat for prevention of decline in native species	B2.11	LTWPVM2
WB5	8.06,6(b)	Condition of priority ecosystem functions - creation of vital habitat - diversity of habitat	B4.5	LTWPMV15

Environmental objectives and targets

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

Table 12 Updated ecological objectives for Walshes Bend

Environmental objective	Target
WB1: By 2030, improve condition and maintain extent from baseline levels of River Red Gum (*Eucalyptus camaldulensis*), and Black Box (*E. largiflorens*) and to sustain communities and processes reliant on such communities at the Walshes Bend asset.	By 2030, a positive trend in the condition score of River Red Gum dominated EVC benchmarks at the Walshes Bend asset at 80% of sites over the 10 year period. OR By 2030, at stressed sites (see Wallace et al. 2020) at the Walshes Bend asset: in standardised transects that span the floodplain elevation gradient and existing spatial distribution, ≥70% of viable trees will have a Tree Condition Index Score (TCI) ≥ 10. Baseline condition of River Red Gum trees needs to be established. **AND** By 2030 a positive trend in the condition score of Black Box dominated EVC benchmarks at Walshes Bend at 80% of sites over the 10 year period OR By 2030, at stressed sites (see Wallace et al. 2020) at the Walshes Bend asset: in standardised transects that span the floodplain elevation gradient and existing spatial distribution,≥70% of viable trees will have a Tree Condition

	Index Score (TCI) ≥ 10
WB2: By 2030, improve vital habitat at the Walshes Bend asset by increasing the diversity of aquatic macrophytes present across a range of Water Regime Indicators	By 2030, increase diversity of native of macrophytes at the Walshes Bend asset with ≥2 species from each of the following Water Regime Indicator Groups present in 80% of years: • Aquatic (small floating) (Asf) (no species recorded) • Aquatic (obligate submerged) (Aos) (no species recorded) • Aquatic (submerged to partially emergent) (Ase) (no species recorded) • Aquatic graminoids (persistent) (Agp) (Broad-leaf Cumbungi *Typha orientalis*) • Aquatic to semi-aquatic (persistent) (Asp) (Common Blown-grass *Lachnagrostis filiformis s.l.*, Common Nardoo *Marsilea drummondii*) • Seasonally immersed – low growing (Slg) (Lesser Joyweed *Alternanthera denticulata s.s.,* Twin-leaf Bedstraw *Asperula gemella*, Yellow Twin-heads *Eclipta platyglossa subsp. Platyglossa*, Narrow-leaf Dock *Rumex tenax*, Rat-tail Couch *Sporobolus mitchellii*, River Bluebell *Wahlenbergia fluminalis*) • Seasonally inundated – emergent non woody (Sen) (Warrego Summer-grass *Paspalidium jubiflorum*)
WB5: By 2030, protect and restore recruitment of small-bodied native fish at the Walshes Bend asset, including Australian Smelt (*Retropinna semoni*), Unspecked Hardyhead (*Craterocephalus stercusmuscarum fulvus*), Murray-Darling Rainbowfish (*Melanotaenia fluviatilis*), Flat-headed Gudgeon (*Philypnodon grandiceps*) and Carp Gudgeon (*Hypseleotris* spp).	By 2030, maintain self-sustaining populations of Australian Smelt (*Retropinna semoni*), Unspecked Hardyhead (*Craterocephalus stercusmuscarum fulvus*), Murray-Darling Rainbowfish (*Melanotaenia fluviatilis*), Flat-headed Gudgeon (*Philypnodon grandiceps*) and Carp Gudgeon (*Hypseleotris* spp) at the Walshes Bend asset. Measured as: • Adults or YoY for each species recorded in 8 out of 10 years

5.3. Hydrological Objectives

Hydrological objectives describe the components of the water regime required to achieve the ecological objectives for the target area. The hydrological objectives aim to provide a water regime which reflects more natural variability in water levels and which provides a watering regime to meet the ongoing maintenance and enhancement of the vegetation communities and aquatic fauna of the site.

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

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

Grassy Riverine Forest/Floodway Pond Herbland Complex should be inundated 3-7 years in 10, for a duration of > 1 month to > 1 year, followed by a drying period (Frood, 2012).

Specifically the EWMP will benefit:

- areas that are currently permanently inundated at the stable weir level including Knights Creek;
- areas that may benefit from maninpulation of the Euston Weir upto 48.2 metres including wetland #7428679683 (as shown in Figure 6) ; and
- wetland #74286583680.

Manipulation of the Euston Weir

Significant benefit to the Walshes Bend target area can be achieved through manipulation of the Euston Weir pool levels as shown in Table 12. The hydrological objectives, or proposed water regime for the weir pool are aimed at mimicking the natural seasonality of river flows and inundation levels. The primary target of the water requirements are the littoral and riparian zones of the wetlands, most areas targeted through this activity within the target area are Floodway Pond Herbland or Grassy Riverine Forest/Floodway Pond Herbland Complex EVCs, although some areas of Intermittent Swampy Woodland and Lignum Swampy Woodland would also benefit.

The objectives as described above are about promoting a broader zone of macrophytes, increasing productivity and habitat quality for aquatic fauna including water birds, frogs and fish. The water regime presented is consistent with the weir pool operating regime provided in the Lock 15 draft Environmental Water Management Plan (Ecological Associates, 2015) and is also relatively consistent with the Bumbang Island EWMP. Some changes to the justifications for the water regime have been made, to meet the local conditions and environmental objectives set for Walshes Bend.

The water regime focusses on a higher inundation regime in late winter to spring (August to November), with the minimum water level being provided between December and May. Changes to the levels should be gradual. The actual pattern of change should follow a 'saw-tooth' design whereby the drawdown and recharge events should be graduated in flow like a series of steps to introduce daily and weekly variability in to the overall flow regime (SKM, 2009). Table 13 provides a proposed weir pool level regime highlighting variation from normal operating levels, and Figure 25 shows the water regime graphically. Figure also provides a minimum and maximum weir pool level which could be used to assist with negotiating the water regime where operational constraints exist. The proposed water regime aims to mimic the seasonal pattern of flows and can be compared to Figure 9 which shows the median monthly flows under pre regulation conditions.

Earlier work by SKM in 2009, identified a similar weir level regime, however the primary focus of that work was on the ecological values within the Euston Lakes. This earlier work recommended a lower drawdown level through autumn; however the operation limitation of 47.3m AHD was exceeded with a minimum level of 46.6m AHD recommended. The maximum level recommended in this project is also higher, reaching 48.2m AHD in September/October. This is based on the need to maximise inundation of low level floodplain woodlands on the low level terraces.

Table 13 - Proposed Euston weir pool regime variation from normal operating level of 47.6m AHD

Month	Optimum variation from normal weir pool operating level of Lock 15 (m)
Jan	0.0
Feb	0.0
March	0.0
April	-0.2
May	-0.3*
June	-0.3*
July	0.0
August	+0.25
September	+0.6
October	+0.6
November	+0.4
December	0.0

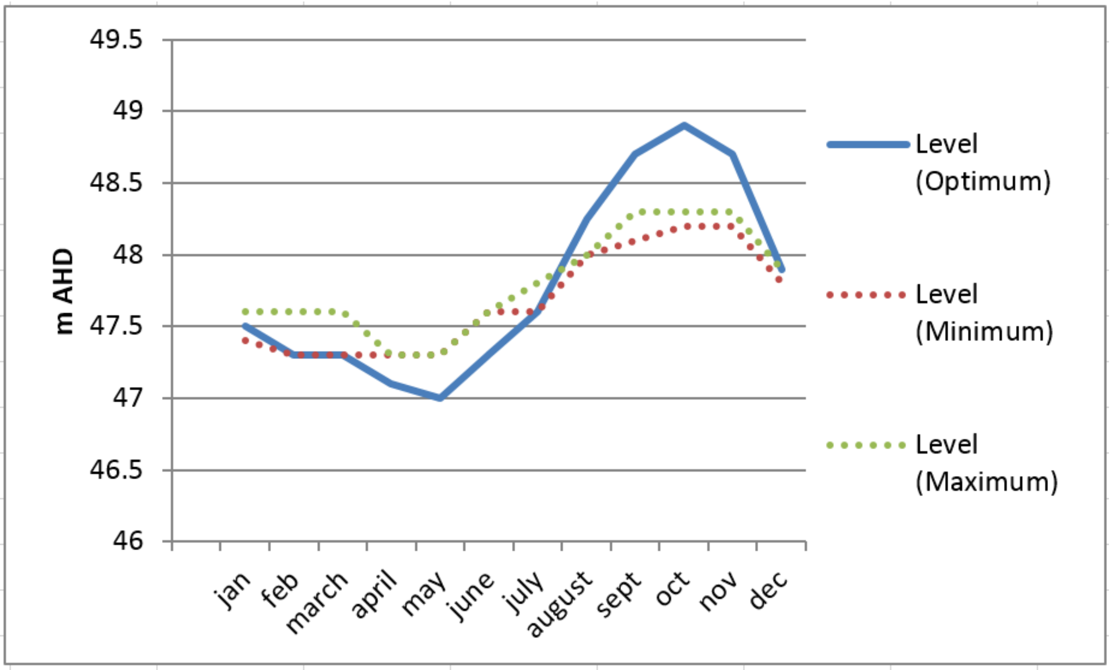

Figure 25 - Proposed annual weir pool water level regime

The approximate inundation of water areas in Walshes Bend was modelled using LiDAR data for weir levels between 47.3m AHD and 48.2m AHD. These levels were provided as the operational limitations for weir level manipulation. It should be noted that no hydraulic modelling of the site has been conducted prior to these recommendations being made. Review of these recommendations should be undertaken, following the trial manipulation of Lock 15 planned for April 2015, to confirm the levels required to provide the ecological outcomes described below.

Table 14 describes the potential ecological outcomes that may result from each stage within the recommended Euston Weir pool regime and Table 15 links these to the hydrological objectives.

Table 14 - Summary of potential ecological outcomes resulting from the recommended Euston Weir pool regime (Adapted from (SKM, 2009).

Timing	Direction of change in weir pool level	Potential ecological outcome
November to March	Drawdown	Wetlands and backwaters begin to slowly drawdown. Connectivity between the floodplain wetlands and the Murray commence to drawdown and provide cues for fish movement.
March to May	Drawdown	The wetlands and channels are isolated and gradually lower through evaporation. Some water remains in wetlands #7428653680 (via the regulator) and #7428679683 (for a short period) providing refuge habitat for aquatic and terrestrial flora and fauna. The wetland and backwater littoral zone is exposed providing opportunities for colonisation by vegetation tolerant of drier conditions. Water levels within Knights Creek commence to drawdown, exposing banks, large wood and encouraging carbon cycling. At the lowest drawdown level, exposure of channel banks and instream benches is achieved. Large wood, benches and in stream debris are exposed, drying biofilms.
Late July to October	Recharge	Timed to coincide with winter and spring. Fish movement and breeding may be stimulated. Longitudinal connection between the floodplain and Murray channel. Newly inundated wetland and channel habitats are available to fauna, and offer a diversity of foraging opportunities. Biofilm and macroinvertebrate communities recolonise structural surfaces. Wetlands and channel littoral habitats are inundated, promoting plant succession. The inundated macrophytes provide diverse shallow water habitat structure for biofilms, macroinvertebrates, small fish and other water-dependent fauna. Riparian flora may respond by flowering and regrowth. The floodplain channels (Floodway Pond Herbland areas) are connected promoting floodplain productivity and enhancing the health of mature woodland trees. There is increased inundation of the channels and wetlands increasing littoral macrophytes and offering a diversity of foraging and refuge habitats for waterbirds and other water-dependent fauna. Available habitat for Freshwater Catfish and other juvenile large-bodied fish who opportunistically use the floodplain (such as Golden Perch) is increased and connected. Flood channels and floodplain wetlands are fully connected and engaged, providing refuge, breeding and foraging habitat for aquatic and terrestrial fauna. These habitats provide opportunities for amphibians, fish and other freshwater fauna including turtles. Conditions are ideal for riparian vegetation recruitment. The provision of water in spring is most beneficial to littoral vegetation, macrophytes and riparian vegetation reproduction.

Table 15 - Hydrological objectives for Walshes Bend

Ecological Objectives	Water management area	Hydrological Objectives: Recommended number of events in 10 years			Tolerable interval between events once wetland is dry (years)			Duration of ponding (months)			Preferred timing of inflows	Depth (mm)
		M	Opt	Max	Min	Opt	Max	Min	Opt	Max		
Increased diversity and productivity (including tree health and shrub health) to meet EVC bencmarks for EVCs #810, #811, #813 and #823.	Grassy Riverine Forest/Floodway Pond Herbland Complex EVC & Floodway Pond Herbland EVC	Objective met through the suggested Euston Weir Pool Watering Regime										
	Wetland #7428653680 Intermittent Swampy Woodland EVC *	3	4	5	5	6	7	2	3	4	Spring-Summer	Not critical
	Wetland #7428653680 Lignum Swampy Woodland**	3	5	10	1	2	7	3	5	7	Not critical	< 1m, but not critical.
Increased aquatic macrophyte diversity and area	Riparian areas and backwaters	2	5	10	0	0	0	1	6	12	Spring, gradual exposure late Spring/ Summer	
Increased dissolved organic matter, particulate matter and macroinvertebrate productivity	Wetlands	3	5	10				2		6	Spring/ Summer	N/A
Increased small-bodied native fish (e.g. Gudgeon spp., Murray-Darling Rainbowfish) diversity and abundance through	All	Ecological Objective met through requirements of other ecological objectives										
Increased biofilm production and diversity	Riparian areas and Knights Creek	10	10	30				1.5			N/A	N/A

* Water regime recommended based on needs of River Red Gum. Regeneration of River Red Gum requires a follow up flood to recharge soil moisture for seedlings. Shallow flooding, 20-30cm, is requied for the first year for duration of 4-6 weeks (Roberts and Marston, 2011).

** Water regime recommended based on needs of Lignum. Lignum generally does not occur in permanently waterlogged soils. Overwatering and ponding can be detrimental to Lignum. Avoid continuous flooding. Lignum regeneration requires flooding in Autumn-Winter. Depth of flooding is 5-15 cm for 4-6 weeks. (Roberts and Marston, 2011).

5.4. Implementation of the watering regime at Walshes Bend

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

As shown in Figure 25, the recommended weir pool water regime is prescribed with minimum, maximum and optimal monthly water levels. The water regime recommened for the weir pool meets a number of the ecological objectives and contributes to a number of other objectives. In addition to the contribution of the weir pool level manipulation, it is recommended to operate the regulator at wetland #7428653680 to provide the following watering regime.

Wetland #7428653680

Water Regime	Inundation area, duration and frequency
Minimum	Inundate the wetland three times in ten years with maximum interval of four years between events (targeting the Lignum Swampy Woodland and seven years targeting the Intermittent Swampy Woodland). Maintain the wetland for two to three months to maintain the health of River Red Gum and Lignum communities. Ensure that irrigation drainage flows are ceased during drying period to ensure that Lignum is not continuously flooded.
Optimal	Inundate the wetland four to five times in ten years with a maximum interval of two years between events. Maintain the wetland to <1 metre depth for five months to maintain the health of River Red Gum and Lignum communities. Ensure that irrigation drainage flows are ceased during drying period to ensure that Lignum is not continuously flooded.
Maximum	Inundate the wetland up to 10 times in 10 years with a maximum interval of one year between events. Maintain the water in the wetland for seven months. Ensure that irrigation drainage flows are ceased during the drying period to ensure that Lignum is not continuously flooded.

6. Managing Risks to Achieving Objectives

Potential risks associated with environmental water delivery at Walshes Bend are outlinedTable 17, along with mitigation actions and the residual risk if these actions were adopted.

Prior to delivering environmental water in any given season, these risks will be further refined as part of the Seasonal Watering Proposal and Environmental Water Delivery Plan process. These documents will provide a greater level of risk analysis and mitigation measures according to conditions observed closer to the proposed delivery (i.e. operational risks). The documents will also include detailed consideration of the impact of proposed mitigation measures on the likelihood and consequence of the risk occurring (residual risk) as this may change according to catchment conditions and operations closer to the proposed delivery. They will clearly outline roles and responsibilities regarding risk management.
Risks associated with the manipulation of Lock 15 are outlined in Lock 15 EWMP (Ecological Associates, 2015 in prep).

Table 16. Risk Matrix

		Consequence		
		Major	Moderate	Minor
Likelihood	Probable	High	High	Moderate
	Possible	High	Moderate	Low
	Unlikely	Moderate	Low	Low

Table 17 Possible risks and mitigation measures associated with environmental water delivery to Lake Murphy

Threat	Likelihood	Consequence	Risk – H, M, L (likelihood x consequence)	Management Measure	Residual Risk
Failure to meet ecological objectives	Possible	Major	H	Monitoring program in place. Adaptive approach.	Low
Inability to deliver optimal water regime through weir pool manipulation	Possible	Major	H	N/A	
Species, communities or ecological processes have been overlooked in water regime due to lack of data	Possible	Moderate	M	N/A	
Water not available for weir recharge following drawdown in Autumn	Possible	High	M	Review of seasonal weather predictions, appropriate engagement in place and adaptive management of water regime.	Low
Flood duration too long or too short	Possible	Major	H	Monitoring program in place. Adaptive approach as additional baseline and monitoring outcome data is available.	Low
Water regime enhances habitat for exotic species of flora and fauna	Possible	Moderate	M	Monitor and adjust water regime accordingly	
Water quality decline due to saline groundwater intrusion from weir drawdown	Possible	Moderate	M	Monitor water quality and impacts on species	
Poor water quality in inundated wetlands due to mixing with irrigation drainage water	Possible	Major	H	It is recommended that nutrient and pollutant management within the Robinvale Irrigation District Section B be investigated, along with a further program of irrigation efficiency to minimise drainage flows through Walshes Bend and more specifically through wetland 7428653680.	Low

Threat	Likelihood	Consequence	Risk – H, M, L (likelihood x consequence)	Management Measure	Residual Risk
Recommended weir pool manipulation regime is not complimentary to watering needs at other sites within the weir pool extent (70+ km upstream of Lock 15).	Unlikely	Major	M	Monitoring of sites within the weir pool extent	
Weir level manipulation affects Irrigator ability to access water at pump points or results in increased costs	Probable	Moderate	H	Engagement program to identify issues. Compensation, incentives to change operations may be considered. Some flexibility with timing.	Low
Environmental watering program negatively affects cultural heritage sites (Burial sites at Knights Bend)	Possible	Major	H	It is recommended that complimentary management measures such as fencing be put in place to ensure that any access to Knights Bend is minimised during lowering of the Lock 15 weir pool and exposure of a crossing point to Knights Bend	Low
Weir pool manipulation negatively impacts major recreational events	Possible	Major	H	Weir level manipulation to be undertaken in consultation with major stakeholders including recreational to avoid key events i.e. water ski race in March	Low
Drainage efficiency from Robinvale Irrigation District Section B is impacted by inundation of wetlands	Possible	Major	H	It is recommended that works to provide storage of irrigation drainage water for the period of environmental watering at Wetland #7428653680 e.g. a dam be installed to allow collection of irrigation water.	Low

7. Environmental Water Delivery Infrastructure

7.1. Constraints

Euston Weir (Lock 15)

As mentioned previously, there is limited ability to manipulate the Euston Weir to improve ecological outcomes. The normal operating level of the weir is 47.6m AHD. The weir pool level can be adjusted from normal operating level by -0.3m AHD and +0.6m AHD based on advice from the weir operator (P. Cocks pers. comm. September 2014) and the Lock 15 EWMP. The lower limit of operation is based on the requirements of irrigators to access pumping points. The upper limit is guided by safe operation of the weir structure.

An assessment of the environmental water requirement for the whole Euston Weir pool reach has been undertaken by Ecological Associates (Ecological Associates, 2015). Watering recommendations for Walshes Bend are complimentary to the other sites within the influence of the weir.

Irrigation Drainage

Four main drains from the Robinvale Irrigation District Section B feed into Walshes Bend and join a single drain which flows through wetland #7428653680 before joining the Murray River. Volumes of drainage water, estimated during field work as 1-2 ML/ day, was running through the site. Lower Murray Water have indicated that it is important that irrigation drainage does not back up as the result of any infrastructure works or environmental watering activities.

7.2. Infrastructure or complementary works recommendations

Irrigation drainage

There is significant irrigation drainage water entering Walshes Bend and flowing through wetland #7428653680. This drainage water does not allow a regular drying phase for this wetland.

The continuous ‘drip-feed’ of drainage water through the channel and into the wetland provides ideal growing conditions for Cumbungi. Maintenance works, mechanical and herbicide, have recently been carried out on the channel to remove Cumbungi.

Investigation of drainage management options should be undertaken.

Investigating and mitigating water quality issues associated with drainage water

In field investigations identified significant growth of algae within the irrigation drainage channel flowing through wetland #7428653680. This appears to indicate significant nutrient levels.There is also the potential for other pollutants to flow through the wetland via the channel. Water quality should be investigated and measures put in place to improve water quality entering the site via irrigation drainage. The removal of reeds and other vegetation from the drainage channel would be providing hydraulic efficiency for drainage flow, but would remove any filtering of drainage water by ‘in-stream’ vegetation.

Protection of indigenous cultural heritage

Engagement with indigenous representatives from the area identified concern that lowering of the weir pool may provide access to Knights Bend, via crossing Knights Creek. There are significant sites at Knights Bend, including burial sites. These issues should be further investigated prior to implementing the recommended watering regime.

8. Demonstrating Outcomes

8.1. Monitoring Priorities at the Site

As mentioned previously, there is very little site specific data available regarding Walshes Bend. Management recommendations have been made based on field observations, expert knowledge and extrapolation of information from other similar sites.

The priorities for filling of knowledge gaps are listed below.

1. Baseline condition assessment – Index of Wetland Condition (IWC), Index of Stream Condition (ISC)
2. Fish and waterbird assessments
3. Lidar or Aerial photography capturing inundation extent at low water levels (47.3m AHD)
4. Onground mapping to confirm the extent of inundation and connections of creeks and wetlands associated with weir pool manipulation during April 2015 and April 2016.
5. The extent and density of littoral vegetation by means of photopoints.
6. Mapping of cultural sites of significance particularly within Knights Bend.

9. Consultation

This plan was developed in collaboration with key stakeholders namely Parks Victoria, local indigenous communities, DELWP, landholders and local interest groups (**Error! Reference source not found.**). Various meetings were held during the development phase to seek input and gather information from experts and stakeholders as well as meetings with DELWP and other CMAs involved in the development of EWMPs.

May 2015 Local landholder - Would like to be kept informed on the changes to weir heights.

Table 18 - Consultation with key EWMP stakeholders

Meeting Date	Stakeholders	Details
TBA	Parks Victoria	Initial discussion to introduce concept of plan
TBA	Department of Environment, Land, Water and Planning	Consultation on environmental management and project development
TBA	Indigenous Communities	Presentation and review of draft plan
May 2015	Local residents and landholders	Four local landholders were contacted, no issues were raised. Local landholder - Would like to be kept informed on the changes to weir heights

10. Knowledge Gaps and Recommendations

Baseline condition monitoring should be undertaken within the target area. Assessments such as the IWC could be used. There is very limited fauna data from the site, including aquatic fauna. Although data from nearby sites can be used as indicators for this site, it would be useful to have site specific data.

Drainage water management should be further investigated. This would include gathering data on volumes, timing, quality and existing programs which may assist with improving drainage water management.

Water quality monitoring of the irrigation drainage water running through both Walshes and Knights Bends should be undertaken and analysed to determine likely effects at the site and to set baselines from which improvements can be made. This EWMP has assumed that the quality of irrigation drainage water is poor, and is likely to be having negative impacts on the ecological community at the site.

Assessment of inundation associated with any weir level manipulation trials should also be undertaken to confirm the assumptions developed through review of the LiDAR data.

Feasbility assessment, and then (subject to successful outputs) detailed design is required for the regulator proposed for wetlands #7428653680.

Feasibility assessment and an engagement program is required to discuss options to implement a drying phase to wetland #7428653680 and drainage water management.

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12. Abbreviations and Acronyms

ANCA	Australian Nature Conservation Agency
CEWH	Commonwealth Environmental Water Holder
CMA	Catchment Management Authority
DEPI	Department of Environment and Primary Industries
DELWP	Department of Environment, Land, Water and Planning
DSE	Department of Sustainability and Environment
EPBC	Environment Protection and Biodiversity Conservation Act
EVC	Ecological Vegetation Class
EWMP	Environmental Water Management Plan
EWH	Environmental Water Holder
EWR	Environmental Water Reserve
FFG	Flora and Fauna Guarantee Act
Mallee CMA	Mallee Catchment Management Authority
MDBA	Murray-Darling Basin Authority (formally Murray-Darling Basin Commission, MDBC)
MRUF	Murray River Unregulated Flow
VEWH	Victorian Environmental Water Holder
WMU	Waterway Management Unit

Appendix 1 – Fauna Species List (from VBA Data 16/02/2015)

Taxon ID	Scientific Name	Common Name	Victorian Advisory List	Count of Sightings
10640	*Acanthagenys rufogularis*	Spiny-cheeked Honeyeater		1
10486	*Acanthiza chrysorrhoa*	Yellow-rumped Thornbill		1
10471	*Acanthiza nana*	Yellow Thornbill		2
10481	*Acanthiza uropygialis*	Chestnut-rumped Thornbill		2
10638	*Anthochaera carunculata*	Red Wattlebird		1
10466	*Aphelocephala leucopsis*	Southern Whiteface		1
10408	*Colluricincla harmonica*	Grey Shrike-thrush		1
10700	*Cracticus nigrogularis*	Pied Butcherbird		1
10273	*Eolophus roseicapilla*	Galah		1
10625	*Lichenostomus penicillatus*	White-plumed Honeyeater		1
10608	*Lichenostomus virescens*	Singing Honeyeater		1
10529	*Malurus cyaneus*	Superb Fairy-wren		1
10536	*Malurus lamberti*	Variegated Fairy-wren		1
10532	*Malurus splendens*	Splendid Fairy-wren		1
10401	*Pachycephala rufiventris*	Rufous Whistler		1
10381	*Petroica goodenovii*	Red-capped Robin		1
10034	*Phaps chalcoptera*	Common Bronzewing		1
10361	*Rhipidura albiscarpa*	Grey Fantail		2
10364	*Rhipidura leucophrys*	Willie Wagtail		1
10465	*Smicrornis brevirostris*	Weebill		1

Taxon ID	Scientific Name	Common Name	Victorian Advisory List	Count of Sightings
10180	*Threskiornis spinicollis*	Straw-necked Ibis		1

Appendix 2 – Ecological Vegetation Classes (EVCs)

EVC No.	EVC Name	Area (Ha)	Bioregional Conservation Signifnicance	Description
97	Semi-arid Woodland	0.35	Vulnerable	Non-eucalypt woodland or open forest to 12 m tall, of low rainfall areas. Occurs in a range of somewhat elevated positions not subject to flooding or inundation. The surface soils are typically light textured loamy sands or sandy loams.
98	Semi-arid Chenopod Woodland	0.86	Vulnerable	Sparse, low non-eucalypt woodland to 12 m tall of the arid zone with a tall open chenopod shrub-dominated understorey or a treeless, tall chenopod shrubland to 3 m tall. This EVC may occur as either a woodland (typically with a very open structure but tree cover >10%) or a shrubland (tree cover <10%) with trees as an occasional emergent.
103	Riverine Chenopod Woodland (syn. Black Box Chenopod Woodland)	60.37	Depleted	Eucalypt woodland to 15 m tall with a diverse shrubby and grassy understorey occurring on most elevated riverine terraces. Confined to heavy clay soils on higher level terraces within or on the margins of riverine floodplains (or former floodplains), naturally subject to only extremely infrequent incidental shallow flooding from major events if at all flooded.
104	Lignum Swamp	22.93	Vulnerable	Typically treeless shrubland to 4 m tall, with robust (but sometimes patchy) growth of lignum. Widespread wetland vegetation type in low rainfall areas on heavy soils, subject to infrequent inundation resulting from overbank flows from rivers or local runoff.
106	Grassy Riverine Forest	38.71	Depleted	Occurs on the floodplain of major rivers, in a slightly elevated position where floods are infrequent, on deposited silts and sands, forming fertile alluvial soils. River Red Gum forest to 25 m tall with a groundlayer dominated by tussock-forming graminoids. Occasional tall shrubs present.
295	Riverine Grassy Woodland	55.91	Depleted	Occurs on the floodplain of major rivers, in a slightly elevated position where floods are rare, on deposited silts and sands,

				forming fertile alluvial soils. River Red Gum woodland to 20 m tall with a groundlayer dominated by graminoids and sometimes lightly shrubby or with chenopod shrubs.
810	Floodway Pond Herbland	14.81	Depleted	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.
811	Grassy Riverine Forest/ Floodway Pond Herbland Complex	69.17		Eucalypt forest or woodland of flood-prone areas, where herbaceous species characteristic of drying mud within wetlands (Floodway Pond Herbland or in part Lake Bed Herbland) are conspicuous in association or fine-scale mosaic with Paspalidium jubiflorum and other species characteristic of Grassy Riverine Forest. Restricted extent, Murray River system mainly in far north-west, but upstream at least as far as Barmah Forest.
813	Intermittent Swampy Woodland	93.95	Depleted	Eucalypt woodland to 15 m tall with a variously shrubby and rhizomatous sedgy - turf grass understorey, at best development dominated by flood stimulated species in association with flora tolerant of inundation. Flooding is unreliable but extensive when it happens. Occupies low elevation areas on river terraces (mostly at the rear of point-bar deposits or adjacent to major floodways) and lacustrine verges (where sometimes localised to narrow transitional bands). Soils often have a shallow sand layer over heavy and frequently slightly brackish soils.
818	Shrubby Riverine Woodland	57.61	Least concern	Eucalypt woodland to open forest to 15 m tall of less flood-prone (riverine) watercourse fringes, principally on levees and higher sections of point-bar deposits. The understorey includes a range of species shared with drier floodplain habitats with a sparse shrub component, ground-layer patchily dominated by various life-forms. A range of large dicot herbs (mostly herbaceous perennial,

				several with a growth-form approaching that of small shrub) are often conspicuous.
821	Tall Marsh	8.24	Depleted	Wetland dominated by tall emergent graminoids (rushes, sedges, reeds), typically in thick species-poor swards. Competitive exclusion in core wetland habitat - of optimum growing conditions for species tolerant of sustained shallow inundation. Occupies wetlands usually associated with anabranch creeks. Soils are almost permanently moist. Dominant species are tolerant of relatively deep and sustained inundation, but not total immersion for any sustained period.
823	Lignum Swampy Woodland	125.56	Depleted	Understorey dominated by Lignum, typically of robust character and relatively dense (at least in patches), in association with a low Eucalypt and/or Acacia woodland to 15 m tall. The ground layer includes a component of obligate wetland flora that is able to persist even if dormant over dry periods.
828	Semi-arid Parilla Woodland	1.77	Vulnerable	A shrubby, non-eucalypt woodland or open forest to 15 m tall of low rainfall areas associated with topographic highs created by weathered Parilla sandstone ridges and dominated by Belah Casuarina pauper. This EVC represents a distinctive floristic segregate of Semi-arid Woodland – comprising relatively undisturbed remnants of this broader vegetation descriptor with little or no groundwater influence.

Appendix 3 – Flora Species List (from VBA Data 16/02/2015)

Taxon ID	Scientific Name	Common Name	Victorian Advisory List	Records
500015	*Acacia ligulata*	Small Cooba		1
500070	*Acacia oswaldii*	Umbrella Wattle	Vulnerable	3
500090	*Acacia stenophylla*	Eumong		2
508102	*Acetosa* spp.*	Dock		3
500124	*Actinobole uliginosum*	Flannel Cudweed		1
501659	*Alectryon oleifolius subsp. canescens*	Cattle Bush		1
505097	*Alternanthera denticulata* s.s.	Lesser Joyweed		7
500218	*Amyema miquelii*	Box Mistletoe		1
500219	*Amyema miraculosa* subsp. *boormanii*	Fleshy Mistletoe		1
500280	*Asperula gemella*	Twin-leaf Bedstraw	Rare	6
508082	*Asperula spp.*	Woodruff		6
500286	*Asphodelus fistulosus**	Onion Weed		3
500297	*Aster subulatus**	Aster-weed		18
500317	*Atriplex eardleyae*	Small Saltbush		1
500321	*Atriplex leptocarpa*	Slender-fruit Saltbush		2
503622	*Atriplex pumilio*	Mat Saltbush		1
500334	*Atriplex stipitata*	Kidney Saltbush		1
500335	*Atriplex suberecta*	Sprawling Saltbush		1
500336	*Atriplex vesicaria*	Bladder Saltbush		2
503264	*Austrostipa acrociliata*	Graceful Spear-grass		1

503273	*Austrostipa elegantissima*	Feather Spear-grass		2
503283	*Austrostipa nitida*	Balcarra Spear-Grass		3
503275	*Austrostipa scabra* subsp. *falcata*	Rough Spear-grass		2
500340	*Avena barbata**	Bearded Oat		2
500463	*Brachyscome lineariloba*	Hard-head Daisy		1
500494	*Brassica tournefortii**	Mediterranean Turnip		4
500500	*Bromus diandrus**	Great Brome		3
500504	*Bromus rubens**	Red Brome		3
500511	*Bulbine semibarbata*	Leek Lily		1
500554	*Calandrinia eremaea*	Small Purslane		1
500578	*Callitris gracilis*	Slender Cypress-pine		1
500584	*Calocephalus sonderi*	Pale Beauty-heads		2
508198	*Carthamus* spp.*	Thistle		1
500675	*Casuarina pauper*	Belah		1
500698	*Centaurea melitensis**	Malta Thistle		1
500707	*Centipeda cunninghamii*	Common Sneezeweed		1
500740	*Chenopodium curvispicatum*	Cottony Saltbush		1
504380	*Chenopodium desertorum* subsp. *desertorum*	Frosted Goosefoot	Rare	1
504381	*Chenopodium desertorum* subsp. *microphyllum*	Small-leaf Goosefoot		1
500747	*Chenopodium nitrariaceum*	Nitre Goosefoot		2
501606	*Chrysocephalum apiculatum* s.l.	Common Everlasting		1

500790	*Clematis microphylla* s.l.	Small-leaved Clematis		1
500859	*Crassula colorata*	Dense Crassula		2
500866	*Crassula sieberiana* s.l.	Sieber Crassula		3
500907	*Cynodon dactylon*	Couch		9
501075	*Dissocarpus paradoxus*	Hard-head Saltbush		4
504428	*Dodonaea viscosa* subsp. *angustissima*	Slender Hop-bush		3
502227	*Duma florulenta*	Tangled Lignum		11
500748	*Dysphania pumilio*	Clammy Goosefoot		1
501118	*Echinochloa crus-galli**	Barnyard Grass		1
501125	*Eclipta platyglossa* subsp. *platyglossa*	Yellow Twin-heads		3
501133	*Einadia nutans*	Nodding Saltbush		6
501156	*Enchylaena tomentosa* var. *tomentosa*	Ruby Saltbush		14
501160	*Enteropogon acicularis*	Spider Grass		4
502237	*Eremophila deserti*	Turkey Bush		1
502112	*Eriochiton sclerolaenoides*	Woolly-fruit Bluebush		1
501258	*Eucalyptus camaldulensis*	River Red-gum		1
501273	*Eucalyptus dumosa*	Dumosa Mallee		1
501292	*Eucalyptus largiflorens*	Black Box		2
501320	*Eucalyptus socialis*	Grey Mallee		1
501471	*Euchiton sphaericus*	Annual Cudweed		1
508427	*Euchiton* spp.	Cudweed		2
500728	*Euphorbia drummondii*	Flat Spurge		11

501349	*Exocarpos aphyllus*	Leafless Ballart		2
501498	*Goodenia glauca*	Pale Goodenia		2
501509	*Goodenia pinnatifida*	Cut-leaf Goodenia		2
501572	*Hakea tephrosperma*	Hooked Needlewood		1
501637	*Heliotropium supinum**	Creeping Heliotrope		1
501657	*Herniaria cinerea**	Hairy Rupture-wort		1
503695	*Hordeum murinum* s.l.*	Barley-grass		4
501747	*Hypochaeris glabra**	Smooth Cat's-ear		5
501801	*Jasminum didymum* subsp. *Lineare*	Desert Jasmine	Vulnerable	1
501802	*Juncus acutus* subsp. *Acutus**	Spiny Rush		2
500151	*Lachnagrostis filiformis* s.l.	Common Blown-grass		1
501860	*Lactuca serriola**	Prickly Lettuce		9
502037	*Lolium rigidum**	Wimmera Rye-grass		1
502078	*Lycium ferocissimum**	African Box-thorn		1
502088	*Lysiana exocarpi*	Harlequin Mistletoe		1
502098	*Maireana brevifolia*	Short-leaf Bluebush		5
502102	*Maireana erioclada*	Rosy Bluebush		1
502108	*Maireana pentatropis*	Erect Bluebush		1
502109	*Maireana pyramidata*	Sago Bush		1
501892	*Marsdenia australis*	Doubah	Vulnerable	1
502127	*Marsilea drummondii*	Common Nardoo		1
502138	*Medicago minima**	Little Medic		2

502140	*Medicago polymorpha**	Burr Medic		4
502143	*Medicago truncatula**	Barrel Medic		1
502174	*Mesembryanthemum crystallinum**	Common Ice-plant		4
502175	*Mesembryanthemum nodiflorum**	Small Ice-plant		5
508741	*Mimulus* spp.	Monkey Flower		1
504613	*Myoporum platycarpum* subsp. *platycarpum*	Sugarwood		1
502321	*Olearia pimeleoides*	Pimelea Daisy-bush		2
502336	*Onopordum acanthium* subsp. *Acanthium**	Scotch Thistle		6
502386	*Oxalis perennans*	Grassland Wood-sorrel		4
508835	*Oxalis* spp.	Wood Sorrel		1
502418	*Parapholis incurva**	Coast Barb-grass		1
502427	*Paspalidium constrictum*	Knottybutt Grass		1
502429	*Paspalidium jubiflorum*	Warrego Summer-grass		13
502431	*Paspalum distichum**	Water Couch		12
508863	*Paspalum* spp.*	Paspalum		2
502457	*Pentameris airoides* subsp. *Airoides**	False Hair-grass		1
502498	*Phyla canescens**	Fog-fruit		2
502526	*Pimelea microcephala* subsp. *microcephala*	Mallee Rice-flower		2
502541	*Pittosporum angustifolium*	Weeping Pittosporum		3
502765	*Psilocaulon granulicaule**	Wiry Noon-flower		4
502826	*Ptilotus nobilis*	Mulla Mulla		1

502831	*Ptilotus seminudus*	Rabbit Tails		1
502824	*Ptilotus sessilifolius*	Crimson Tails	Poorly known	2
508978	*Ranunculus* spp.	Buttercup		4
502920	*Reichardia tingitana**	False Sow-thistle		2
502930	*Rhagodia spinescens*	Hedge Saltbush		3
501650	*Rhodanthe pygmaea*	Pygmy Sunray		1
502055	*Rostraria pumila**	Tiny Bristle-grass		1
509000	*Rumex* spp.	Dock		4
503963	*Rumex tenax*	Narrow-leaf Dock		2
500961	*Rytidosperma caespitosum*	Common Wallaby-grass		4
500980	*Rytidosperma setaceum*	Bristly Wallaby-grass		1
502993	*Salsola tragus*	Prickly Saltwort		3
503028	*Schismus barbatus**	Arabian Grass		5
503072	*Sclerolaena diacantha*	Grey Copperburr		5
503077	*Sclerolaena obliquicuspis*	Limestone Copperburr		5
503108	*Senecio glossanthus* s.l.	Slender Groundsel		1
504354	*Senna form* taxon 'coriacea'	Broad-leaf Desert Cassia		2
504355	*Senna form* taxon 'filifolia'	Fine-leaf Desert Cassia		2
504356	*Senna form* taxon 'petiolaris'	Woody Cassia		3
503141	*Sida corrugata*	Variable Sida		1
503142	*Sida fibulifera*	Pin Sida	Vulnerable	1
503143	*Sida intricata*	Twiggy Sida	Vulnerable	1
503147	*Sida trichopoda*	Narrow-leaf Sida		3

503159	*Sisymbrium erysimoides**	Smooth Mustard		3
503160	*Sisymbrium irio**	London Rocket		4
503176	*Solanum esuriale*	Quena		2
505322	*Solanum nigrum* s.s.*	Black Nightshade		1
503204	*Sonchus oleraceus**	Common Sow-thistle		8
503229	*Sporobolus mitchellii*	Rat-tail Couch		32
501592	*Tecticornia pergranulata*	Blackseed Glasswort		2
504001	*Tetragonia eremaea* s.l.	Desert Spinach		2
505002	*Teucrium albicaule*	Scurfy Germander	Poorly known	1
503358	*Teucrium racemosum* s.l.	Grey Germander		1
509161	*Trifolium spp.**	Clover		1
503442	*Trifolium tomentosum* var. *tomentosum**	Woolly Clover		1
503469	*Typha latifolia**	Lesser Reed-mace		4
503470	*Typha orientalis*	Broad-leaf Cumbungi		2
509178	*Typha spp.*	Bulrush		1
509214	*Verbena spp.*	Verbena		3
505064	*Vittadinia cervicularis* var. *subcervicularis*	Annual New Holland Daisy		3
503537	*Vittadinia cuneata*	Fuzzy New Holland Daisy		1
503538	*Vittadinia dissecta* s.l.	Dissected New Holland Daisy		2
503539	*Vittadinia gracilis*	Woolly New Holland Daisy		1
503549	*Vulpia myuros**	Rat's-tail Fescue		3

503553	*Wahlenbergia fluminalis*	River Bluebell		2
503558	*Wahlenbergia gracilis*	Sprawling Bluebell		1
502406	*Walwhalleya proluta*	Rigid Panic		1
503613	*Zygophyllum apiculatum*	Pointed Twin-leaf		2
503614	*Zygophyllum aurantiacum* subsp. *aurantiacum*	Shrubby Twin-leaf		1
504121	*Zygophyllum eremaeum*	Climbing Twin-leaf		1
503619	*Zygophyllum iodocarpum*	Violet Twin-leaf		1
503620	*Zygophyllum ovatum*	Dwarf Twin-leaf		1

*Indicates introduced species.