Bumbang Island Environmental Water Management Plan

mallee catchment management authority

Department of Environment, Land, Water & Planning

State Government Victoria

DOCUMENT CONTROL

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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 Bumbang Island. It is an important part of the Victorian Environmental Water Planning Framework and provides the long-term management intentions, based on scientific information and stakeholder consultation that can be used by the respective agencies; Mallee Catchment Management Authority (CMA), Department of Environment, Land, Water and Planning (DELWP) and the Victorian Environmental Water Holder (VEWH); for both short and longer-term environmental water planning.

This EWMP is not a holistic management plan for the Island, 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).

Bumbang Island is located in the Robinvale Plains bioregion. It is one kilometre north east of Robinvale and covers approximately 566 hectares. The island is formed by the River Murray and a meander cut-off called the Bumbang Cut (the Cut). As an island it is largely unaffected by surrounding catchment land uses. It retains reasonably intact vegetation, of varying age classes, significant intact cultural heritage and a mosaic of faunal habitats. It is an important Aboriginal place, with a dense distribution of scarred trees (769 registered sites), shell middens on the river banks and other scattered artefacts (Long & Berrill, 2001).

Within the Island, a mosaic of water dependant habitats exist, incorporating:

- Permanent and ephemeral wetlands;
- Water dependant floodplain vegetation;
- The Bumbang Creek;
- The Bumbang Cut; and
- Various channels

There are eleven ecological vegetation communities mapped on Bumbang Island, of these seven are listed as depleted in the Robinvale Plains Bioregion and two are listed as vulnerable, Lignum Swamp and Woorinen Mallee (although not water dependant). Channels and the Bumbang Creek provide slow flowing habitats, whilst the Bumbang Cut provides fast flowing habitats, incorporating both deep pools and shallow benches. Significant large woody habitat is available across the different habitats.

The target area for managed water regimes on Bumbang Island is the area that can be influenced by the manipulation of the Lock 15 weir. A weir height of 48.3 mAHD will inundate approximately 72.8 ha of Bumbang Island.

The Island supports the nationally listed White-bellied Sea Eagle (*Haliaeetus leucogaster*) sighted during a site visit (Mallee CMA, 2010). Whilst no targeted surveys have been undertaken on the Island it provides habitat that is likely to support the nationally listed Regent Parrot (*Polytelis anthopeplus monarchoides*) and state listed Carpet Python (*Morelia spilota metcalfei*). These species rely on healthy mature River Red Gum (*Eucalyptus camaldulensis*). It is also likely to provide important habitat for a range of large bodied native fish species including a regionally significant population of Freshwater Catfish (*Tandanus tandanus*). Small bodied fish species such as Gudgeon (*Hypseleotrix spp., Philypnodon grandiceps* and others) and Murray-Darling Rainbowfish (*Melanotaenia fluviatilis*) could flourish in the wetlands and areas of emergent macrophytes or flooded

grassland. The Island provides excellent habitat for waterbirds including waterfowl, shoreline foragers and small waders. The water regime conditions currently favour piscivorous (fish eating) waterbirds.

The key threat to the ecological and cultural values associated with Bumbang Island is the stable water regime provided by the Euston Weir Pool on the Murray River (Lock 15).

The long term management goal for Bumbang Island is:

"to provide a water regime which reflects natural water level variability and seasonality to maintain and promote the mosaic of available habitats and significant cultural heritage values".

The ecological objectives for Bumbang Island are based on the values that the Island is likely to support and includes:

BI1: By 2030, improve condition and maintain extent from baseline levels of River Red Gum (*Eucalyptus camaldulensis*) to sustain communities and processes reliant on River Red Gum woodlands at the Bumbang Island asset.

BI4: By 2030, improve vital habitat at the Bumbang Island asset by increasing the diversity of aquatic macrophytes present across a range of Water Regime Indicators Groups.

BI5: By 2030, protect and restore recruitment of small-bodied native fish at the Bumbang Island asset, including Carp Gudgeon spp. (*Hypseleotris* spp.), Fly-Specked Hardyhead (*Craterocephalus stercusmuscarum*), Flathead Gudgeon *(Philypnodon grandiceps*), Australian Smelt (*Retropinna semoni*), Murray-Darling Rainbowfish (*Melanotaenia fluviatilis*), Murray Hardyhead (*Craterocephalus fluviatilis*.

BI6: By 2030, protect and restore recruitment of large-bodied native fish at the Bumbang Island asset, including Golden Perch (*Macquaria ambigua*), Silver Perch (*Bidyanus bidyanus*) and Murray Cod (*Maccullochella peelii*).

BI7a: By 2030, maintain representative populations of shallow-water and deep-water feeding guilds of waterbird (F2 and F3, respectively, after Jaensch 2002) at the Bumbang Island asset, by maintaining a mixture of shallow and deep-water habitats.

BI7b: By 2030, maintain nesting and recruitment of non-colonial waterbirds (N1, N2, N3 and N4, after Jaensch 2002) at the Bumbang Island asset, by maintaining a mixture of tree, low vegetation/shrubs, and ground/islet nesting habitat.

In addition to these ecological objectives a significant focus for Bumbang Island is about the preservation of the natural values associated with the cultural heritage.

The ecological objectives are aimed at mimicking the natural seasonality of river flows and inundation levels. However, the water regime for the Bumbang Island EWMP is limited to those which can be achieved by manipulation of the Euston weir pool level. There are significant benefits to the Bumbang Island ecosystem which can be achieved through manipulation of the Euston Weir pool levels. The primary target of the water regimes are the littoral and riparian zones of the wetlands and waterways across the island. The objectives as described above are about promoting a broader zone of macrophytes and increasing productivity and habitat quality for aquatic fauna including water birds and fish.

There are three key constraints to achieving the optimum ecological objectives for Bumbang Island. These are summarised as:

Weir Pool Operation- 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 +0.7m AHD based on advice from the weir operator

(P. Cocks pers. comm. September 2014). 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.

Fish Ladder Operation - A Denil fishway was installed on Euston Weir in 2005. Operation of the fishway is an important consideration in any weir pool level manipulations.

Recreational Use of the Weir Pool - The Euston weir pool is valued by the communities of Euston and Robinvale and other small towns for the recreational opportunities that it provides. A significant water skiing event is held in March each year within the weir pool. Given the economic value of such events to the local community, this may act as a constraint to lowering the weir pool to the optimum level in March for the period of the event.

An assessment of the environmental water requirement for the whole Euston Weir pool reach has been undertaken in the *EWMP for the River Murray at the Lock 15 Weir Pool* (Ecological Assocatiates, 2015). Watering recommendations for Bumbang Island have been developed which are complimentary to the other sites within the influence of the weir.

Acknowledgements

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

1. Introduction

This EWMP has been prepared to establish the long-term management goals of the wetlands.

The key purposes of the EWMP are to:

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

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

Key documents that support this Bumbang island EWMP are shown in Table 1.

Table 1. Key support documents to the Bumbang Island EWMP

Name	Author	Summary
Mallee Waterway Strategy	Mallee CMA 2014	• Sets regional goals for waterway management that align with the Mallee RCSs broader objectives • Identifies high value waterways • Details strategic work programs for priority waterways • Identifies the roles and responsibilities of regional stakeholders • Establishes principles to guide the implementation
Regional Context Document for Environmental Water Management Plans; Mallee CMA Region	Sunraysia Environmental 2014	• Background context the region • Outlines significant wetlands and river • Sources of environmental water • Policy, legislative and planning frameworks
Lock 15 EWMP	Ecological Associates 2015	• EWMP for the River Murray and its floodplain in the Lock 15 weir pool • Provides a guide to environmental watering constraints and opportunities in this reach
Investigation of Water Management Options for the Murray River – Nyah to Robinvale	Ecological Associates 2006	• Identifies management units • Identifies ecological values • Develops objectives • Defines water regimes • Identifies threats • Proposes management actions
Water Management Options for the Murray River – Nyah to Robinvale, Stage II	Ecological Associates 2007	• Costs designs • Proposes alternative water management options • Documents environmental impacts • Documents Cultural heritage values

2. Site Overview

2.1 Site Location

The Mallee CMA region is located in the north-west of Victoria covering approximately 39,000km² with an estimated regional population of 65,000. Major towns include Mildura, Birchip, Sea Lake, Ouyen, Robnivale, Red Cliffs and Merbein. The area is semi-arid, with an annual rainfall of around 250mm. Average daily temperature at Mildura ranges from 32°C in summer to 15°C in winter (MCMA 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 (MCMA 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 (MCMA 2006).

Bumbang Island is located between Murray River chainage 1124 and 1138, 1 km north east of Robinvale (Figure 2). The island is formed by the River Murray and a meander cut-off called the Bumbang Cut. It is in the Robinvale Plains bioregion and covers approximately 566 hectares.

In 2006 the Mallee CMA engaged consultants Ecological Associates (EA) to investigate water management options for the Murray River floodplain from Robinvale to Wallpolla Island. One of the major outcomes of these investigations was the development of a system of Floodplain Management Units (FMUs). These divide the floodplain into management units in which water regimes can be managed independently of another FMU. 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 (WMU) for planning within its Mallee Waterway Strategy (Figure 1; MCMA 2014).

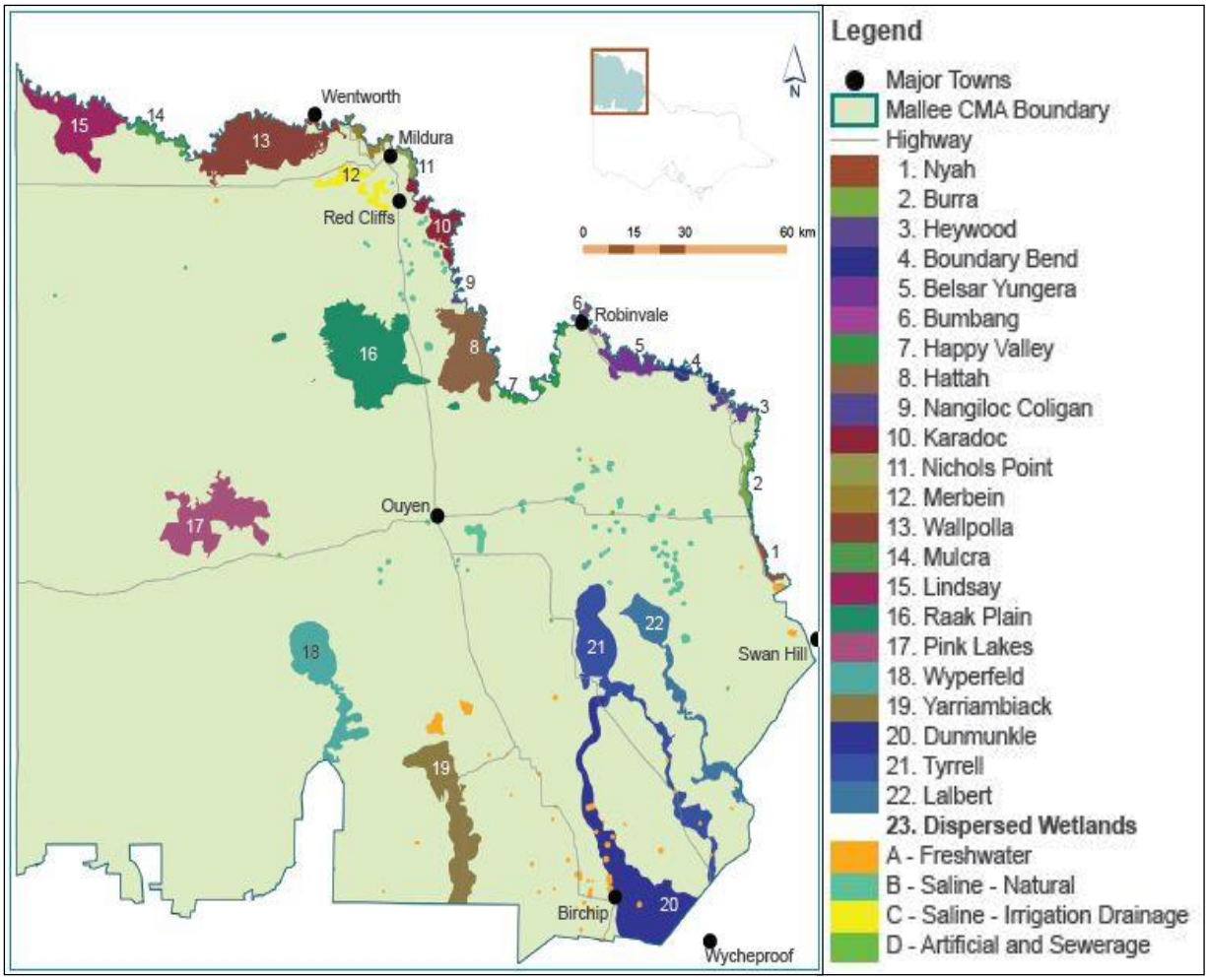

Figure 1. Mallee Water Management Units (Mallee CMA, 2014)

There are two waterways associated with the Island, the main meander cut-off between the Murray River, known as the Bumbang Cut and a waterway north of the Cut called Bumbang Creek.

There are four distinct wetlands on Bumbang Island all with direct flow paths to the Murray River. The wetlands on Bumbang Island have not been named, however for the purpose of this document they have been named as per Table 2.

Wetlands in Victoria are classified and given wetland identification numbers based on the 1994 Victorian wetland classification system, developed by Corrick and Norman (see Figure 2). There are three wetlands classified under this system on Bumbang Island..

Table 2. Wetland classification identification numbers and names in the EWMP

1994 Wetland Classification	Name in this EWMP
652741	Eastern wetland
661727	Southern wetland
638738	Western wetland
Unclassified	Northern wetland

Figure 2. Location of wetlands and waterways on Bumbang Island Waterway Management Sub-Unit.

2.2 Conceptualisation of the Site

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

1. Euston Weir creates stable water environment at 47.6 m AHD in the Murray River.
2. The weir creates a shallow freshwater lens of groundwater.
3. The Bumbang Cut and Murray River meander loop provide open water habitat, with a variety of slow and fast moving sections, deep pools and shallow benches. Sediment is building up through the meander loop and growth of Typha and Phragmites is spreading.
4. Bumbang Creek is retained at a stable water level, with low water velocities.
5. Wetlands also retain some water at normal operating level of 47.6 m AHD
6. Numerous stands of drowned River Red Gum are located in the now-permanent, river backwaters, wetlands, channels, and Bumbang Creek.
7. Mature trees are healthy in the River Red Gum woodlands at higher elevations in the landsacpe.
8. River Red Gum recruitment is high on the low floodplain terraces, assisted by high groundwater levels. However, the understorey lacks diversity.
9. Channels that feed the wetlands across the Island have sills that are higher than the 47.6 m AHD that rarely flow, and growth of Phragmites is prevalent at the entrances. This limits the recruitment of organic matter and invertebrates which would be potential food sources and habitat for wetland residents. Wetlands also have limited water supply.
10. The Island is a mosaic of vegetation types with complex wetland/ woodland interactions. Providing exceptional habitat opportunities with an improved water regime.
11. Higher terraces are characterised Riverine Chenopod Woodland, interspersed with relatively open areas of Lignum Shrubland.
12. Drowned River Red Gum provide roosting habitat for piscivorous water birds such as Pelican, Darter and Cormorant around the backwaters and wetlands. The drowned River Red Gums will eventually rot and result in a loss of habitat.These species will use live mature River Red Gum if water levels fluctuate and periodically flood live trees.
13. Large woody habitat is plentiful across the Island in all the water management areas. However, biofilms are dominated by algae through lack of disturbance, which would be created by a wetting and drying cycle.
14. Freshwater catfish and Golden Perch are likely to inhabit Bumbang Creek and could also use the wetland habitats if appropriate water regime was delivered. Turtles are also likely to find suitable habitat at Bumbang Creek.
15. Submergent and emergent macrophytes provide ideal habitat for small bodied fish which may include Murray-Darling Rainbow Fish, Gudgeons and Bony Bream. Turtles may also be present in the wetlands.
16. Deeper water habitats through the cut support large bodied fish species such as Murray Cod and Silver Perch.
17. Bumbang Island is an important breeding area for the White-bellied sea-eagle who nests in mature River Red Gum overlooking the Murray River near the eastern end of Bumbang Creek. Water-dependent species such as Regent Parrot, Carpet Python, and Brown Tree-creeper require healthy mature River red gum for roosting, protection and other habitat requirements. Waterbirds will use the backwaters, creeks and wetlands using shallow water, mudflats and the littoral zone, if the water regime can increase habitat complexity. These would include small waders, shoreline foragers and waterfowl.

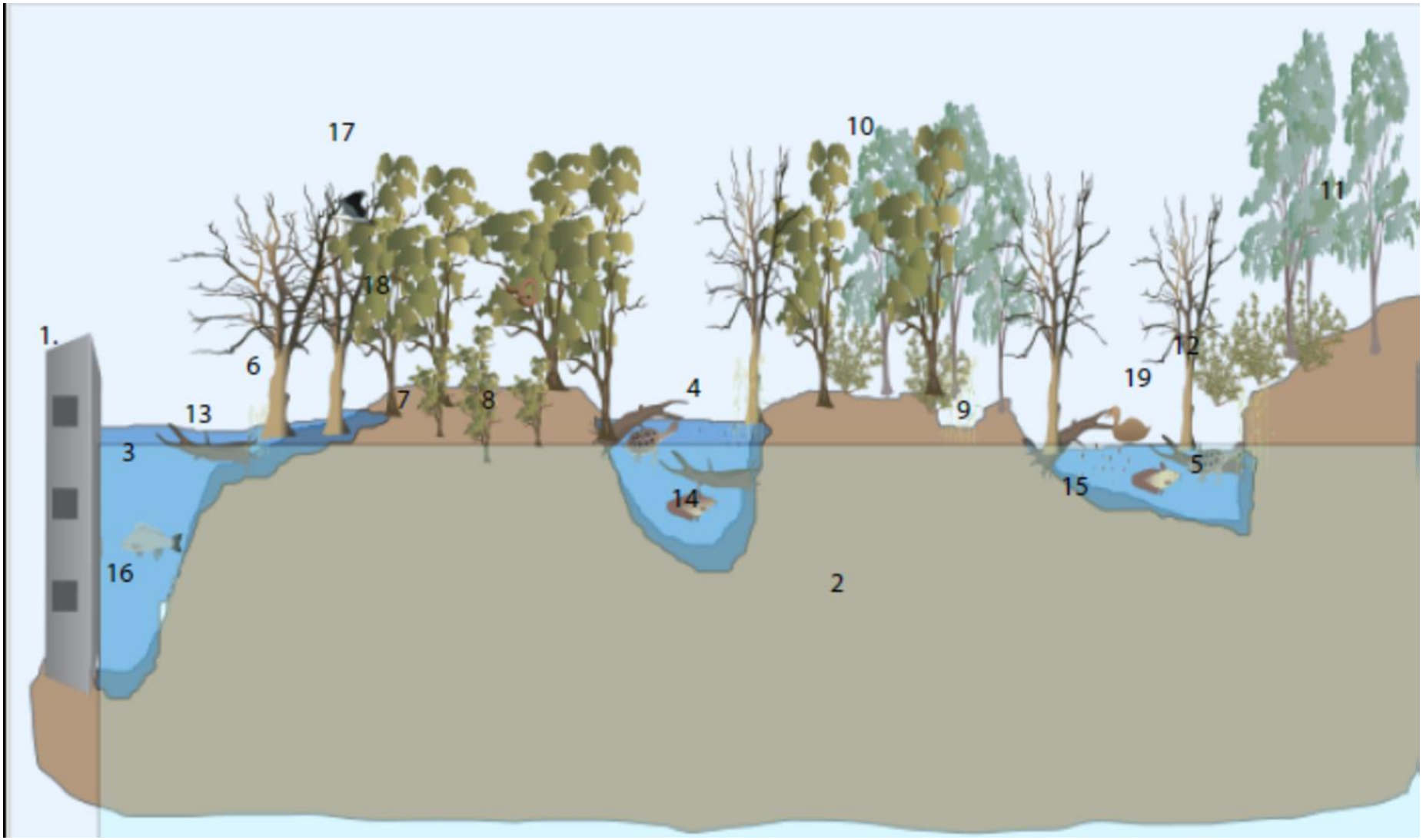

Figure 3. Conceptual model of Bumbang Island under current water conditions

2.3 Catchment Setting

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.).

Climate

Climate data was obtained from the nearest Bureau of Meteorology (BOM) meteorological station at Robinvale (one km away). Mean rainfall in Robinvqale is 305.5 mm/year, with October (average of 29.9 mm/month) significantly wetter than March (average of 19.8 mm/ month). The closest meteorological station for temperature is Ouyen (66 km away). Average temperature ranges from 32.4°C in January to 15.2°C in July(Bureau of Meteorology, 2015).

2.4 Land Status and Management

Until the late 1980s Bumbang Island was listed as Reserved Forest; however the Land Conservations Council's (LCC) Mallee Area Review Final Recommendations (LCC, 1987) recommended that Bumbang Island be managed as a Historic Cultural Reserve. It is now listed as a Historic and Cultural Features Reserve under the *Reserves Forest Act 1958* and is managed by Parks Victoria. It has been recommended based on their primary land use to protect historic and cultural features and extend public knowledge.

It is an important Aboriginal place, with a dense distribution of scarred trees (769 registered sites), shell middens on river banks and other scattered artefacts (Long & Berrill, 2001). The LCC recommended that Bumbang Island be managed to:

- Protect specific sites that carry or contain evidence of past Aboriginal occupation; and
- Provide opportunities for recreation and education associated with the history of the locality (development of recreational facilities would be minimal).

There is currently no infrastructure development on the Island and very little visitation or management intervention. Its cultural and environmental values are relatively intact in comparison with other, more accessible, riverine floodplain forests (Long & Berrill, 2001).

A Cultural Heritage Management Plan was developed for the island in 2001 (Long & Berrill, 2001) and included an associated Cultural Tourism Development Plan, which explored opportunities and constraints for the promotion of Aboriginal values of the island. It included a proposal for an interpretive facility, walking trail and guided water trail (Long & Berrill, 2001). To date these have not come to fruition, but should be noted as potential future considerations for environmental water management planning.

2.5 Stakeholders for Bumbang Island EWMP

Stakeholders associated with or interested in environmental water management outcomes for Bumbang Island are listed in Table 4.

Table 3. Bumbang Island Environmental Water Management Stakeholders.

Group	Role
Parks Victoria	Land Manager
Mallee Catchment Management Authority (MCMA)	Regional waterway 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
Aboriginal Communities	Indigenous Representation
Murray Darling Basin Authority (MDBA)	River Murray operations
Murray-Darling Freshwater Research Centre	Research
Landowners	Landowners
Recreational users	Land user
General community	Land user

2.6 Wetland Characteristics

Victoria's wetland classification and inventory was updated in 2013 and replaces the system developed by Corrick and Norman. The wetlands on Bumbang Island have not been classified under the new system, therefore the 1994 classification has been used on the three wetlands which were classified.

A brief overview of the wetland characteristics of the Island is provided in

Table 4.

Table 4- Summary of Bumbang Island wetland characteristics.

Characteristics	Waterbodies		
Name	East Wetland	South Wetland	West Wetland
Mapping Id	652741	631727*	638738
Area (ha)	7.26	3.47	15.4
Bioregion	Robinvale Plains		
Conservation Status	Bioregional Conservation Status: Bumbang Island EVCs are all listed: Vulnerable, Depleted and Least Concern		
Land Status	Historic Reserve		
Land Manager	Parks Victoria		
Surrounding Land Use	Irrigated Agriculture/ Residential		
Water Supply	Murray River		
1788 Wetland Category	Permanent open freshwater	Permanent open freshwater	Permanent open freshwater
1994 Wetland Category	Open water Subcategory: Shallow (<5m) ,	Open water Subcategory: Shallow (<5m)	Open water Subcategory: Red Gum/ Dead Timber**
Wetland Volume (ML)	N/A		
Mean wetland depth at Capacity (m)	N/A		

*labelled as 661727 on the Biodiversity Interactive Map

**has two subcategories on the Biodiversity Interactive Map

2.7 Other Waterway Characteristics

Bumbang Cut

Prior to the 1930s, Bumbang Island formed a large meander loop or peninsula on the southern bank of the Murray River. Local research suggested that 'The Cut'(Figure 4), as it is locally known was occasionally breached during flooding episodes (Long & Berrill, 2001). Construction of Lock 15 and a weir downstream of Bumbang Peninsula was completed around 1938 and lifted the river height, consequently breaching the Peninsula along the Cut on a more permanent basis (Long & Berrill, 2001). The Cut dries out occasionally, when the weir pool is >2 metres below normal operating level (P. Cocks pers. comm. September 2014), and reveals a 'mudstone' base.

Figure 4. Bumbang Cut view from Robinvale towards Bumbang Island.

Bumbang Creek

Bumbang Creek, Figure 5, crosses the southern section of the Island. It is a former floodplain effluent which, like the Cut, would have flowed during flooding episodes. The Creek is now permanently inundated by the influence of the Euston Weir pool.

Figure 5. Bumbang Creek (west end).

Channels

A number of other small ephemeral channels (Figure 6) cross Bumbang Island, and link three permanent open freshwater wetlands to the Murray River.

Figure 6. Ephemeral floodway channel connecting the Murray River to the Eastern Wetland.

Wetlands

The wetlands although classified as permanent open freshwater wetlands, are likely to have been historically ephemeral, wetting and drying in response to seasonal and annual flow and rainfall conditions. The Eastern Wetland is shown in Figure 7.

Figure 7. Eastern Wetland.

Other water dependant ecosystems

As well as the listed wetlands (from the 1994 DEPI wetlands layer) a number of other significant waterway areas are found on the Island. These include low lying floodplain terraces, the ephemeral channels, and a wetland located on the north- west corner of the island (Figure 8). These significant water areas can be seen in the LiDAR image of Bumbang Island (Figure 9).

Figure 8. Backwater located on the north of the Island linking to Eastern Wetland via an ephemeral channel.

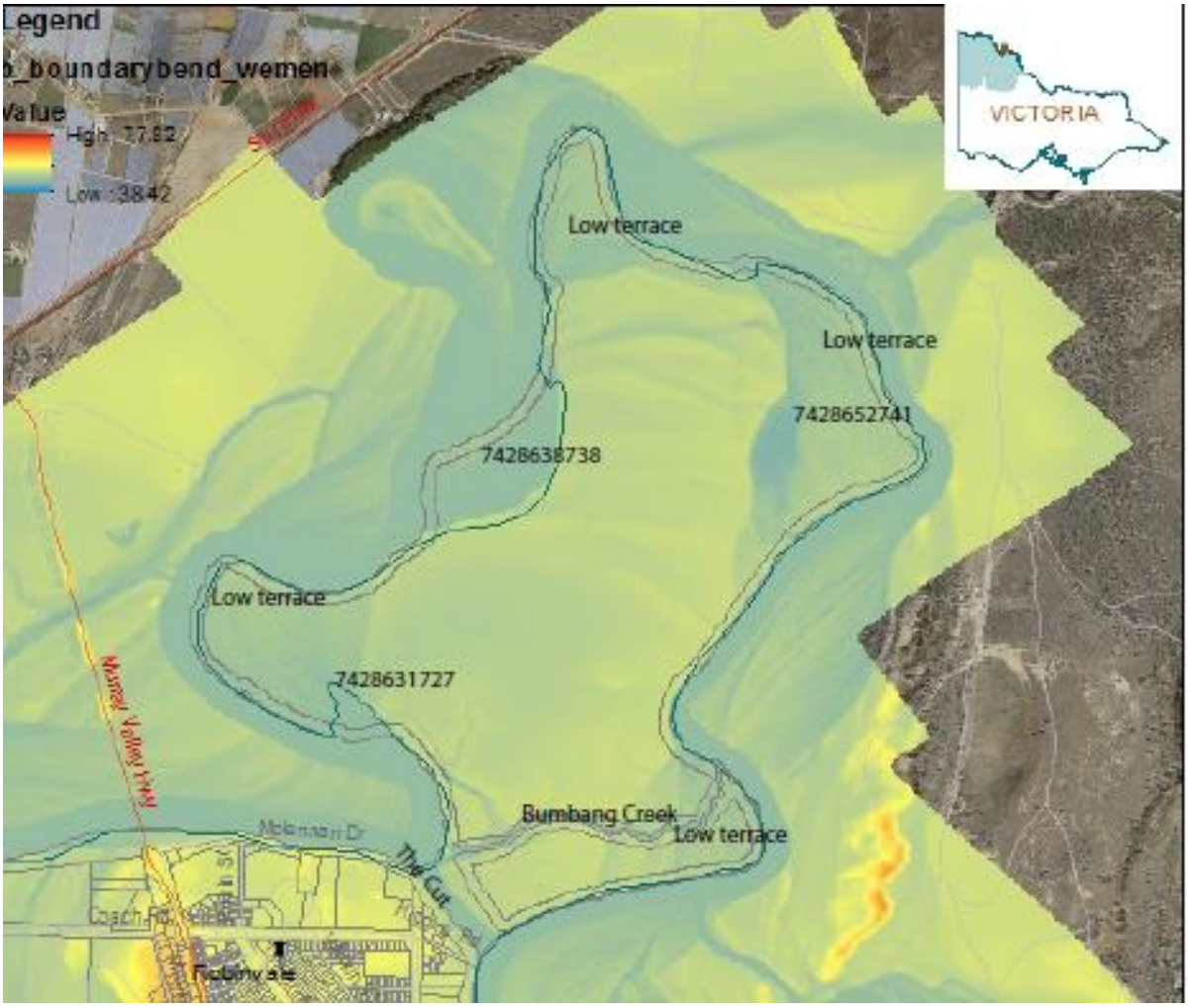

Figure 9. LiDAR image of Bumbang Island showing wetlands, low floodplain terraces and flood channels.

Bumbang Island is predominately vegetated by River Red Gum woodland and forest on lower terraces and Black Box woodlands and Lignum shrublands on higher floodplain areas. Watering frequency and duration of the Black Box woodlands and Lignum shrublands would have been significantly altered due to the regulation and diversion of the Murray River (Ecological Associates, 2006).

The weir pool has drowned some low-lying floodplain terraces and backwaters which now feature shallow water and dead River Red Gum. The shallow fringes of the Island support beds of Common Reed (*Phragmites australis*) and Cumbungi (*Typha spp*.) which are reported to be spreading (Ecological Associates, 2006). These species have spread across the entrances of Bumbang Creek and the other floodplain effluents (P. Cocks pers. comm. August 2014).

The weir has created shallow fresh groundwater below the low-lying terraces promoting dense growth of River Red Gum. At higher elevations, the health of the River Red Gum remains good, however understorey species, which are dependent on flooding, are sparse (Ecological Associates 2007).

2.8 Management Scale

As discussed above, Bumbang Island has been chosen as the appropriate scale for environmental water management planning for this EWMP. The EWMP covers the original Bumbang Island FMU described by Ecological Associates (Ecological Associates, 2006).

This EWMP will prioritise environmental water management options which can be implemented through manipulation of the Euston Weir pool level.

The weir pool has a capacity of approximately 37 GL (SKM, 2009) and it extends upstream for an estimated 70 (Ecological Associates, 2006) to 100 kilometres (SKM, 2009). The water regime recommended for Bumbang Island is explicitly linked to other significant wetlands sites including Euston Lakes, Belsar and Yungera Islands and Margoya Lagoon as shown in Figure 10. Consideration of the requirements of these sites would need to be made before implementing an improved water regime for Bumbang Island. An EWMP for the Lock 15 Weir pool is complete. (Ecological Associates 2015).

Figure 10. Map showing location of Euston weir (Lock 15), Bumbang Island, Euston Lakes and Belsar Island.

There are operational constraints around the weir operating levels and it is understood that the minimum weir pool level is 47.3m AHD and the maximum height that could be recommended is 48.3m

AHD (P. Cocks pers. comm., August 2014). The inundation extent estimated from LiDAR data for 48.3m AHD is shown Figure 12.

The LiDAR was flown when the weir pool was at normal operating level of 47.6m AHD. An estimation of inundation extent for levels lower than 47.6m AHD cannot be made without the assistance of a hydraulic model or LiDAR data captured when the weir pool is lower. Analysis of hydraulic model outputs is required to confirm the inundation extents associated with all of the weir pool levels.

Figure 11. Extent of inundation associated with normal weir operating level of 47.6m AHD

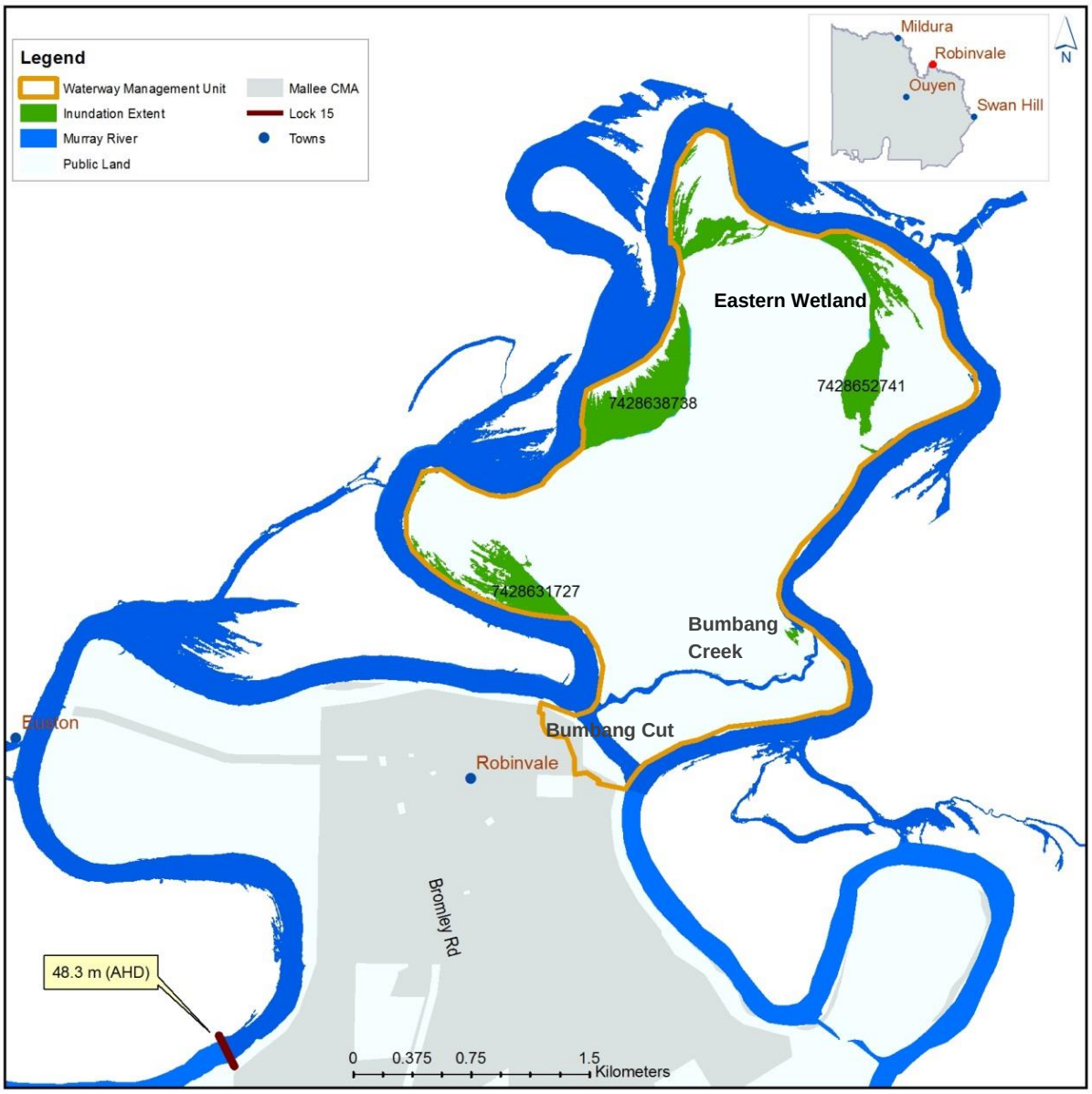

Figure 12. Extent of inundation associated with weir operating level of 48.3m AHD

2.9 Environmental Water Sources

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

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

Environmental water for Bumbang Island may be sourced from the water entitlements and their agencies listed in Table 5 below.

Table 5. Summary of environmental water sources available to Bumbang Island.

Water Entitlement	Responsible Agency
Murray River Unregulated Flows	Murray Darling Basin Authority
Murray River Surplus Flows	
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.

2.9 Related Agreements, Policy, Plans and Activities

The following policies, plans and activities are directly relevant to the environmental management of Bumbang Island:

Environmental Water Management Plan for the River Murray at the Lock 15 Weir Pool - System Characterisation

EWMP for the River Murray and its floodplain in the Lock 15 weir pool (EA, 2015). 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.

Mallee Waterway Strategy

The Mallee Regional Waterway Strategy includes the Bumbang Water Management Unit, which includes the Bumbang Island Sub-management unit. The Waterway Strategy prioritises the development of the EWMP for Bumbang Island.

Scoping Study: Environmental Water Management Plans

Identifies priorities for the development of environmental water management plans. The scoping study identified the top five priorities for EWMP preparation in the region.

The study identified Bumbang Island as priority number four using the following criteria:

- Criteria within the Murray-Darling Basin Plan schedule 8;
- Ability to deliver environmental water to the site without significant works;
- Priorities identified in the Mallee Waterway Strategy; and
- Access to the site so there has been minimal impact to the natural environment compared to other sites.

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

In 2006, the Mallee CMA engaged consultants EA to investigate water management options for the floodplain of the Murray River from Nyah to Robinvale (EA, 2006). This investigation prioritised

options to increase the frequency and duration of floodplain inundation based on Floodplain Management Units. The investigation also looked at the scope of manipulating river levels to benefit ecosystems through operation of the Euston Weir.

The Living Murray Initiative

Bumbang Island is located within a reach of the Murray River listed as a "Significant Ecological Asset" under the Living Murray Initiative (EA, 2006).

Mallee CMA Frontage Action Plan for Nyah to Robinvale

Frontage Actions Plans outline a range of actions to enhance the management of frontages to the Murray River. Bumbang Island is within the area covered by the Mallee CMA Frontage Action Plan (FAP) for Nyah to Robinvale (Mallee CMA, 2003) and has the potential to attract future funding and works through that project.

Other

Bumbang Island 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.

3. Hydrology and System Operations

Wetland hydrology is the most important determinant in the establishment and maintenance of wetland types and processes. It affects the chemical and physical aspects of the wetland which in turn affects the type of flora and fauna that the wetland supports. 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.

3.1 Wetland Hydrology, Water Management and Delivery

The weir is currently managed to a normal operating level of 47.6m AHD. The extent of inundation associated with this level for the site is shown in Figure 11. The normal operating level provides permanent water in some of the wetlands and a static water level in Bumbang Creek and the Cut, except during floods.

The regulation and 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 Bumbang Island is heavily influenced by Euston Weir pool. The current flow thresholds are selected by the pool level and are not based on the natural wetlands sills; many are currently located below the water surface (Ecological Associates, 2006). Under pre-regulation conditions (pre-Euston weir) Bumbang Island would have had higher inundation discharge thresholds, as the river level would have been lower for the same level of discharge (Ecological Associates, 2006).

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 the Sunraysia irrigation diverters. 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 Euston Weir is most marked at the Weir wall at very low flows, when the water surface is elevated by 5.86m compared to downstream. This impact decreases with increasing discharge and with distance upstream. Detail on Lock 15 Weir operation is in the EWMP for the River Murray at Lock 15 Weir Pool - System Characterisation (Ecological Associates, 2015, in prep.). The natural variation of river levels has been greatly reduced by the operation of the weirs and the depletion of flows through storage and diversion (Ecological Associates, 2015, in prep.). An analysis of natural and current (baseline) weir levels at Lock 15 is provided in Figure 13.

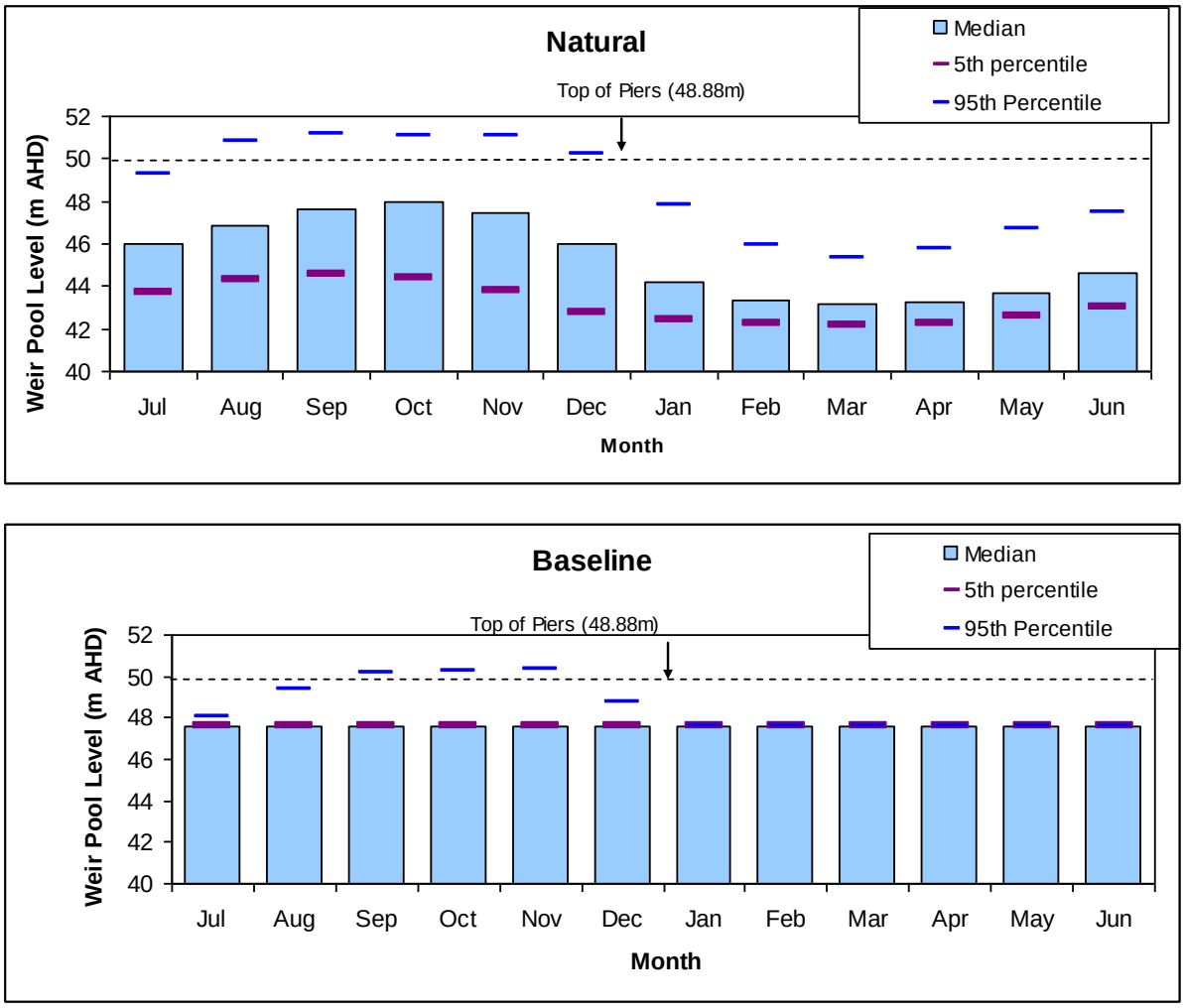

Figure 13. Modelled monthly water level variations downstream of Lock 15 under natural and baseline scenarios (Ecological Associates, 2015, in prep.).

Bumbang Creek and a number of wetlands on the Island are inundated at a flow of 5,000 ML/d (Ecological Associates, 2015). Such events occur frequently, have long durations and short intervals between spells, as seen in Figure 14 (Gippel, 2014). Under natural conditions such events were less frequent, but of a much longer duration. The weir artificially elevates the water level above the natural sill levels of wetlands at Bumbang Island. Figure 15 shows the permanently inundated wetlands at Bumbang Island.

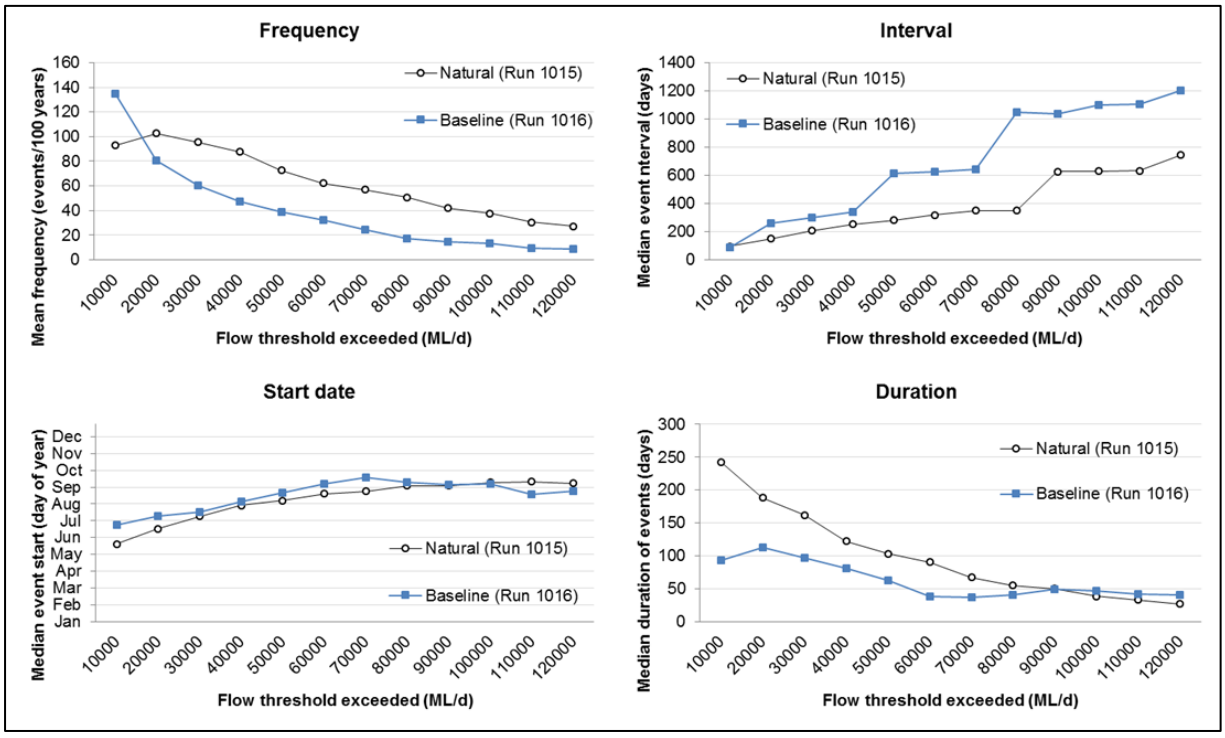

Figure 14. Comparison of Natural and Baseline Modelled Flow Scenarios for Euston Downstream (Gippel 2014).

Figure 15. Inundation extent at baseline weir pool height (47.6 mAHD).

3.2 Groundwater

The Euston Weir also impacts on the local groundwater condition around Bumbang Island. The weir creates a freshwater lens, having raised the groundwater up to 3m, with the groundwater levels at or near the river level (Ecological Associates, 2006). Recharge from the river can create a flushed zone of low salinity and 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, cited in 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).

3.3 Environmental Watering

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

Between 22 July and 29 August 2014, 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 would have increased the inundation extent on the Island. 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, 2012 and 2016, 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 had an impact on the inundation extent on the Island.

The operation of Lock 15 during the millennium drought saw it drawn down 700mm, with some impacts to irrigators (S. Jaensch pers. comm. March 2015). The benefits of this draw down on the Island are unknown.

4. Water Dependent Values

4.1 Environmental Values

Listings and Significance

The availability of flora and fauna data for Bumbang Island is limited. Parks Victoria staff have confirmed that there has been limited, if any studies undertaken on the Island (P. Goldring pers. comm. August 2014). Records from the Victorian Biodiversity Atlas (VBA) are limited and do not align with brief observations in the field. While data from the VBA has been referenced, the EWMP has been developed around the Ecological Vegetation Classes (EVC) 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: Final 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, including fish and water dependant fauna such as the White-bellied Sea-Eagle and the Brown Treecreeper to confirm some of the assumptions used in the development of this EWMP. Appendix 1 lists the fauna species identified from the VBA.

4.1.1 Fauna

As mentioned above there is very little data on the fauna of Bumbang Island. Table 6 provides the listed species on Bumbang Island. These species are included as water dependent due to their habitat requirements.

Table 6. Listed Fauna on Bumbang Island

Common name	Scientific name	Type	EPBC status	FFG Status	Advisory List
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	B	VU	L	VU
Brown Treecreeper (south-eastern ssp.)	*Climacteris picumnus victoriae*	B		NL	NT

Legend

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

EPBC status: EXtinct, CRitically endangered, ENdangered, VUlnerable, Conservation Dependent, Not Listed

FFG status: Listed as threatened, Nominated, Delisted, Never Listed, Ineligible for listing

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

Despite having only two listed fauna species identified from the VBA as present on Bumbang Island, it is fair to assume that a number of other listed species would also occur.. In addition to those fauna species listed in Table 6, this EWMP also assumes that the listed species provided in Table 7 occur on the Island. This assumption is reasonable as:

- Suitable habitat is available on the Island;
- The species have been found in close proximity to the Island; and/or

- Recovery programs and management plans have identified the Island as suitable habitat.

Table 7. Listed species potentially found on Bumbang Island.

Common name	Scientific name	Type	EPBC status	FFG Status	Advisory List
Carpet Python	Morelia spilota metcalfei	R		L	EN
Regent Parrot	Polytelis anthopeplus monarchoides	B	VU	L	V
Freshwater Catfish	Tandanus tandanus	F		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		L	VU
Growling Grass Frog	Litoria ranformis	A	VU	L	

Legend

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

EPBC status: EXtinct, CRitically endangered, ENdangered, VUlnerable, Conservation Dependent, Not Listed

FFG status: Listed as threatened, Nominated, Delisted, Never Listed, Ineligible for listing

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

4.1.1.1 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 Bumbang Island, is not available. Two sites, Margooya Lagoon and Belsar Island, within this study are relevant to Bumbang Island and the species lists from these sites are provided in Appendix 2. Margooya Lagoon is located approximately 10 km from Bumbang Island and is also regulated by Lock 15. The Murray River at Belsar Island forms the upstream section of the Lock 15 weir pool and is located 8 km from Bumbang Island. It is therefore likely that the fish, turtles and frog species found at these sites may also be supported at Bumbang Island. The presence of Golden Perch, Freshwater Catfish and Murray Cod at Bumbang Island has been noted (P. Cocks pers. comm. September 2014).

McCarthy, et al. (2007) surveyed the Euston Lakes, which are located on the Murray floodplain (NSW side), adjacent to Bumbang Island and found 15 species of fish. Four species were exotic and 12 native. Murray Cod, Silver Perch and Freshwater Catfish were amongst those found. The most abundant large bodied fish in Euston Lakes were the Freshwater Catfish.

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 habitat features are found in Bumbang Creek, the channels and the wetlands on the island. The fallen logs and smaller woody habitat which is plentiful at Bumbang Island will provide significant habitat diversity, protection from predators and enhanced food supplies for the Catfish (Rogers & Ralph, 2010).An improved hydrological regime that supports a mosaic of habitats at Bumbang Island should support Freshwater Catfish and other large bodied native fish species.

Bumbang Island provides excellent habitat for many species of small-bodied native fish. The complexity and diversity of habitat means that there is an abundance of food and protection from predators. Many native fish species such as *Gudgeon spp*. and Murray-Darling Rainbowfish prefer slow-flowing waters and wetlands where submerged macrophytes are abundant along with other riparian cover, including smaller woody habitat (Allen, et al., 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; Lyon, et al., 2010). Manipulating the weir pool level will provide these movement opportunities on the Island.

4.1.1.2 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 et al. cited in MDBA 2009). Water depth in particular influences waterbird diversity due to the specific feeding behaviours of different species (Bancroft, et al., 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, et al., 2002).

Due to limited data, recommendations within this EWMP will be directed toward the water requirements of the waterbird guilds rather than specific species. These guilds are limited to dabbling ducks, grazing waterfowl, piscivorous waterbirds, small waders and shoreline foragers. This is based on the habitat types available on the Island. The resource requirements of these groups are presented in Table 8.

Table 8- Waterbird functional feeding groups (Roshier, et al., 2002) and their resource use

Waterbird Group	Food Resource	Habitat Use	Breeding Strategy
Dabbling ducks (ie Chestnut teal, Pink-eared duck & Freckled duck)	Generalists; plankton, small invertebrates, plant material	Shallow Water (Dabblers)	Solitary
Grazing Waterfowl (ie Shellduck &Wood Duck)	Plant material, seeds, invertebrates	Shallow Water and littoral zone	Colonial or solitary
Piscivores (ie Pelican, Cormorants, Grebes, Darter, Egret, Heron & Tern)	Fish	Open and deep water	Colonial
Small Waders (ie Stilts, Plovers &Dotterels)	Small invertebrates, seeds	Littoral zone and mudflats	Solitary
Shoreline Foragers (ie Lapwings & Hens)	Plant material, seeds, invertebrates,	Littoral zone and 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). For example, White-faced Heron (*Egretta novaehollandiae*) use wetlands where River Red Gum are flooded for at least four months, but not long enough to kill the trees (Briggs, et al., 1997), while Darter (*Anhinga melanogaster*) nest over water (Vestjens, 1975) in dead or living River Red Gum (Leslie, 2001). While some species such as Darter, will nest in dead River Red Gum, the eventual loss of dead trees through decay mean that the water regime must promote the recruitment and health of live trees. Ideal flooding for River Red Gum recruitment is late spring to early summer (Johns, 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 & Ralph, 2010).

Water level fluctuations will support macrophyte diversity and growth, floodplain productivity, bacterial biofilm growth, and macro-invertebrate diversity and abundance, these will in turn support the waterbird functional feeding groups found on the Island. The weir pool conditions are currently favouring fish species (SKM, 2009) hence piscivores are currently being favoured at Bumbang Island. An improved watering regime will support suitable habitat and native fish populations, which will support piscivores in the long term.

4.1.1.3 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- Eagle nest at Bumbang Island. An active nest is located near the eastern entrance of Bumbang Island and an abandoned nest is located on the western side of the island (P. Cocks, pers. comm., August 2014). White-bellied Sea Eagle form pairs for life and are mostly sedentary once a home range is established (Department of Sustainability and Environment, 1994). They nest near water, in tall live or dead trees. River Red Gums are commonly used as nest trees (Emison & Bilney, 1982). The total Victorian population is thought to consist of only 100 breeding pairs (Department of

Sustainability and Environment, 2003), making the pair at Bumbang Island significant in a state-wide context.

The Regent Parrot (*Polytelis anthopeplus)* is also indirectly water dependent, and relies on the habitat provided by mature River Red Gums. The eastern Regent Parrot breeds almost entirely in River Red Gum forest and woodland. Nest trees are typically large, mature, healthy River Red Gums 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 Bumbang Island and surrounding River Murray frontage as likely breeding sites.

A watering regime that supports the longevity of large trees such as River Red Gum will provide nesting sites into the future for Regent Parrots and White-bellied Sea Eagles.

4.1.1.4 Frogs

Frog data associated with the nearby Euston Lakes found nine species present. Of these the Growling Grass Frog (*Litoria ranformis*) is listed under the *EPBC Act* as vulnerable and the *Flora and Fauna Guarantee Act* as threatened. The Growing Grass Frog is usually found in or around permanent or ephemeral Black Box/Lignum/Nitre Goosefoot swamps, Lignum/Typha swamps and Red Gum Swamps or billabongs along river valleys (SKM, 2009). These habitats are all found on Bumbang Island. Breeding is triggered by flooding or a significant rise in water levels in late winter/ spring (SKM, 2009). It is likely that Bumbang Island could support Growling Grass Frog populations.

4.1.1.5 Carpet python

Carpet Python (*Morelia spilota metcalfei*) are 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 the water regimes proposed in this EWMP.

4.1.2 Vegetation Communities

There are ten water dependant ecological vegetation communities mapped on Bumbang Island as shown in Figure 16 and listed in Table 9. Of these seven are listed as depleted in the Robinvale Plains Bioregion and two are listed as vulnerable. Appendix 3 provides a full description of each EVC.

Table 9. Conservation status of water dependent EVCs at Bumbang Island.

EVC No.	EVC Name	Structurally dominant species	Bioregional Conservation Significance (Robinvale Plains Bioregion)
103	Riverine Chenopod Woodland (syn. Black Box Chenopod Woodland)	Black Box	Depleted
104	Lignum Swamp	Lignum	Vulnerable
106	Grassy Riverine Forest	River Red Gum	Depleted
295	Riverine Grassy Woodland	Either or both River Red Gum and Black Box	Depleted
808	Lignum Shrubland	Tangled Lignum	Least Concern
810	Floodway Pond Herbland	River Red Gum	Depleted
811	Grassy Riverine Forest/ Floodway Pond Herbland Complex	River Red Gum	Depleted
813	Intermittent Swampy Woodland	Either or both River Red Gum and Black Box	Depleted
818	Shrubby Riverine Woodland	Either or both River Red Gum and Black Box	Least concern
823	Lignum Swampy Woodland	Either or both River Red Gum and Black Box	Depleted
824	Woorinen Mallee	Mallee Eucalypts	Vulnerable

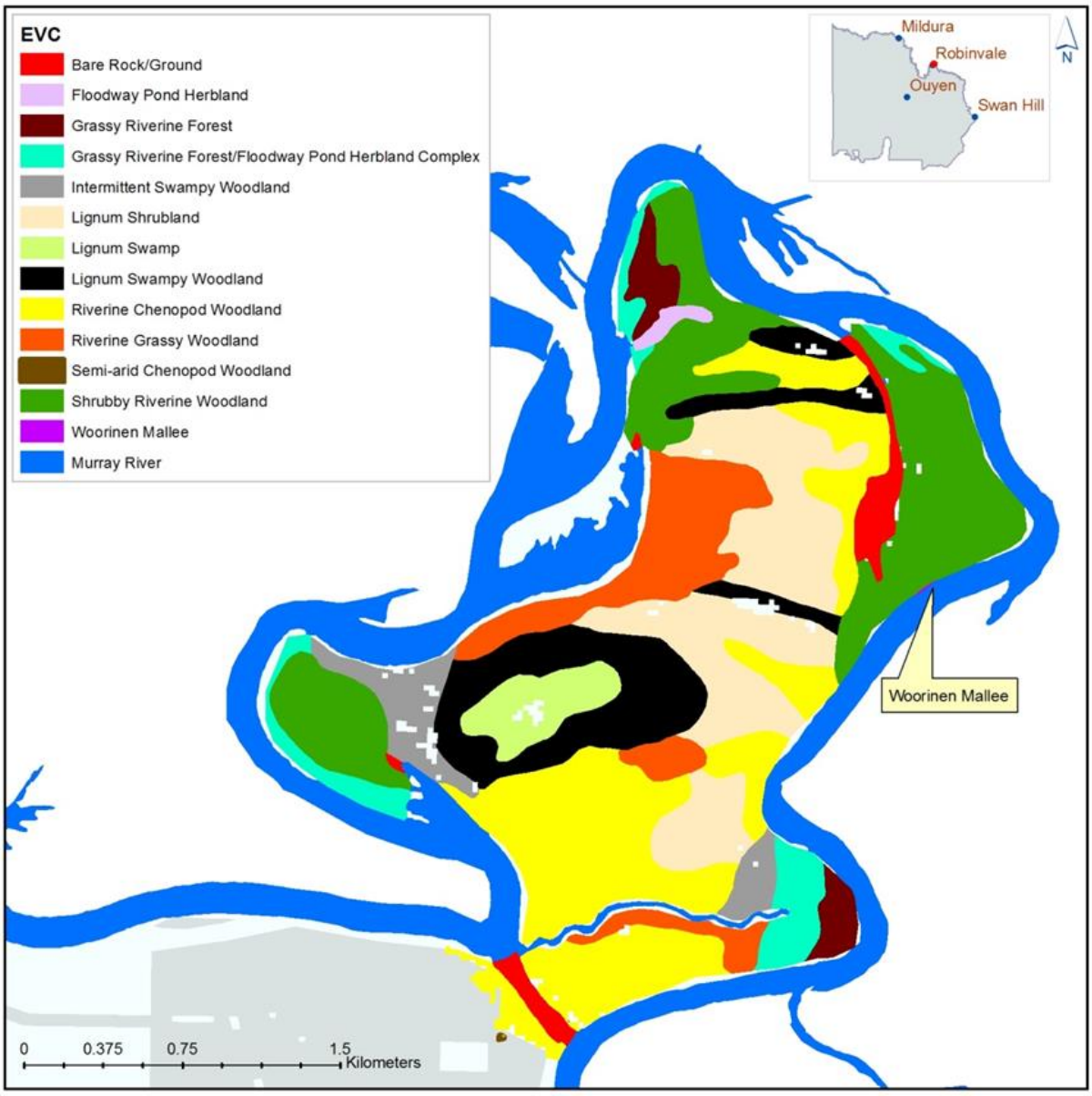

Figure 16. EVCs found on Bumbang Island.

Grassy Riverine Forest (106), Riverine Grassy Woodland (295), Grassy River Forest/Floodway Pond Herbland Complex (811) and Shrubby Riverine Woodland (818) are the main EVC's influenced by weir manipulation at Lock 15. These EVCs are dominated by River Red Gum and/or Black Box communities. River Red Gum and Black Box communities provide essential habitat and foraging opportunities for a range of species including mammals and reptiles, and support a high proportion of ground foraging and hollow-nesting species, such as the Carpet Python and Regent Parrot. EVCs located in areas influenced by the weir pool will benefit from a more natural weir regime.

4.1.3 Flora

Based on data provided through a search of the VBA (October 2014), there are no significant flora species recorded on Bumbang Island. However, there are a number of significant flora species found in close proximity to the island in the Robinvale area. These are presented in Table 10. A complete species listing from the VBA for the site is provided in Appendix 4. This is unlikely to reflect actual conditions and investigation into the flora on the Island is identified as a knowledge gap.

The EVC/Bioregional Benchmark for Vegetation Quality Assessment – Robinvale Plains bioregion (Department of Sustainability and Environment, 2004) has been used to determine species typical of the EVCs which occur on Bumbang Island.

Table 10. Significant flora species located in close proximity to Bumbang Island (from VBA, October 2014).

Scientific Name	Common Name	Victorian Advisory List
Swainsona phacoides	Dwarf Swainson-pea	Endangered
Ceratophyllum demersum	Hornwort	Poorly known
Dactyloctenium radulans	Finger Grass	Rare
Tragus australianus	Small Burr-grass	Rare
Trigonella suavissima	Sweet Fenugreek	Rare
Triraphis mollis	Needle Grass	Rare
Velleia arguta	Grassland Velleia	Rare
Acacia melvillei	Yarran	Vulnerable
Heliotropium asperrimum	Rough Heliotrope	Vulnerable
Sclerolaena patenticuspis	Spear-fruit Copperburr	Vulnerable
Sida fibulifera	Pin Sida	Vulnerable
Sida intricata	Twiggy Sida	Vulnerable

4.2 Wetland Depletion and Rarity

Victoria's wetlands are currently mapped and are contained within a state wetland database, using an accepted statewide wetland classification system (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

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

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

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

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

Bumbang Island's wetlands are all Permanent Open Freshwater. Permanent Open Freshwater wetlands in Victoria have decreased by six per cent in area since 1788. 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 per cent (Mallee CMA, 2006).

The wetland layers identified three wetlands within the study area. There are also a number of other wetlands/wetland features within the study area which are not included in the wetlands1994 layer.

Ecosystem Functions

Native flora, fauna and ecological communities have adapted to the extremely variable climate within Australia. Variability in water availability and the wetting and drying cycle of wetlands and other habitats, is a key driver of ecosystem function.

Four key broad ecosystem functions have been identified for the Bumbang Island 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, et al., 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; Lyon, et al., 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 surrounded by floodwaters.

Diversity of habitat for feeding, breeding and nursery

Seasonal fluctuations in the water levels around Bumbang Island will encourage diversity of waterbird habitats across the Islands water areas. 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 provide shallow open water and expose mudflats required by small waders (Roshier, et al., 2002). The open water conditions created by the normal operating level favour the piscivorous water birds (Scott, 1997).

Inundation of the wetlands and River Red Gum woodlands on the Island will provide roosting and nesting habitat for species such as Darters (Vestjens, 1975) and Cormorants (Loyn, et al., 2002), while the increase in macrophyte diversity and abundance will increase habitat values for shoreline foragers such as Purple Swamphens (I) and small-bodied fish such as Murray-Darling Rainbowfish (*Melanotaenia fluviatilis*)and *Hardyhead spp.* (Allen, et al., 2003).

Current water conditions in the Euston Weir pool are favouring 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

Weir recharge following autumn will connect the channels and low level terraces transporting nutrients and carbon into the water column, which will become available for consumption by bacteria, algae, macrophytes and macroinvertebrates. Terrestrial invertebrate species (e.g. 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 river levels, 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 species that offer a range of food resources for macroinvertebrates and fish (SKM, 2009).

Increase and diversity in biofilms

Permanent inundation of wetlands, backwaters and benches associated with stable weir pool levels promotes algae dominated biofilms, while bacterial dominated biofilms decline (Sheldon & Walker, 1993). Disturbances such as exposure and drying for period exceeding 40 days (Burns & Walker, 2000) and scouring flows (Burns & Ryder, 2001) can re-establish bacteria as the dominant component of biofilms. Bacterial dominated biofilms are more nutritious to grazers (Sheldon & Walker, 1993).

An appropriate annual weir pool regime, with monthly variations, gradual drawdown and recharge will encourage the key ecosystem functions and promote ecosystem productivity.

5. Social Values

5.1 Cultural Value

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

Given the semi-arid climate of the region, ready access to more permanent water has been a major determinant of human habitation, and as such the highest density of identified Indigenous Cultural Heritage 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 Aboriginal groups, containing many places of spiritual significance. The high number of Indigenous Cultural Heritage sites throughout the Murray floodplain is unique in Victoria, for both concentration and diversity. They include large numbers of burial, middens and hunting sites.

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

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

5.1.1 Cultural Heritage

Aboriginal occupation of Bumbang Island is likely to extend back over the last 10-12,000 years. Bumbang Island is an important Aboriginal place, best known for its distribution of scar trees (769 registered sites). Shell middens are located on the riverbanks and a relatively modern 'mia-mia' and occasional artefacts have also been recorded. Nearly 90% of all registered archaeological sites recorded in the Robinvale district have been found on Bumbang Island (Long & Berrill, 2001).

The Island lies within the shared county of the Ladjiladji and Dadidadi language groups who occupied both sides of the Murray River. The Ladjiladji and Dadidadi groups are also the traditional owners of the area. The Jungeegatchera clan of the Dadidadi is identified with the area around Euston, while the Latjilatji are more specifically associated with the Bumbang area (Long & Berrill, 2001).

Bumbang Island is subject to a native title claim made under the *Native Title Act 1993*. The claimants are the Manatunga Elders claimant group and the Latji Latji peoples claimant group (Long & Berrill, 2001).

The cultural landscape of Bumbang Island is well preserved in comparison to much of the Murray Valley floodplain, despite past impacts. Processes which normally threaten cultural heritage that are not evident on Bumbang Island include stock trampling, firewood removal, accidental bushfire damage, vandalism, road/ path/ camping area construction and 4WD use (Long & Berrill, 2001).

Long and Berrill (2001) described the cultural heritage of the site in relation to the landforms. This is presented in Figure 18. The descriptions are relevant to this EWMP, and will be useful in identifying key areas for cultural heritage protection which may be impacted by environmental watering. The zones as described by Long and Berrill (2001) are outlined in Table 11.

Table 11. Landscape zones as they relate to cultural heritage sensitivity as described by (Long & Berrill, 2001).

Landscape zone	Description of cultural heritage sensitivity and relevant environmental characteristics
1	The elevated western and central parts of the southern section of the Island. Characterised by Black box woodland. This zone comprises an insulate of the main part of Bumbang Island (Zone 3), from which it is separated by Bumbang Creek.
2	The low lying eastern part of the southern section of the Island. The area is characterised by River red gum forest. Bumbang Creek divides the zone into northern and southern parts, though the characteristics of both sections are broadly similar.
3	The main central block of the Island. Characterised by Black box woodland and lignum scrub. This zone contains the majority of recorded archaeological sites and landforms of high archaeological potential. It has been divided into sub zones, 3a the river margins and 3b the hinterland. Zone 3a has been extensively surveyed and contains numerous scar trees and midden deposits. Zone 3b has been less extensively surveyed and is thought to contain and overall lower density of cultural sites.
4	The western extremity of the Island, characterised by River red gum forest. Some scar trees may have been recorded.
5	A relatively young alluvial peninsula adjoining the central western margin of the island, characterised by River red gum forest.
6	The northern extremity of the Island, largely River red gum forest. Some scar trees have been recorded.
7	The eastern extremity of the Island, characterised by River red gum forest. A relatively high number of River red gum scar trees have been recorded in this zone.

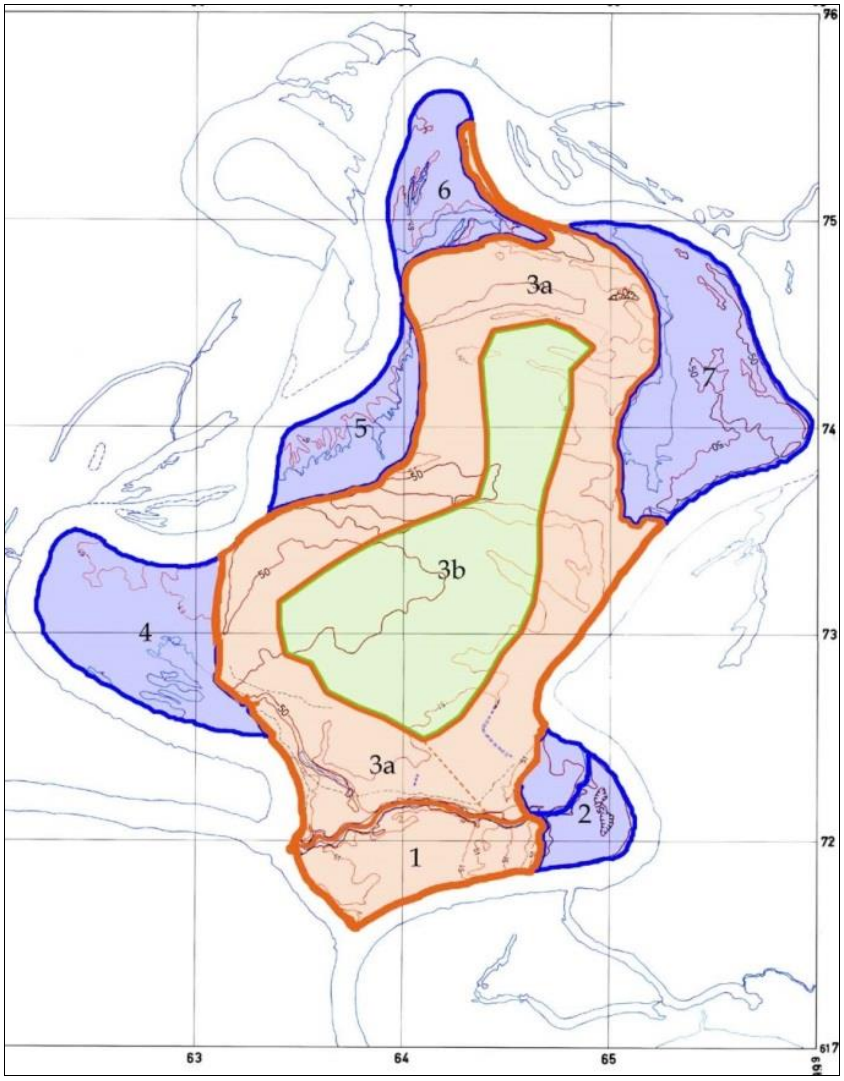

Figure 17- Landscape zones on Bumbang Island relating to cultural heritage significance.

5.1.2 European Heritage

European settlement began in the district in the 1840s. A grazing licence over the area was obtained in 1847 and forfeited in 1883. This phase of occupation is likely to have resulted in some tree clearance for grazing purposes, and the ringbarking of black box trees in the central areas of the Island. Between the 1850s and 1900s paddle steamers traversed the Murray River. It is likely that they sought fuel, including River Red Gum from the river margins of Bumbang Island. Evidence of historic grazing activities has been observed on the banks of Bumbang Creek where relics of stock yards remain Figure 18.

Figure 18. Relic stock yards found on the banks of Bumbang Creek (August 2014).

5.2 Recreation

As mentioned earlier, Bumbang Island has no infrastructure development and very little access for recreational purposes. Field observations showed little evidence of recreational use of the Island, except for small amounts of litter. Access is by boat only.

Lock 15 (Euston Weir) is located just downstream of Robinvale, the 'normal' water level of 47.6 m AHD ensures that there is water permanently available near Robinvale for water activities such as water skiing. This includes a major water skiing event held in March each year.

A Cultural Heritage Management Plan (Long & Berrill, 2001) identified the option of developing a Cultural Tourism initiative, including a water trail. To date this has not occurred.

5.3 Economic Values

The Euston Weir provides water for diversions to the Robinvale Irrigation District and parts of the Sunraysia Irrigation District, private diverters in NSW as well as providing urban water to Robinvale and Euston (Gippel & 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).

5.4 Significance

Bumbang Island is isolated from the 'mainland' by the Bumbang Cut, and is largely unimpacted by surrounding catchment land uses. It retains reasonably intact vegetation, of varying age classes, significant intact cultural heritage and a mosaic of habitats. The Island supports White-bellied Sea Eagle, and is likely to support Regent Parrot and Carpet Python. All these species rely on mature River Red Gum for nesting.

Within the 566 ha of the island, a mosaic of habitats, incorporating permanent and ephemeral wetlands, Black box and Lignum shurblands and woodland, and riverine woodlands. Backwaters and the Bumbang Creek provide slow flowing habitats, whilst the Bumbang Cut and the River Murray meander provide fast flowing habitats, incorporating both deep pools and shallow benches. Significant large wood habitat is available across the different habitats. The Island is likely to provide important habitat for a range of large bodied native fish species including Golden Perch, Silver Perch, Murray Cod and the Freshwater Catfish. Whilst small bodied fish species such as Gudgeon and Rainbowfish could flourish in the wetlands and areas of emergent macrophytes or flooded grassland.

6. Ecological Condition and Threats

6.1 Current Condition

There has been no Index of Stream Condition or Index of Wetland Condition Assessments for the wetlands on Bumbang Island or for Bumbang Creek. Due to its isolation from the 'mainland', its protection as a historic reserve and lack of access Bumbang Island is in a relatively healthy condition. It is free of major invasive pest species such as foxes and cats and therefore provides significant protection for native species than other sites which are subject to high predation levels.

Despite this generally good condition, impacts from the changed water regime associated with the Euston Weir are evident, as seen by dead trees (Figure 19) and lack of understorey diversity (Figure 20).

Figure 19. Drowned trees in a channel at Bumbang Island.

Figure 20. Lack of understorey diversity in River Red Gum woodlands.

6.2 Condition Trajectory

Much of the impact associated with the operation of the Euston Weir has already occurred. Many mature River Red Gum have drowned around the fringes of the Island, within the Creek and wetlands. Many of the dead trees are hollow bearing and provide significant roosting and nesting habitat. This habitat will be lost over time as the dead trees decay. It is expected that a decline in species relying on these trees may be seen.

As mentioned earlier, the shallow fresh groundwater is excluding a diverse understorey within the River Red Gum woodlands and forest on the low terraces. The lack of a diverse understorey will have resulted in a reduced ability to support a diverse fauna community.

Although the wetland and backwaters provide good habitat values, even at normal operating level, the range of habitats and food resources available is limited. The sills of the channels across the Island require the weir pool to be at least 48.0 m AHD before they become engaged (P. Cocks pers. comm. September 2014). Engagement of the channels will increase the recruitment of organic matter, invertebrates and small fish to the wetlands. Figure 21 and Figure 22 show Eastern Wetland and a channel into Eastern Wetland during the weir pool raising trial. The channel into Eastern Wetland had improved connectivity during this event.

Regular weir manipulation, both drawdown and surcharge phases, will provide a more natural drying and wetting cycle, providing greater opportunities for flora and fauna species on Bumbang Island.

Figure 21. Wetland Eastern Wetland following the weir pool raising trial. Levels had been approximately 15cm higher than when photo was taken.

Figure 22. Channel leading into Eastern Wetland had improved connectivity during weir pool raising trial. Photo taken at 47.8m AHD, following level of 47.9m AHD in previous weeks.

6.3 Water Related Threats

Altered water regime – Hydrology is the most important component of wetland ecosystems. It drives the physical and chemical properties of a wetland, and the biota it supports. As described in Section 3, Hydrology and Systems Operations, the natural hydrological regime at Bumbang Island has been altered by the construction of Lock 15 and the regulation of the Murray River. This has led to relatively stable water levels at Bumbang Island.

Permanent flooding is harmful to many wetland plants since they rely on a flooding and drying cycle. Permanent inundation caused by higher water levels has killed many River Red Gums along the Murray River. These trees are important nesting sites and many waterbirds will only nest in live River Red Gums (Scott, 1997). Waterbirds that benefit in the short term from dead trees (for nesting and roosting) will eventually lose habitat as these plants decay (Kingsford , 1995; Briggs, et al., 1997). Seasonality of flows at the site is natural; however the magnitude of flows has reduced.

Permanent inundation of wetlands initially provides habitat for fish and waterbirds, as organic matter and nutrients are released and invertebrate populations build up. Inundation over a period greater than two years leads to a decrease in biodiversity (Cadwallader, 1978; Kingsford , 1995). The waterbird communities become dominated by fish eating waterbirds, replacing duck and wading bird communities (Kingsford , 1995). This has not necessarily occurred across the wetland habitats within Bumbang Island, but may have occurred in the channels, the Cut and Murray River.

Altered groundwater state – The construction of Lock 15 has also resulted in shallow fresh groundwater close to river level. Weir pool manipulation may result in groundwater intrusion, which may increase salinity.

7. Management Objectives

7.1 Management Goal

The management goal for Bumbang Island is:

To provide a water regime which reflects natural water level variability and seasonality, that will maintain and promote the mosaic of available habitats and significant cultural heritage values..

7.2 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 Bumbang Island can be found in Section 5.4.1 of Butcher et al. (2020).

7.2.1 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.

7.2.2 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 12 maps the current EWMP objectives against these objectives to provide a line of sight.

Table 12 Mapping updated Bumbang Island 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
BI1	8.05,3(b) 8.06,6(b)	Condition of priority asset - prevention of decline in native biota Condition of priority ecosystem functions - creation of vital habitat - habitat for prevention of decline in native species	B2.8	LTWPVM5 LTWPVM6

		Condition of native water dependent vegetation		
BI4	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	None specified	LTWPVM2
BI5	8.06,6(b)	Recruitment and populations of native fish Condition of priority asset - prevention of decline in native biota	B4.2	LTWPVM15
BI6	8.06,6(b)	Recruitment and populations of native fish Condition of priority ecosystem functions - creation of vital habitat - diversity of habitat	4.2	LTWPMV14
BI7a	8.05,3(b)	Condition of priority ecosystem functions - creation of vital habitat - feeding, breeding, nursery	B3.2	LTWPVM13 LTWPVM12
BI7b	8.06,6(b)	Recruitment and populations of native water-dependent birds	B3.2	LTWPVM11 LTWPVM12 LTWPVM13

7.2.3 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 13 Updated ecological objectives for Bumbang Island

Environmental objective	Target
BI1: By 2030, improve condition and maintain extent from baseline levels of River Red Gum (*Eucalyptus camaldulensis*) to sustain communities and processes reliant on River Red Gum woodlands at the Bumbang Island asset	By 2030, a positive trend in the condition score of River Red Gum dominated EVC benchmarks at 80% of sites over the 10 year period. OR By 2030, at stressed sites (see Wallace et al. 2020) at the Bumbang Island asset: in standardised transects that span the floodplain elevation gradient and existing spatial distribution at Bumbang Island, ≥70% of viable trees will have a Tree Condition Index Score (TCI) ≥ 10. Baseline condition of River Red Gum trees to be established.
BI4: By 2030, improve vital habitat at the Bumbang Island asset by increasing the diversity of aquatic macrophytes present across a range of Water Regime Indicators Groups.	By 2030, increase diversity of native of aquatic macrophytes at the Bumbang Island 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) (Hornwort *Ceratophyllum demersum*)

	• Aquatic (submerged to partially emergent) (Ase) (no species recorded) • Aquatic graminoids (persistent) (Agp) (Common Reed *Phragmites australis*) Keep?? • Aquatic to semi-aquatic (persistent) (Asp) (no species recorded) • Seasonally immersed – low growing (Slg) (Yellow Twin-heads *Eclipta platyglossa subsp. Platyglossa*) • Seasonally inundated – emergent non woody (Sen) (no species recorded) This target may not be measurable until baseline list of WRIGs is established
BI5: By 2030, protect and restore recruitment of small-bodied native fish at the Bumbang Island asset, including Carp Gudgeon spp. (*Hypseleotris* spp.), Fly-Specked Hardyhead (*Craterocephalus stercusmuscarum*), Flathead Gudgeon *(Philypnodon grandiceps*), Australian Smelt (*Retropinna semoni*), Murray-Darling Rainbowfish (*Melanotaenia fluviatilis*), Murray Hardyhead (*Craterocephalus fluviatilis*.	By 2030, maintain self-sustaining populations of Carp Gudgeon spp. (*Hypseleotris* spp.), Fly-Specked Hardyhead (*Craterocephalus stercusmuscarum*), Flathead Gudgeon *(Philypnodon grandiceps*), Australian Smelt (*Retropinna semoni*), Murray-Darling Rainbowfish (*Melanotaenia fluviatilis*), Murray Hardyhead (*Craterocephalus fluviatilis*) at the Bumbang Island asset. Measured as: • Adults or YoY for each species recorded in 8 out of 10 years
BI6: By 2030, protect and restore recruitment of large-bodied native fish at the Bumbang Island asset, including Golden Perch (*Macquaria ambigua*), Silver Perch (*Bidyanus bidyanus*) and Murray Cod (*Maccullochella peelii*).	By 2030, maintain self-sustaining populations Golden Perch (*Macquaria ambigua*), Silver Perch (*Bidyanus bidyanus*) and Murray Cod (*Maccullochella peelii*) at the Bumbang Island asset. Measured as: • Adults for each species recorded in 8 out of 10 years • Young of the year (YoY) for each species recorded in 5 out of any 10 years
BI7a: By 2030, maintain representative populations of shallow-water and deep-water feeding guilds of waterbird (F2 and F3, respectively, after Jaensch 2002) at the Bumbang Island asset, by maintaining a mixture of shallow and deep-water habitats.	By 2030, 80% of representative F2 and F3 species recorded at the Bumbang Island asset in 8 year out of any 10-year period where conditions are suitable. • Representative F2 species include: Australasian Grebe (*Tachybaptus novaehollandiae*), Pacific Black Duck (*Anas superciliosa*), White-necked Heron (*Ardea pacifica*), Australian White Ibis (*Threskiornis molucca*), Masked Lapwing (*Vanellus miles*) • Representative F3 species include: Australian Pelican (*Pelecanus conspicillatus*), Great Cormorant (*Phalacrocorax carbo*), Little Black Cormorant (*Phalacrocorax sulcirostris*), White-bellied Sea Eagle (*Haliaeetus leucogaster*) • Feeding habitat defined as a mixture of deep feeding areas (water >1 m) and shallow feeding areas (<0.5 m depth and or drying mud) with intermittent inundation of densely vegetated shrublands.
BI7b: By 2030, maintain nesting and recruitment of non-colonial waterbirds (N1, N2, N3 and N4, after Jaensch 2002) at the Bumbang Island asset, by maintaining a mixture of tree, low vegetation/shrubs, and ground/islet nesting habitat.	There is a lack of data on species that breed at the site, other than White-bellied Sea Eagle. The expectation is that the list of species commonly nesting at the Bumbang Island asset will be confirmed over time. By 2030, at least two of the following species to be recorded as nesting and/or breeding at the Bumbang Island asset in 7 out of

	any 10 year period in which nesting/breeding conditions are suitable: • Representative N1 and N2 species include: White-bellied Sea Eagle (*Haliaeetus leucogaster*) • Representative N3 and N4 species include: Australasian Grebe (*Tachybaptus novaehollandiae*), Masked Lapwing (*Vanellus miles*), Pacific Black Duck (*Anas supercilliosa*)

7.3 Hydrological Objectives

The hydrological objectives 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 and channels across the island. The objectives as described above are about promoting a broader zone of macrophytes, increasing productivity and habitat quality for aquatic fauna including water birds and fish. In addition to these ecological objectives a significant focus for Bumbang Island is about the preservation of the natural values associated with the cultural heritage.

The objectives focus on a higher inundation level in late winter to spring (August to November), with the minimum water level being provided between March and July. 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 14 provides the proposed weir pool level regime highlighting variation from normal operating levels, this regime was derived from the Weir 15 EWMP (Ecological Associates, 2015, in prep.). The proposed water regime aims to mimic the seasonal pattern of flows. The variation in weir pool height in the proposed regime is much smaller than a natural regime.

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 48.3m AHD in October. This is based on the need to maximise inundation of low level floodplain woodlands on the low level terraces.

Pool level drawdown would ideally commence in January, however, irrigators and the ski event held in late March require the weir to be maintained at pool level. Drawdown of the weir pool can commence after the ski race.

Table 14. Proposed weir pool regime variation from normal operating level of 47.6m AHD (Ecological Associates, 2015).

Month	Variation from Normal Operating Level (m)	Level (m AHD)
Jan	0	47.3
Feb	0	47.3
March	0	47.3
April	-0.2	47.3
May	-0.3	47.3
June	0	47.6
July	0	47.6
August	+0.4	48.0
September	+0.5	48.1
October	+0.5	48.3
November	+0.6	48.3
December	+0.3	47.9

Figure 23 through to Figure 30 show the approximate inundation extent of wetlands over Bumbang Island using LiDAR data for weir levels between 47.6m AHD and 48.3m AHD. These levels were provided as the operational limitations for weir level manipulation. Inundation extents cannot be determined for areas below the weir pool. For further information on Lock 15 weir manipulation please refer to the Lock 15 EWMP (Ecological Associated 2015).

Table 15 broadly describes the potential ecological outcomes that may result from a more natural regime at Lock 15.

Figure 23. Approximate inundation extent of weir pool at 47.6 m AHD (0 m variation from normal operational height), inundating around 39 ha.

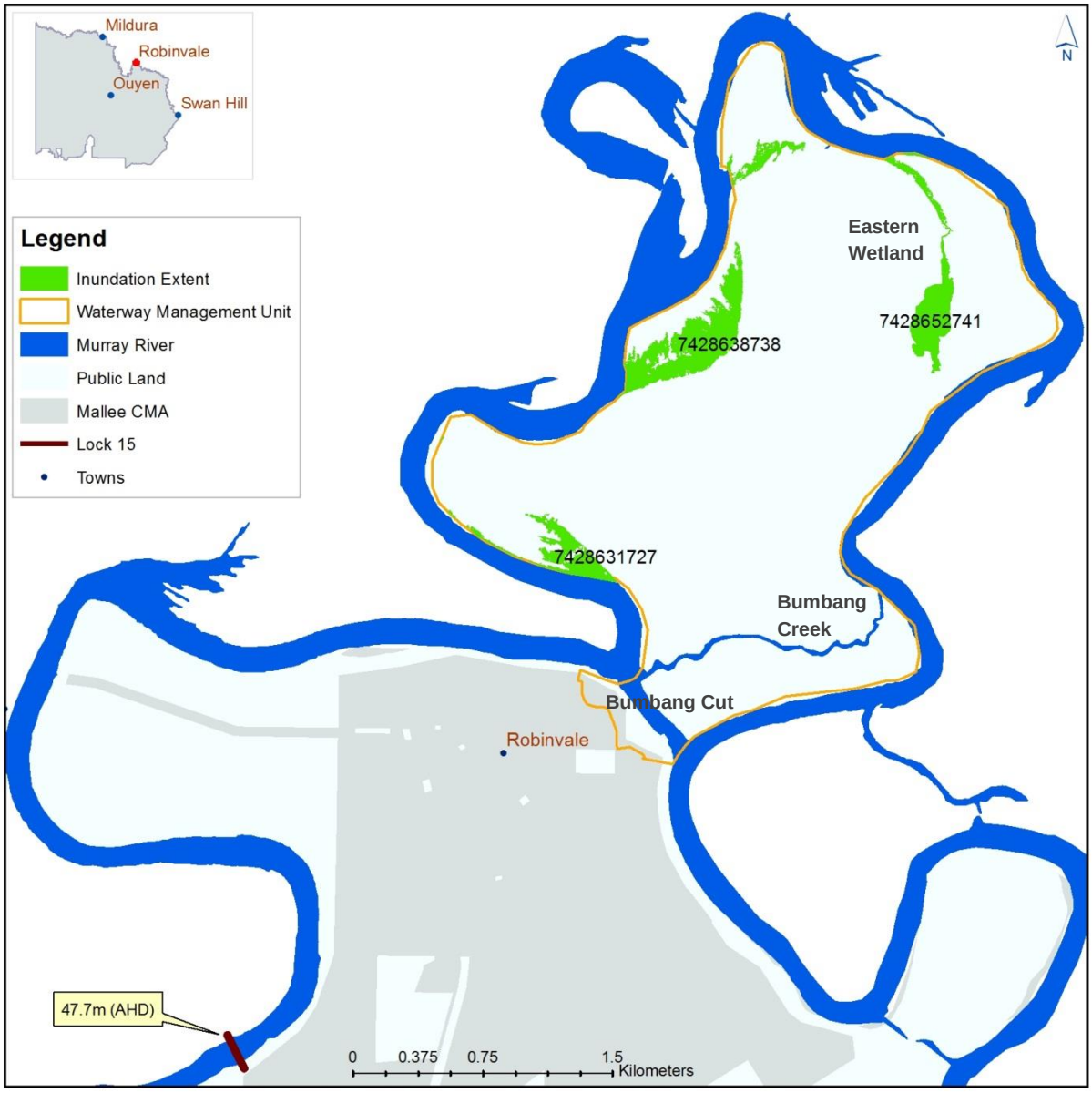

Figure 24. Approximate inundation extent of weir pool at 47.7 m AHD (+0.1 m variation from normal operational height), inundating around 39.5 ha.

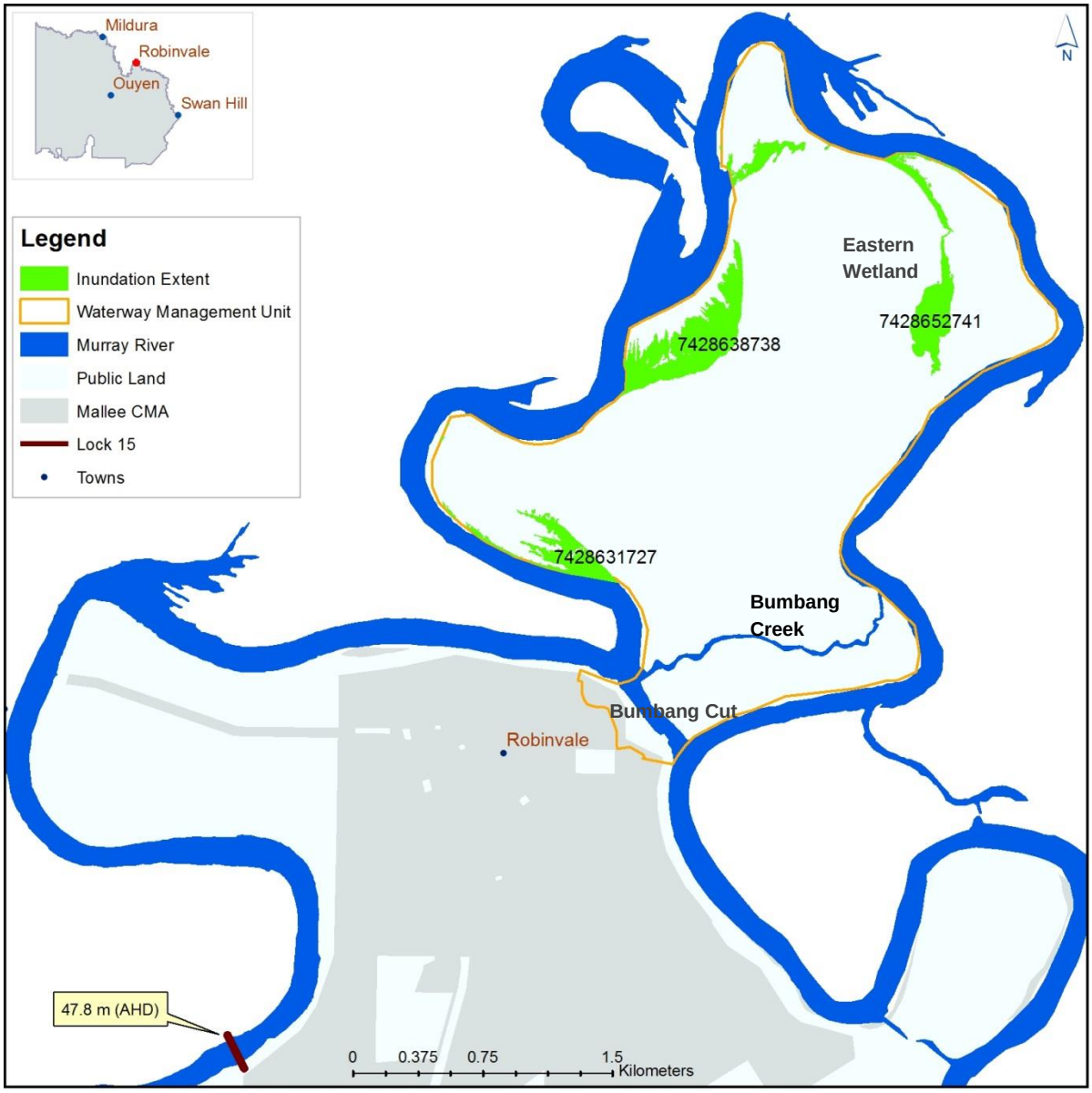

Figure 25. Approximate inundation extent of weir pool at 47.8 m AHD (+0.2 m variation from normal operational height), inundating around 44.5 ha.

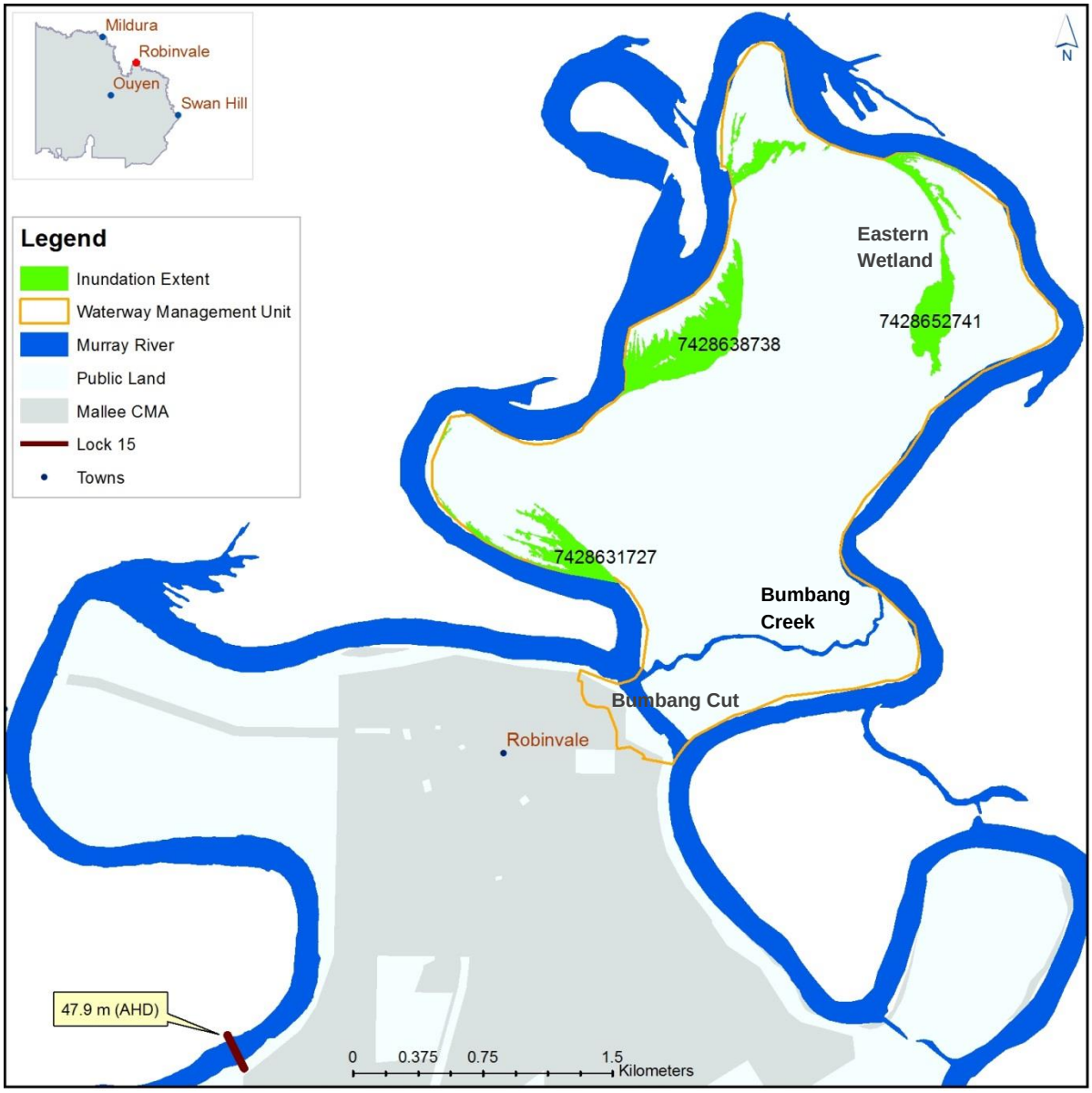

Figure 26. Approximate inundation extent of weir pool at 47.9 m AHD (+0.3 m variation from normal operational height), inundating around 49 ha.

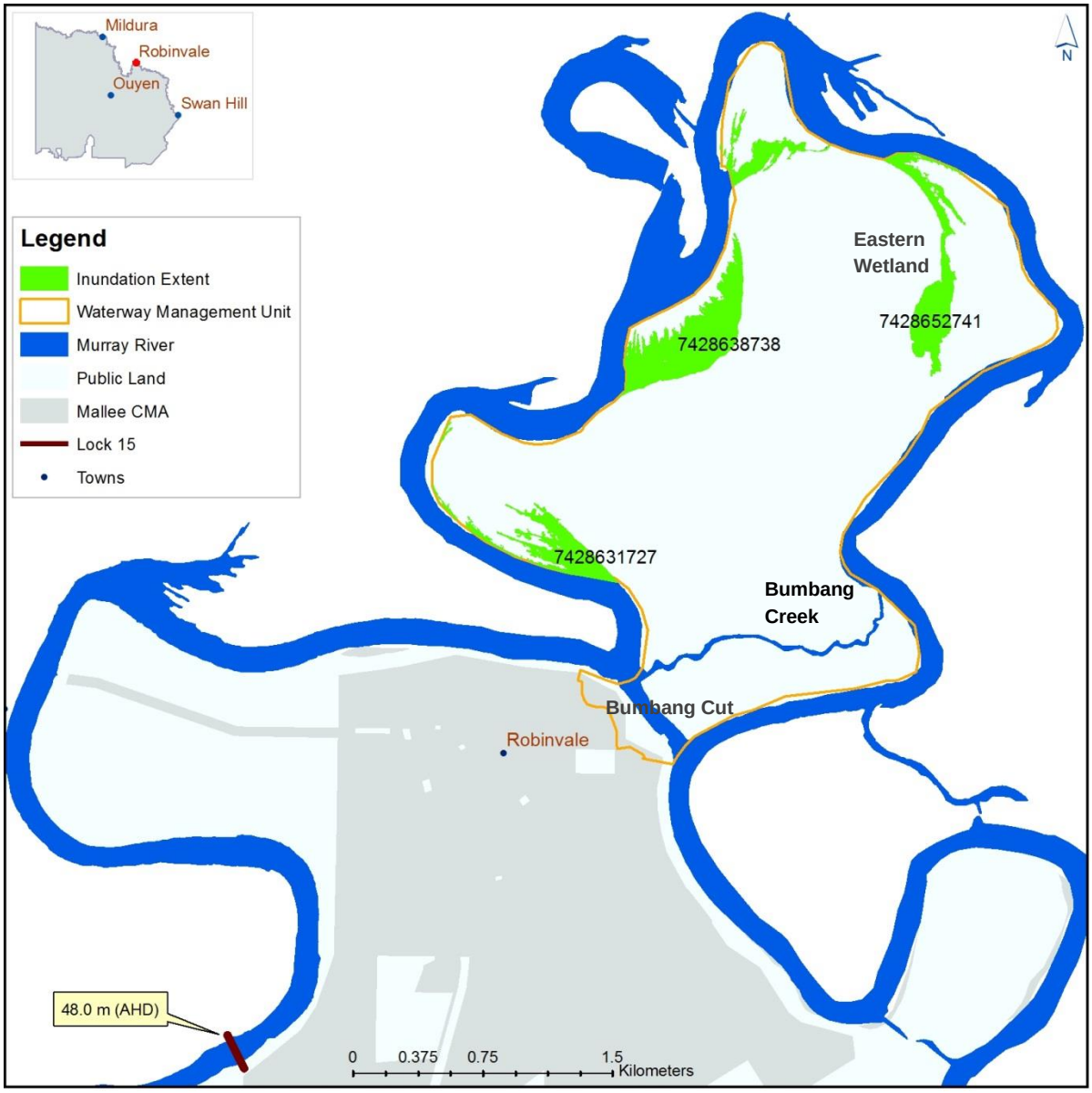

Figure 27. Approximate inundation extent of weir pool at 48 m AHD (+0.4 m variation from normal operational height), inundating around 54 ha.

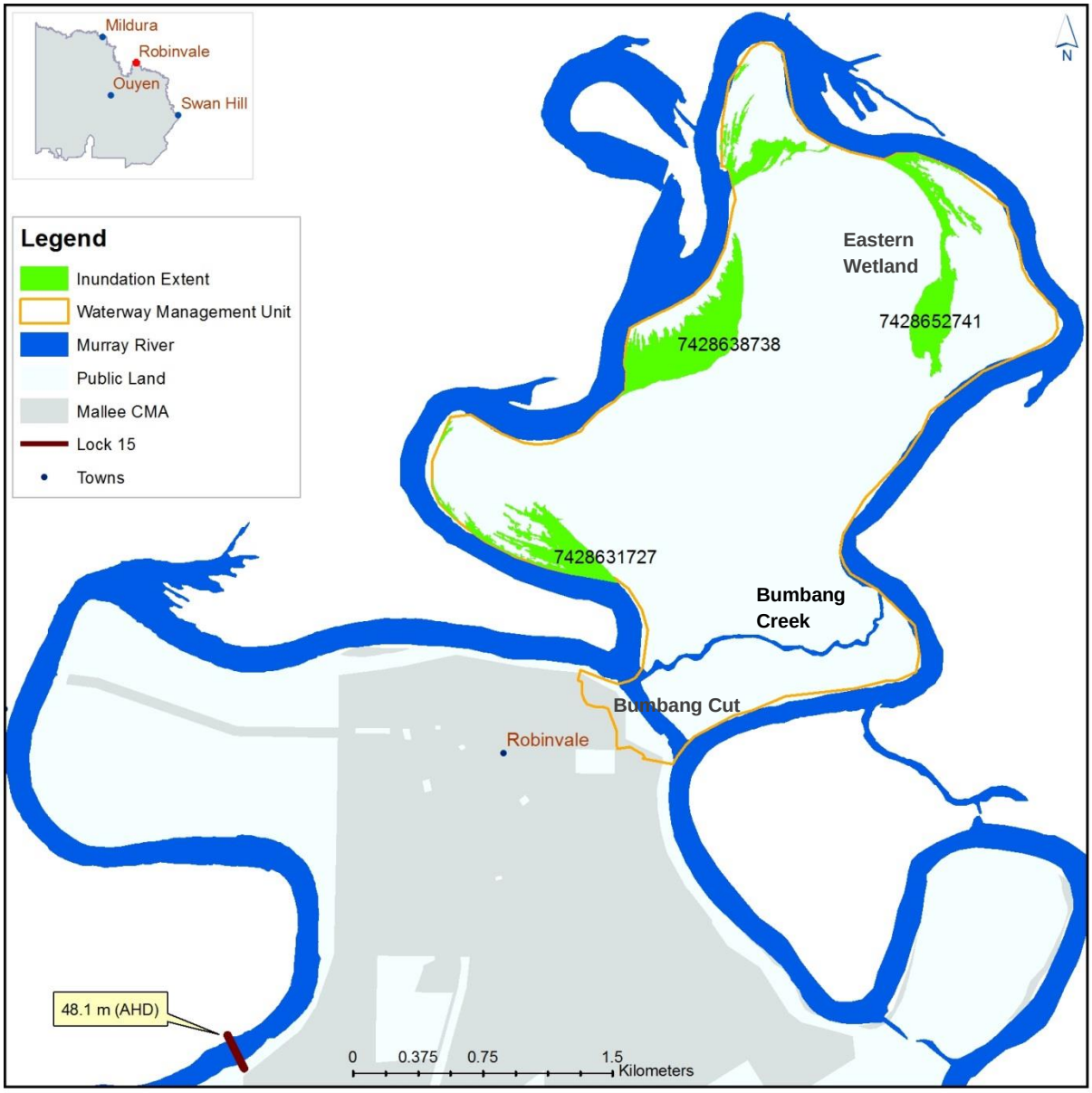

Figure 28. Approximate inundation extent of weir pool at 48.1 m AHD (+0.5 m variation from normal operational height), inundating around 60 ha.

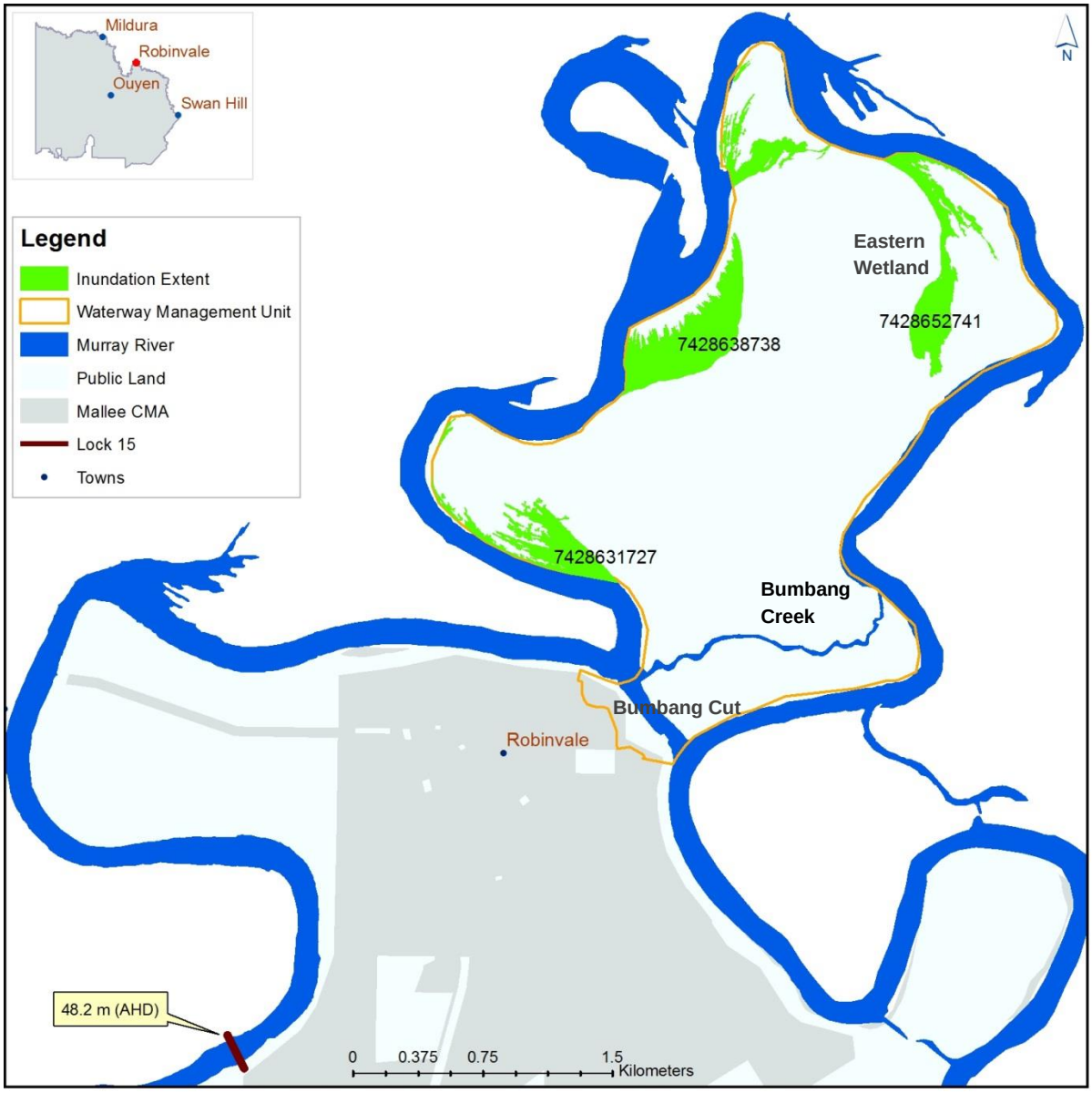

Figure 29. Approximate inundation extent of weir pool at 48.2 m AHD (+0.6 m variation from normal operational height), inundating around 64.6 ha.

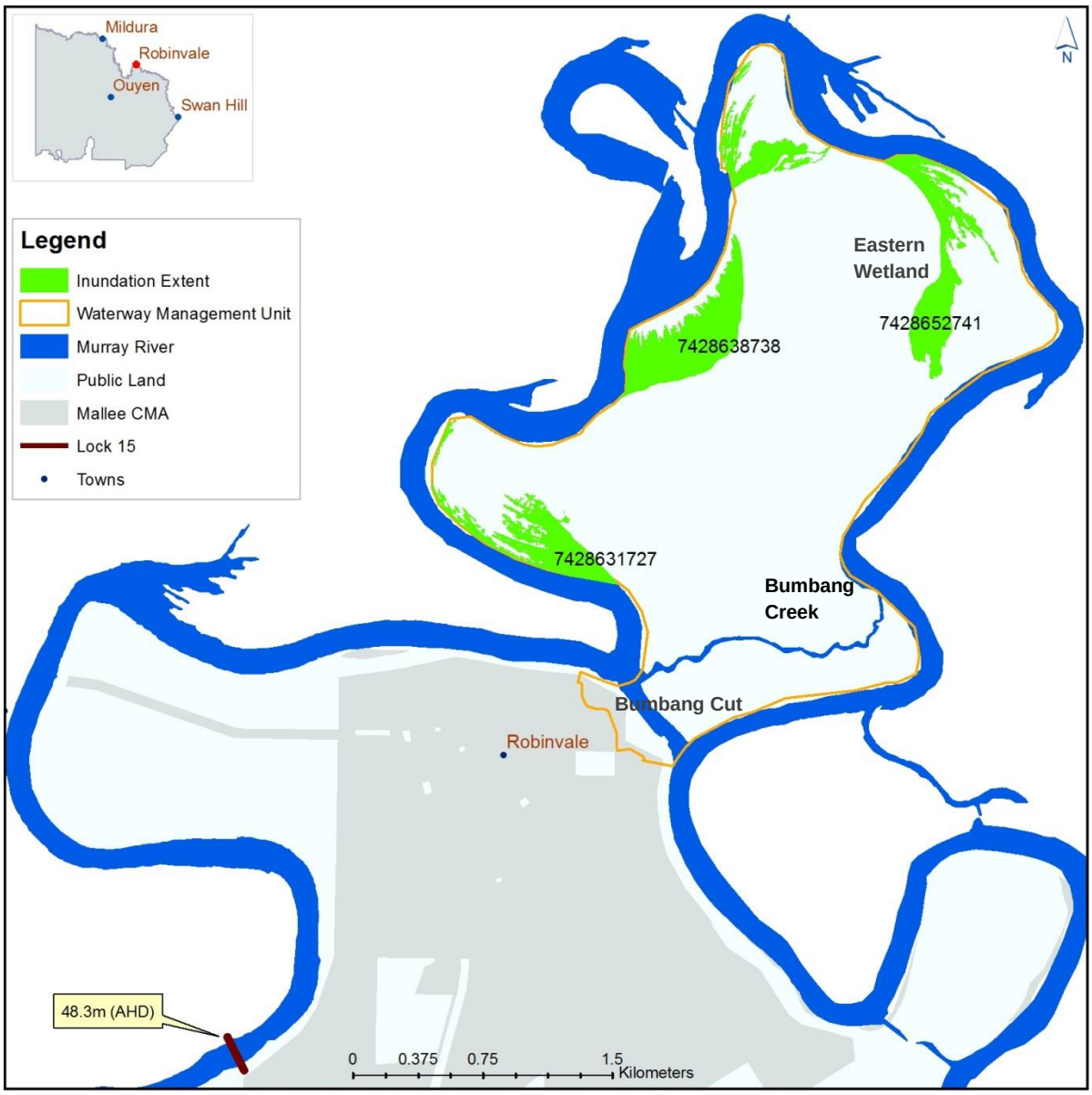

Figure 30. Approximate inundation extent of weir pool at 48.3 m AHD (+0.7 m variation from normal operational height), inundating around 72.8 ha.

Table 15. Summary of potential ecological outcomes resulting from a more natural Lock 15 weir pool regime (Adapted from (SKM, 2009).

Timing	Direction of Change in Weir Pool Level	Potential Ecological Outcomes
December to March	Lowering	Wetlands and backwaters begin to slowly drawdown Connectivity between the floodplain wetlands and the Murray River commence to drawdown and provide cues for movement of Golden Perch, Freshwater Catfish and Gudgeon spp. to permanent waters.
March to May	Lowering	The wetlands on the Island are isolated and gradually lower through evaporation. Some water remains in Eastern Wetland (7428 652741) 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 Bumbang Creek and the Murray River 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 September	Raising	Timed to coincide with winter and spring Longitudinal connection between the floodplain and Murray River. Newly inundated wetland and backwater 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. Exposed benches, banks and large wood within the Murray River are inundated.

October to November	Raising	The low terraces are connected promoting floodplain productivity, enhancing the health of mature woodland trees. There is increased inundation of the channels, wetlands and backwaters promoting a broader zone of littoral macrophytes and offering a diversity of foraging and refuge habitats for waterbirds and other water-dependent fauna. Breeding and movement of fish such as Golden Perch, Murray Cod and Silver Perch movement and breeding may be stimulated. Available habitat, for Freshwater Catfish and other large-bodied fish such as Golden Perch who opportunistically use the floodplain, 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.

8. Managing Risks to Achieving Objectives

Potential risks associated with environmental water delivery at Bumbang

Island are outlined below, 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. Possible risks and mitigation measures associated with environmental water delivery to Bumbang Island

Threat	Likelihood	Consequence	Risk – H, M, L (likelihood x consequence)	Management Measure	Residual Risk
Failure to meet ecological objectives or show achievement of objectives	Possible	High	H	Monitoring program in place. Adaptive approach.	Low
Inability to deliver optimal water regime through weir pool manipulation	Possible	High	M	N/A	
Species/ communities or ecological processes have been overlooked in water regime due to lack of data	Likely	Low	L	Monitoring and ongoing updates to the EWMP	
Water not available for weir recharge following drawdown in autumn	Unlikely	High	M		
Flood duration too long or too short	Possible	High	M	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	L	Monitoring and control measures	
Water quality decline due to saline groundwater intrusion from weir drawdown	Possible	Moderate	L	Monitoring and adjustment of weir manipulation	
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	High	L	Monitoring and review of watering regime	
Environmental watering program negatively affects cultural heritage sites	Likely	Moderate	M	Monitoring, assessing and evaluating outcomes	Low

9. Environmental Water Delivery Infrastructure

9.1 Constraints

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 +0.7m AHD based on advice from the weir operator (P. Cocks pers. comm. September 2014). 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 is currently being undertaken (Ecological Associates, 2012 in prep.). Watering recommendations for Bumbang Island should be complimentary to the other sites within the influence of the weir.

Fish Ladder

A Denil fishway was installed on Euston Weir in 2005. Operation of the fishway is an important consideration in any weir pool level manipulations.

Recreation

The Euston weir pool is valued by the communities of Euston and Robinvale and other small towns for the recreational opportunities that it provides. A significant water skiing event is held in March each year within the weir pool. Given the economic value of such events to the local community, this may act as a constraint to lowering the weir pool to the optimum level in March for the period of the event. Further investigation would be required to determine the impact.

9.2 Infrastructure or complementary works recommendations

Ecological Associates (2006) investigated flow management opportunities for Bumbang Island as part of the broader investigation of wetlands between Nyah and Robinvale. The primary recommendation was around the benefits associated with weir pool manipulation. Infrastructural options were not recommended for Bumbang Island.

10. Demonstrating Outcomes

10.1 Monitoring Priorities at the Site

Ecological monitoring is required to demonstrate the effectiveness of weir pool manipulation in achieving ecological objectives, to help manage environmental risks and to identify opportunities to improve the efficiency and effectiveness of the program.

There is very little information available on the flora and fauna at this site. Therefore flora and fauna surveys should be undertaken, focusing on the ecological objectives. Baseline condition information such as Index of Wetland Condition assessments should also be undertaken. In the short term, weir pool manipulation without these studies will provide widespread benefits experienced along the weir pool. Photopoints in the short term should be sufficient to show changes in vegetation quality and diversity at different times of the year. In field and community observations of species at/around the island will also be valuable to show improvements at Bumbang Island.

As the site is managed by Parks Victoria for its cultural significance, monitoring of the cultural heritage sites should also be a priority. The focus should be on minimising risk to the sites, such as scar trees and middens which may be affected by the water regime.

An ecological monitoring program was developed to assess environmental responses to drying and flooding the Euston Lakes floodplain during the Millennium Drought and subsequent 2011 flood event. This program monitors environmental variables including water levels, water quality and ecological responses including native and pest fish abundances, waterbird visitation and breeding and vegetation health. Elements of this program could be extended to additional sites within the weir pool, such as Bumbang Island.

11. Consultation

The following stakeholders were consulted in the preparation of this EWMP.

Table 17 Stakeholders consulted during preparation of this EWMP.

Meeting Date	Stakeholders	Details
9th Feb 2015	Parks Victoria	Discussion to introduce concept of plan
2nd March 2015	Aboriginal Reference Group	Presentation of plan
April 2015	Indigenous Groups	Face-to-face discussions/on-Country visits
12th February 2015	Land and Water Advisory Committee	Presentation of plan

12. Knowledge Gaps and Recommendations

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.

Action	Priority (H,M,L)	Responsibility
Determine sill level of wetlands	H	CMA
Baseline condition assessment – IWC, ISC	M	CMA
Fish and waterbird surveys	H	CMA
Hydraulic modelling (subject to review of the Lock 15 hydraulic modelling results)	H	CMA
Lidar or Aerial photography capturing inundation extent at low water levels 47.6m AHD	H	CMA
On ground mapping of actual inundation levels associated with weir pool manipulation	H	CMA
Mapping of cultural sites of significance within Island (areas 2, 4,5,6,7 identified by (Long & Berrill, 2001)). Ongoing monitoring following weir pool manipulation.	M	Parks Victoria

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14. Abbreviations and Acronyms

CMA	Catchment Management Authority
DELWP	Department of Environment, Land, Water and Planning
EVC	Ecological Vegetation Class
EWMP	Environmental Water Management Plan
MDBA	Murray-Darling Basin Authority (formally Murray-Darling Basin Commission, MDBC)
RRG	River Red Gum
VEWH	Victorian Environmental Water Holder

15. Appendix 1 – Fauna Species List

Taxon ID	Scientific Name	Common Name	Victorian Advisory List	EPBC	Count of Sightings
60555	*Climacteris picumnus victoriae*	Brown Treecreeper (south-eastern ssp.)	Near threatened		1
10226	*Haliaeetus leucogaster*	White-bellied Sea-Eagle	Vulnerable		1
10043	*Ocyphaps lophotes*	Crested Pigeon			1
10061	*Tachybaptus novaehollandiae*	Australasian Grebe			1
10096	*Phalacrocorax carbo*	Great Cormorant			2
10097	*Phalacrocorax sulcirostris*	Little Black Cormorant			1
10106	*Pelecanus conspicillatus*	Australian Pelican			2
10125	*Chroicocephalus novaehollandiae*	Silver Gull			1
10133	*Vanellus miles*	Masked Lapwing			2
10179	*Threskiornis molucca*	Australian White Ibis			2
10189	*Ardea pacifica*	White-necked Heron			1
10202	*Chenonetta jubata*	Australian Wood Duck			2
10208	*Anas superciliosa*	Pacific Black Duck			2
10228	*Haliastur sphenurus*	Whistling Kite			1
10269	*Cacatua galerita*	Sulphur-crested Cockatoo			3
10271	*Cacatua sanguinea*	Little Corella			2
10273	*Eolophus roseicapilla*	Galah			3
10282	*Platycercus elegans*	Crimson Rosella			2
10295	*Psephotus haematonotus*	Red-rumped Parrot			2
10322	*Dacelo novaeguineae*	Laughing Kookaburra			2

Taxon ID	Scientific Name	Common Name	Victorian Advisory List	EPBC	Count of Sightings
10357	*Petrochelidon neoxena*	Welcome Swallow			1
10364	*Rhipidura leucophrys*	Willie Wagtail			2
10415	*Grallina cyanoleuca*	Magpie-lark			2
10529	*Malurus cyaneus*	Superb Fairy-wren			1
10625	*Lichenostomus penicillatus*	White-plumed Honeyeater			1
10634	*Manorina melanocephala*	Noisy Miner			2
10638	*Anthochaera carunculata*	Red Wattlebird			2
10641	*Entomyzon cyanotis*	Blue-faced Honeyeater			1
10700	*Cracticus nigrogularis*	Pied Butcherbird			1
10705	*Gymnorhina tibicen*	Australian Magpie			2
10930	*Corvus coronoides*	Australian Raven			2
10976	*Pardalotus striatus*	Striated Pardalote			1

16. Appendix 2 – Likely fish, turtles and frog species supported by Bumbang Island

Table 13 - Species of fish sampled at Murray River at Belsar Island (Ho, et al., 2004)* and likely to be found at Bumbang Island.

Common Name	Scientific Name	Belsar Island	Marcooyia Lagoon
Carp Gudgeon spp.	*Hypseleotris spp.*	√	√
Fly-Specked Hardyhead	*Craterocephalus stercusmuscarum*	√	√
Bony Bream	*Nematalosa erebi*	√	
Flathead Gudgeon	*Philypnodon grandiceps*	√	√
Australian Smelt	*Retropinna semoni*	√	
Golden Perch	*Macquaria ambigua*	√	
Crimson Spotted Rainbowfish	*Melanotaenia fluviatilis*	√	
Dwarf Flathead Gudgeon	*Philypnodon species*	√	
Murray Hardyhead	*Craterocephalus fluviatilis*	√	

* (Ho, et al., 2004) also suggest that Murray Cod, Silver Perch and Freshwater Catfish may have been present at many of the sampled sites, however the sampling techniques did not favour species that were generally found in deeper habitats.

Table 14 - Species of turtles sampled at Marcooyia Lagoon (Ho, et al., 2004) and likely to be found at Bumbang Island.

Common Name	Scientific Name	Belsar Island	Marcooyia Lagoon
Broad-Shelled Turtle	*Chelodina expansa*		√
Eastern Long-Necked Turtle	*Chelodina longicollis*		√
Murray Turtle	*Emydura macquarii*		

(Ho, et al., 2004) did not record any frogs calling at either the Belsar Island or Marcooyia Lagoon sites. However, this may have been due to the timing of the study.

17. Appendix 3 – Ecological Vegetation Classes (EVCs)

EVC No.	EVC Name	Area (Ha)	Bioregional Conservation Signifnicance	Description
103	Riverine Chenopod Woodland (syn. Black Box Chenopod Woodland)		Depleted	Eucalypt woodland to 15 m tall with a diverse shrubby and grassy understorey occurring on most elevated riverine terraces. Confined to heavy clay soils on higher level terraces within or on the margins of riverine floodplains (or former floodplains), naturally subject to only extremely infrequent incidental shallow flooding from major events if at all flooded.
104	Lignum Swamp		Vulnerable	Typically treeless shrubland to 4 m tall, with robust (but sometimes patchy) growth of lignum. Widespread wetland vegetation type in low rainfall areas on heavy soils, subject to infrequent inundation resulting from overbank flows from rivers or local runoff.
106	Grassy Riverine Forest		Depleted	Occurs on the floodplain of major rivers, in a slightly elevated position where floods are infrequent, on deposited silts and sands, forming fertile alluvial soils. River Red Gum forest to 25 m tall with a groundlayer dominated by tussock-forming graminoids. Occasional tall shrubs present.
295	Riverine Grassy Woodland		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.
808	Lignum Shrubland		Least Concern	Relatively open shrubland of species of divaricate growth form. The ground-layer is typically herbaceous or a turf grassland, rich in annual/ephemeral herbs and small chenopods. Characterised the open and even distribution of relatively small Lignum shrubs. Occupies heavy soil plains along Murray River, low-lying areas on higher-level (but still potentially flood-prone) terraces.
810	Floodway Pond Herbland		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.

EVC No.	EVC Name	Area (Ha)	Bioregional Conservation Signifnicance	Description
811	Grassy Riverine Forest/ Floodway Pond Herbland Complex			
813	Intermittent Swampy Woodland		Depleted	Eucalypt woodland to 15 m tall with a variously shrubby and rhizomatous sedgy - turf grass understorey, at best development dominated by flood stimulated species in association with flora tolerant of inundation. Flooding is unreliable but extensive when it happens. Occupies low elevation areas on river terraces (mostly at the rear of point-bar deposits or adjacent to major floodways) and lacustrine verges (where sometimes localised to narrow transitional bands). Soils often have a shallow sand layer over heavy and frequently slightly brackish soils.
818	Shrubby Riverine Woodland		Least concern	Eucalypt woodland to open forest to 15 m tall of less flood-prone (riverine) watercourse fringes, principally on levees and higher sections of point-bar deposits. The understorey includes a range of species shared with drier floodplain habitats with a sparse shrub component, ground-layer patchily dominated by various life-forms. A range of large dicot herbs (mostly herbaceous perennial, several with a growth-form approaching that of small shrub) are often conspicuous.
823	Lignum Swampy Woodland		Depleted	Understorey dominated by Lignum, typically of robust character and relatively dense (at least in patches), in association with a low Eucalypt and/or Acacia woodland to 15 m tall. The ground layer includes a component of obligate wetland flora that is able to persist even if dormant over dry periods.
824	Woorinen Mallee		Vulnerable	Widespread mallee woodland to 12 m tall, associated with the east-west orientated calcareous dunefields of the Woorinen Formation with a low, open chenopod dominated shrub understorey. A diverse array of sub-shrubs, herbs and grasses are also present. Typically occurs on fine textured red-brown sandy loam and clay loam soils.

18. Appendix 4 – Flora Species List

Taxon ID	Scientific Name	Common Name	Victorian Advisory List	EPBC
500584	*Calocephalus sonderi*	Pale Beauty-heads		
501125	*Eclipta platyglossa subsp. platyglossa*	Yellow Twin-heads		
501471	*Euchiton sphaericus*	Annual Cudweed		

19. Appendix 5 - Cultural Heritage Contingency Plan

CONTINGENCY PLANS

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

19.1 Management of Aboriginal Cultural Heritage found during the Activity

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

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

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

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

a. Discovery:

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

b. Notification:

- Once suspected human skeletal remains have been found, Victoria Police (use the local number) and the Coroner's Office (1300 309 519) must be notified immediately;

- If there is reasonable grounds to believe that the remains could be Aboriginal, the DSE Emergency Co-ordination Centre must be immediately notified on 1300 888 544; and
- All details of the location and nature of the human remains must be provided to the relevant authorities.
- If it is confirmed by these authorities that the discovered remains are Aboriginal skeletal remains, the person responsible for the activity must report the existence of the human remains to the Secretary, DPCD in accordance with s.17 of the Act.

3. Impact Mitigation or Salvage:

- The Secretary, after taking reasonable steps to consult with any Aboriginal person or body with an interest in the Aboriginal human remains, will determine the appropriate course of action as required by s.18(2)(b) of the Act.
- An appropriate impact mitigation or salvage strategy as determined by the Secretary must be implemented.

4. Curation and Further Analysis:

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

5. Reburial:

- Any reburial site(s) must be fully documented by an experienced and qualified archaeologist, clearly marked and all details provide to AAV;

Appropriate management measures must be implemented to ensure that the remains

are not disturbed in the future