Spence's Bend Environmental Water Management Plan

mallee catchment management authority

Department of Environment, Land, Water & Planning
State Government Victoria

DOCUMENT CONTROL

Version number	Description	Issued to	Issue date
1	Draft Report	Mark Stacey	2010
2	Draft submitted to scientific panel for review	Jane Roberts	2/6/2014
3	Incorporate Comments	Simone Wilkie (Riverness Pty Ltd)	14/11/2014
4	Internal Review Mallee CMA	L. Murphy & L. Chapman	18/02/2015
5	Incorporate Comments	Simone Wilkie (Riverness Pty Ltd)	4/03/2015
6	Submission to DELWP		

Citation

Please cite this document as:

Mallee CMA (2015) Spence's Bend Environmental Water Management Plan, Mallee CMA, Mildura Victoria

Contact

For queries regarding this document, please contact :

Louise Chapman

lchapman@malleecma.com.au

Coordinator Waterways

Mallee Catchment Management Authority

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) identified 23 Waterway Management Units (WMU). The hydrological interconnectedness and commonality of threats impacting on the waterways values were used to group them into planning units. This EWMP has been developed for the Spence's Bend WMU Sub-Unit. Hereafter referred to as Spence's Bend in this document. The EWMP will help to guide future environmental watering activities for this area.

Spence's Bend is located in the Robinvale Plains bioregion within the Mallee Catchment Management Authority (Mallee CMA) region 40 km south-east of Mildura and covers 1,210 ha. A regional context document provides further information on the region and has been created to compliment the Mallee CMAs EWMPs and should be read in conjunction with this document (North, 2014).

The main features of Spence's Bend are Bullock Swamp, Lake Iraak, Carwarp Creek and a series of smaller wetlands including Spence's Bend Billabong and Callander's Swamp. This plan focuses on a target area within Spence's Bend, covering 341 ha, able to be inundated through environmental watering.

Spence's Bend consists of a forested floodplain area with several wetlands, ranging from deep to shallow freshwater and semi-permanent saline systems. These provide habitat for a large range of fauna, including 32 species of waterbirds and six listed species, including the Regent Parrot (Polytelis anthopeplus monarchoides), Golden Perch (Macquaria ambigua) and Growling Grass Frog (Litoria ranformis).

The long term management goal of the Spence's Bend EWMP is to provide a water regime that reflects natural inundation seasonality and duration that will maintain and promote the mosaic of available habitats through the Spence's Bend target area.

To achieve this, ecological and hydrological objectives, were designed with the consideration of four inundation stages. These have been developed to sustain the various ecological components of six targeted wetlands and have been incorporated into minimum, optimal and maximum long-term watering regimes. The ecological objectives for Spence's Bend target area are outlined below:

- Improve Swamp and woodland diversity and productivity to meet EVC benchmarks for Lignum Swamp (104) and Lignum Swampy Woodland (823) Communities in Bullock Swamp north
- Increase woodland and shrubland diversity and productivity (including tree health) to meet EVC benchmarks for EVCs 103, 810, 818, 811, 813
- Maintain and Improve woodland, shrubland and Swamp diversity and productivity (including tree health) to meet EVC benchmarks for EVCs 103, 104, 808, 810, 811, 813, 818, 823
- Improve semi-permanent saline marsh habitat for Murray Hardyhead reintroduction
- Reinstate seasonal connectivity between all wetlands in the target area
- Increase aquatic macrophyte (submerged and emergent) diversity and area
- Increase dissolved organic matter, particulate matter and macroinvertebrate productivity
- Improve or maintain water quality (particularly salinity) to meet standards for each wetland type and key species.

Significant infrastructure is required to fully implement this EWMP. The infrastructure outlined in the document is proposed only and requires further investigation and design.

Acknowledgements

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

Introduction

This Environmental Water Management Plan (EWMP) has been prepared by the Mallee Catchment Management Authority (CMA) to establish the long-term management goals of Spence's Bend.

The key purposes of the EWMP are to:

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

Site overview

Site Location

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

The boundaries of the Mallee CMA region cover almost one fifth of Victoria, making it the largest area managed by a CMA in the state.

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

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

The site for this plan is the Spence's Bend FMU, hereafter referred to as Spence's Bend in this document, situated 40km south-east of Mildura on the Murray River floodplain Figure 1. Spence's Bend falls within the Karadoc WMU in the Mallee Waterway Strategy.

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

Catchment Setting

Spence's Bend is located in the Robinvale Plains bioregion within the Mallee CMA region 40 km south-east of Mildura. The Robinvale Plains bioregion is characterised by a narrow gorge confined by the cliffs along the Murray River, which is entrenched within older sedimentary rocks. Alluvium deposits from the Cainozoic period gave rise to the red brown earths, cracking clays and texture contrast soils (Dermosols, Vertosols,

Chromosols and Sodosols) which support Riverine Grassy Forests and Riverine Grassy Chenopod Woodlands.

The mean annual rainfall at Spence's Bend is between 275 and 300 mm. The area consists of naturally draining riverine soils, in the Murray Trench aquifer. The underlying geology is made up of windblown sands overlaying alluvial sediments, then Channel Sands, followed by Blanchetown Clays and Parilla Sands. The alluvial sediments contain a perched groundwater table, which causes natural groundwater discharge features such as Bullock Swamp. The groundwater beneath Bullock Swamp is now generally within 1.57 – 2.55 m of the surface (SKM, 2002).

The private land surrounding Spence's Bend is irrigated horticulture, with crops being predominantly grapevines for wine production, followed by citrus and other fruit trees. The horticultural area has been classified as Low Impact Zone 4, which correlates to tonnes of salt displaced to the Murray River from irrigation. The classification is used to levy new development and report river salinity impacts to the Murray Darling Basin Authority's salinity register. Irrigation drainage water coming from the north of the area discharges to floodplain basins, whilst that from the west discharges to inland basins (Sunrise 21, 2010).

In 2009, land use comprised 621 ha of irrigated horticulture, 140 ha of crops not irrigated and some private land for rural production. Irrigation methods underwent significant changes from 1997 to 2009, with a 63% decline in overhead sprays and 43% increase in drip irrigation. The irrigation drainage water within the WMU currently outfalls into Lake Iraak. The Lake Iraak drainage system comprises a catchment area of 960 ha, with eight outfall points discharging into the lake (Sunrise 21, 2010).

Spence's Bend

Spence's Bend covers an area of 1,210 ha, which is shown in Figure 1. The main features of Spence's Bend are Bullock Swamp, Lake Iraak, Carwarp Creek (used as water storage for stock and domestic use) and a series of smaller wetlands including Spence's Bend Billabong and Callander's Swamp (Figure 1).

Bullock Swamp is a floodplain wetland of approximately 340 ha in size (SKM, 2002). The Swamp is divided into two sections (north and south) by a road levee (SKM, 2013). Carwarp Creek connects Bullock Swamp north to the Murray River but the creek is now regulated to allow landholders along the creek to irrigate their properties. An irrigation channel also runs along the western and northern side of Bullock Swamp north (SKM, 2002). Historically, Bullock Swamp south received irrigation drainage water from the early 1970s (2000 – 3000 EC) but this ceased when the Nangiloc-Colignan Salinity Management Plan was implemented between 1987 and 1991. However, some seepage to the northern section of the Swamp from the adjacent irrigation channel may still continue (SKM, 1998). Bullock Swamp north has suffered considerable degradation as a result of past irrigation disposal, a high groundwater table and altered flood regimes (Predebon, 1990; SKM, 2002).

Spence's Bend Billabong and Callander's Swamp and two unnamed wetlands[1] (#7329 246886 and #7329 242872) are located between Bullock Swamp and the river in the Murray River Park.

[1] The wetlands within this EWMP have been identified, where possible, with names. Where wetland names are unknown or the wetland is unnamed, the unique identifying number from the 2013 Wetlands Layer (DELWP) has been used.

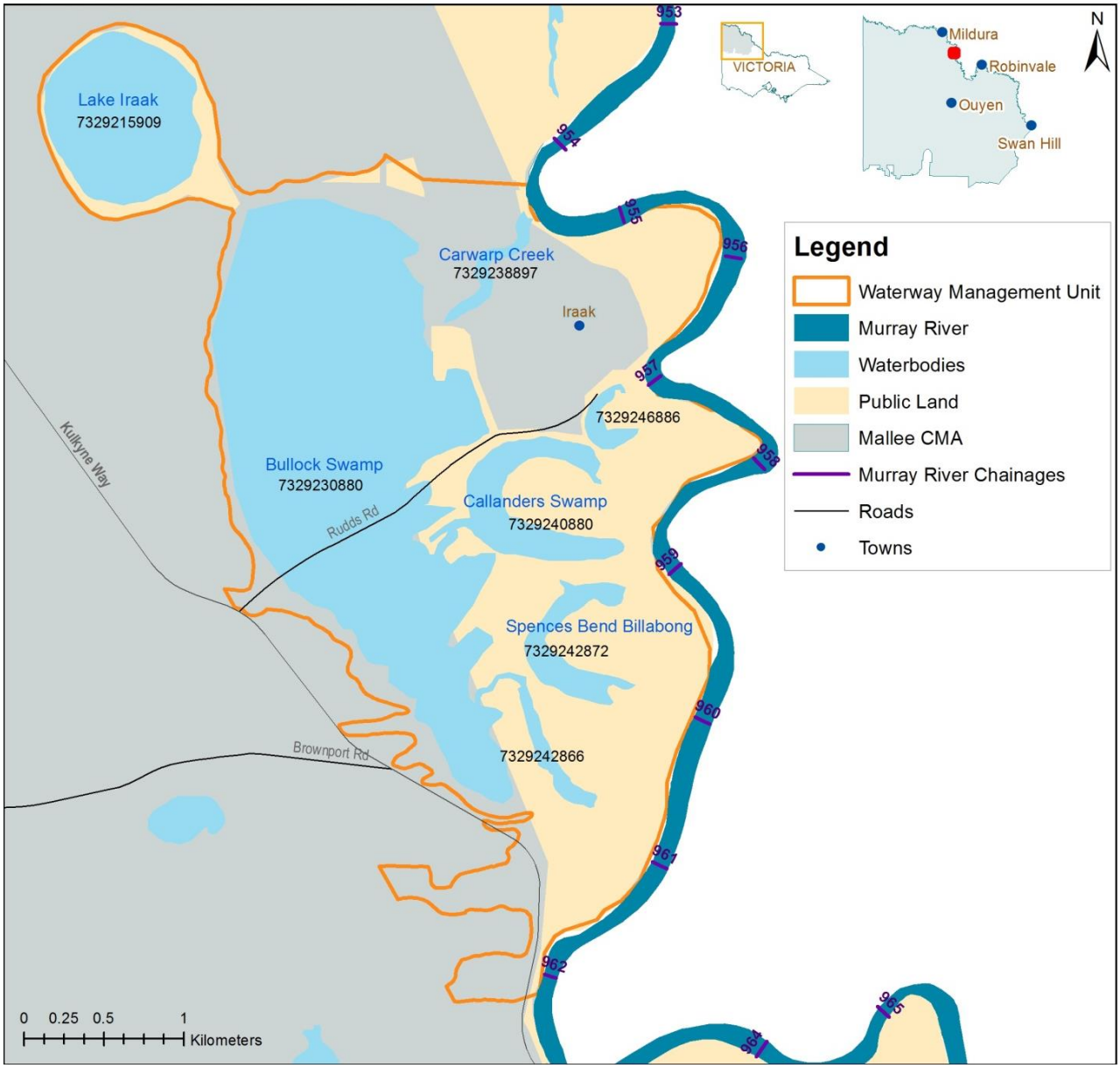
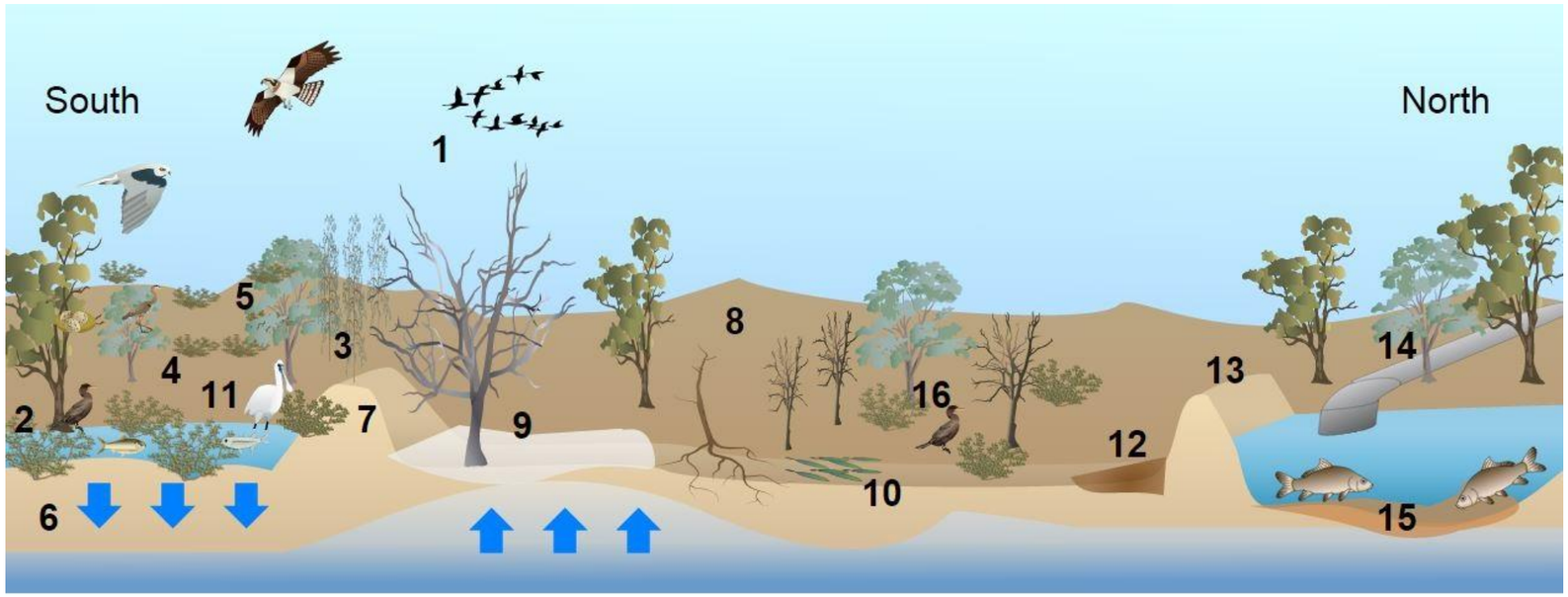


Figure 1 - Map of Spence's Bend

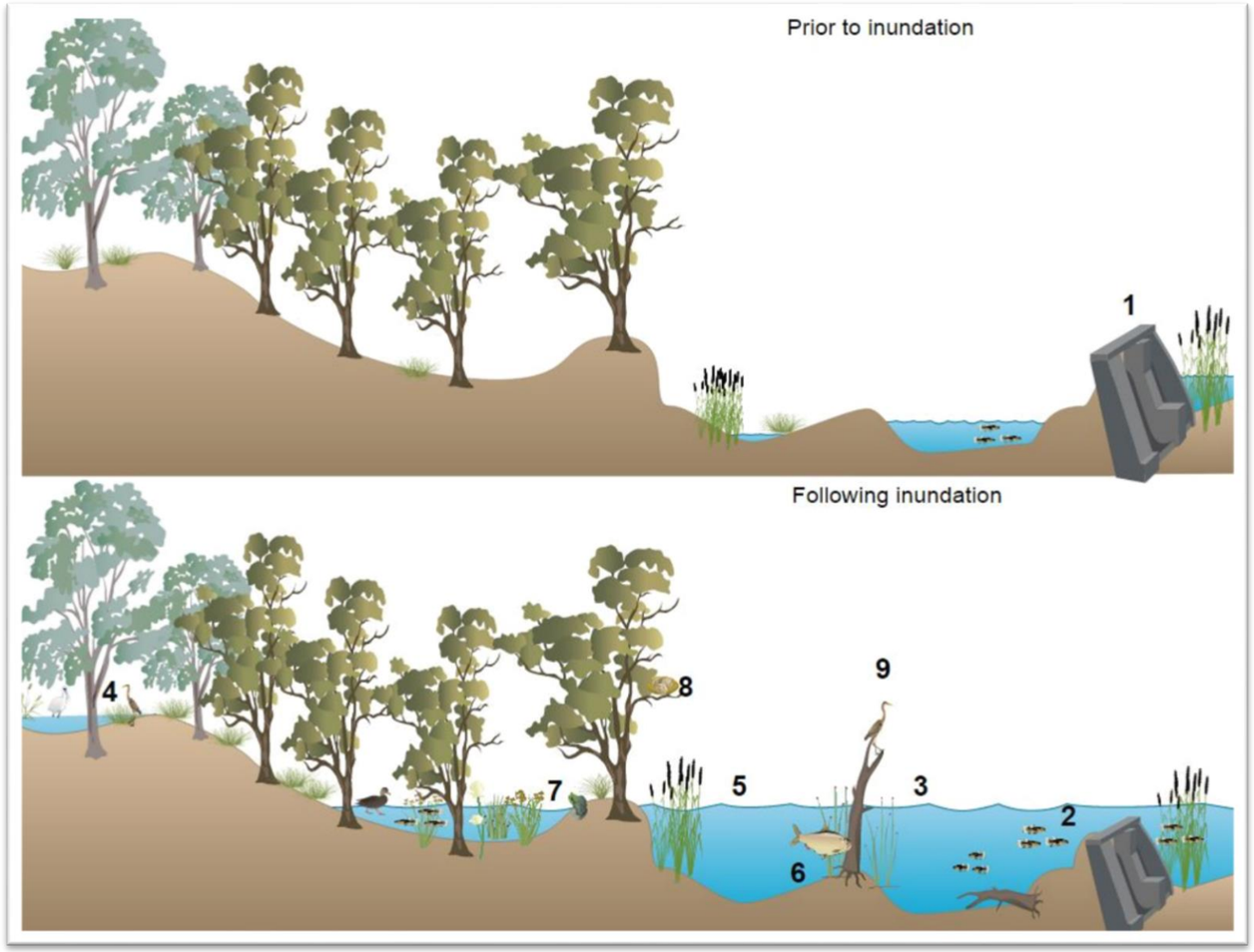
Conceptualisation of the Site

Spence's Bend has been represented in two conceptual models. These models provide a visual representation of the sites processes and components that are discussed throughout the document. They represent the two key types of wetland systems being targeted. The first model is the semi-permanent saline wetland, which is Bullock Swamp (Figure 2), and the second model is the freshwater wetlands, of various types, which represent Callander's Swamp, Spence's Bend Billabong and two unnamed wetlands (#7329 246886 and # 7329 242872) (Figure 3).



1. Bullock Swamp is a semi-permanent saline marsh. Saline marshes provide habitat for crustaceans, attracting dabbling ducks, such as the Hardhead, and significant migratory wading bird species
2. The Lignum Swamp vegetation community covers the majority of Bullock Swamp. When inundated it becomes an aquatic habitat for reptiles and macroinvertebrates and salt-tolerant fish native fish; and provides a feeding area for waterbirds, raptors, owls and reptiles.
3. Lignum Swampy Woodland is found at higher elevations around the eastern edge of Bullock Swamp north and around the southern section of the Swamp. It is dominated by Lignum but also contains River Red Gums and Black Box and small areas of the threatened tree species Buloke and Swamp Sheoak.
4. When inundated, Lignum Swampy Woodland provides feeding, nesting and roosting habitat for waterbirds such as dabbling ducks and Ibis, Spoonbill, Egrets and other wading birds.
5. Lignum shrubland on the higher terraces can be used by Ibis and Spoonbill as nesting sites
6. During flood events water seeps through the substrate and recharges groundwater.
7. A road levee (2m high x 3m wide x 200m long) divides the Swamp into north and south sections, impacting hydraulic connectivity and the movement of flora propagules and fauna.
8. Past irrigation water disposal, a high groundwater table and decreased magnitude and frequency of flood events has led to higher than normal salt loads and water stress for vegetation. This has resulted in degradation of vegetation in the northern section of Bullock Swamp and Black Box tree mortality.
9. In the northern area of the Swamp there is evidence of saline scalds (bare salt-encrusted ground) due to surface seepage
10. Dry conditions diminish the productivity of floodplain plants leading to reduced organic matter inputs into the riverine food chain
11. More frequent flooding has left the vegetation, particularly the understorey, in better condition in Bullock Swamp South.
12. An irrigation channel along the northern and western border of Bullock Swamp leaks water into the Swamp.
13. A regulating structure installed on Carwarp Creek (at the Murray River end) and a levee (at the Bullock Swamp end) reduce connectivity between the Swamp and the river. This restricts the flushing of groundwater and drainage water when floods subside and the movement of aquatic species between the two. It also reduces the frequency and magnitude of flooding events.
14. Regulation of the Murray River, water extraction for irrigation use and in-stream structures such as weirs and dams also reduce the frequency and duration of flooding events.
15. Common Carp present in Carwarp Creek (and potentially in other wetlands at the site) increasing turbidity and reducing aquatic vegetation.
16. Habitat for breeding opportunities for colonial waterbirds such as Ibis and Egrets is greatly reduced by diminished flooding frequency, extent and duration.

Figure 2 – Conceptualisation of semi-permanent saline wetland (Bullock Swamp)



1. Regulation of the Murray River, water extraction for irrigation use and in-stream structures such as regulators and levees reduce the magnitude, frequency and duration of flooding events.
2. In-stream structures prevent the movement of flora and fauna between waterbodies and the Murray River during low flows. This has negative impacts on recolonization, dispersal, genetic diversity within species, breeding and the completion of life cycles
3. A range of wetland types are present, ranging from shallow to deep freshwater and a forested floodplain.
4. During higher Murray River flows, water moves into the billabongs from upstream and floodplains are inundated.
5. These freshwater wetlands will host deep freshwater marsh, permanent open freshwater and shallow freshwater marsh; providing habitat for turtles, frogs, waterbirds and a range of small-bodied fish.
6. Slow-flowing areas of warm, turbid water provide habitat for Golden Perch
7. In areas of intermediate water depth, dense semi-emergent macrophytes covered with biofilms will provide shelter and food for macroinvertebrates, tadpoles and small-bodied fish. Dabbling Ducks will graze on the soft-bodied vegetation and prey on macroinvertebrates.
8. River Red Gum dominated Riverine Forest and Woodland communities fringe the temporary wetlands and creeks at points of intermittent flooding, with Blackbox vegetation communities present further up the terraces that receive less frequent flooding. During flooding of adequate duration and extent these wetland and woodland mosaics provide shelter, food and nesting habitat for Darters, Cormorants, Egrets, Herons and Spoonbills.
9. River Red Gums drop woody debris into wetlands, providing structural habitat such as perching sites for waterbirds and snags for fish.

Figure 3 - Conceptualisation for freshwater wetlands (Callanders Swamp, Spence's Bend Billabong and two unnamed wetlands (#7329 246886 and # 7329 242872)

Land Status and Management

There are many agencies and individuals involved in managing the public and private land in Spence's Bend. Land boundaries are shown in Figure 4.

The majority of the Spence's Bend area has historically been managed by the Department of Environment, Land, Water & Planning (DELWP) as State Forest under the Murray River Reserve (LCC, 1989).

The forested area and river bend of Spence's Bend and the south east section of Bullock Swamp are within the Murray River Park and are now managed by Parks Victoria in accordance with recommendations made by the River Red Gum Forests Investigation (VEAC, 2008). The remaining public land in Spence's Bend is the Carwarp Bushland Area and Lake Iraak. Lake Iraak is managed by Lower Murray Water as an irrigation drainage disposal basin.

The section of Bullock Swamp north of Rudds Road that is privately owned is coveted for conservation. The surrounding area to the west is irrigated horticulture on private property (SKM, 2002). Stakeholders for the Spence's Bend EWMP are shown in Table 1.

. Table 1 - Stakeholders for the Spence's Bend EWMP

Group	Role
Parks Victoria	Land Manager
Mallee CMA	Regional environmental management
Department of Environment, Land, Water and Planning	State level environmental management
Lower Murray Water	Murray River operations and Irrigation drainage
Mildura Rural City Council	Local Government
Local Landholders	Assistance in planning and implementation of programs
Latji Latji and Nyeri Nyeri	Indigenous Representation
Trust for Nature	Oversight of the site in accordance with the conditions of the management covenant for Bullock Swamp north

.

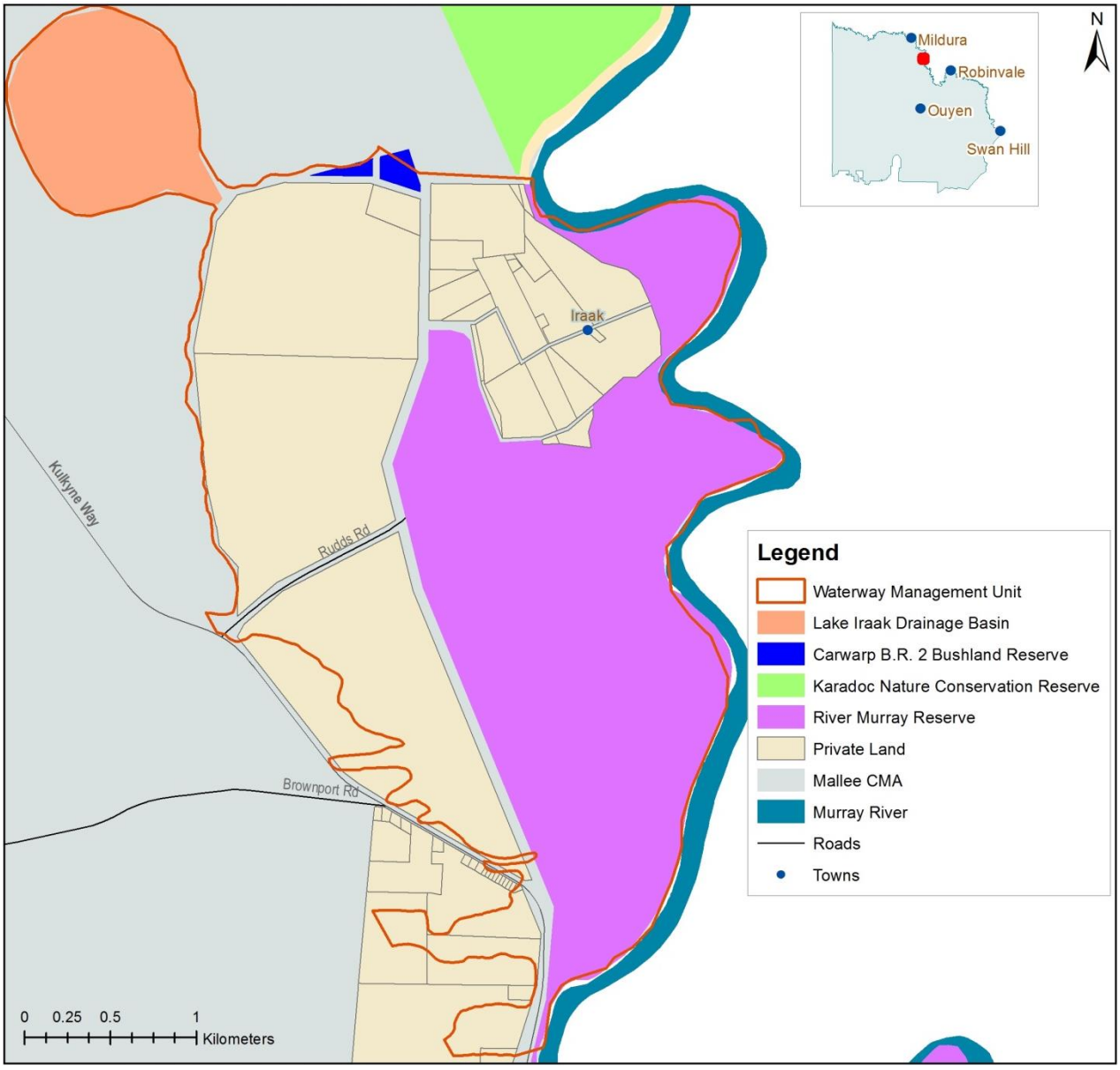


Figure 4 - Land management boundaries at Spence's Bend

Wetland Characteristics

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

Table 2 - Wetland characteristics at Spence's Bend

Characteristics	Description
Name	Spence's Bend
Individual wetlands within Spence's Bend WMU Sub-Unit (numbers follow Corrick numbering system in Wetlands 1994 layer)	Bullock Swamp #7329 230880 Lake Iraak #7329 215909 Carwarp Creek #7329 238897 Spence's Bend Billabong #7329 242872, Callander's Swamp #7329 240880 and #7329 242866 #7329 246886.
Area	Total area of whole WMU 1190 ha Total of all wetlands 519.6 ha • Bullock Swamp (370.7 ha) • Lake Iraak (81.52 ha)* • Carwarp Creek (7.77 ha) • Spence's Bend Billabong (16.65 ha) • Callander's Swamp (28.8 ha) • #7329 242866 (8.17 ha) • #7329 246886 (5.99 ha)
Bioregion	Robinvale Plains
Conservation status of EVCs in Spences Bend WMU Sub-Unit	Vulnerable, Depleted and Least Concern
Land status	Regional Park and Private
Land manager	Parks Victoria and Private landholders

Characteristics	Description
Surrounding land use	Farming Zone
Water supply	Bullock Swamp North receives inflows from the Murray River during very high flow events (140,000 ML/day), seepage from an adjacent irrigation channel, groundwater and rainfall. Bullock Swamp South receives Murray River inflows when the river reaches 86,000 ML/day. Wetland #7329 246886 (ctf** 19,000 ML/day), Spence's Bend Billabong and Callander's Swamp (ctf 19,300 – 37,900 ML/day) receive flows from the Murray River via a regulated channel. Lake Iraak currently receives irrigation drainage water.
1788 wetland category	Deep Freshwater Marsh (Bullock Swamp, Lake Iraak and Spence's Bend Billabong), Permanent open freshwater (x2), Shallow freshwater marsh (x1)
1994 wetland category and sub-category	Semi-permanent saline (Bullock Swamp and Lake Iraak), Deep freshwater marsh (Spence's Bend Billabong), Permanent open water (Callander's Swamp and #7329 246886), Shallow freshwater marsh (#7329 242866)
Wetland depth at capacity	1-4 m approximately

*Lake Iraak is excluded from the Spences Bend EWMP target area

**ctf – CTF is the term 'commence to flow' and refers to the flow in ML/day in the Murray River when the wetland will begin to fill. The ctf's have been estimated through modelling.

Management Scale

Spence's Bend EWMP Target Area

The whole of Spence's Bend has a water requirement as a floodplain complex but the focus for this plan is restricted to a target area within Spence's Bend of 341 ha, as shown in Figures 5 and 6.

This target area is the area of Spence's Bend that is able to be managed with environmental water, following the construction of the infrastructure proposed in this EWMP in place. It does not include the entire FMU, and refers to six of the seven wetlands in Spence's Bend WMU Sub-Unit.

Lake Iraak has been excluded from the target area as this wetland is an active irrigation drainage disposal basin. Rehabilitation of this wetland is not possible as long as active drainage to the lake is occurring. Expansion of the target area is possible only with significant alterations to the operations of the Murray River, such as large releases from storage which is beyond the scope of this plan.

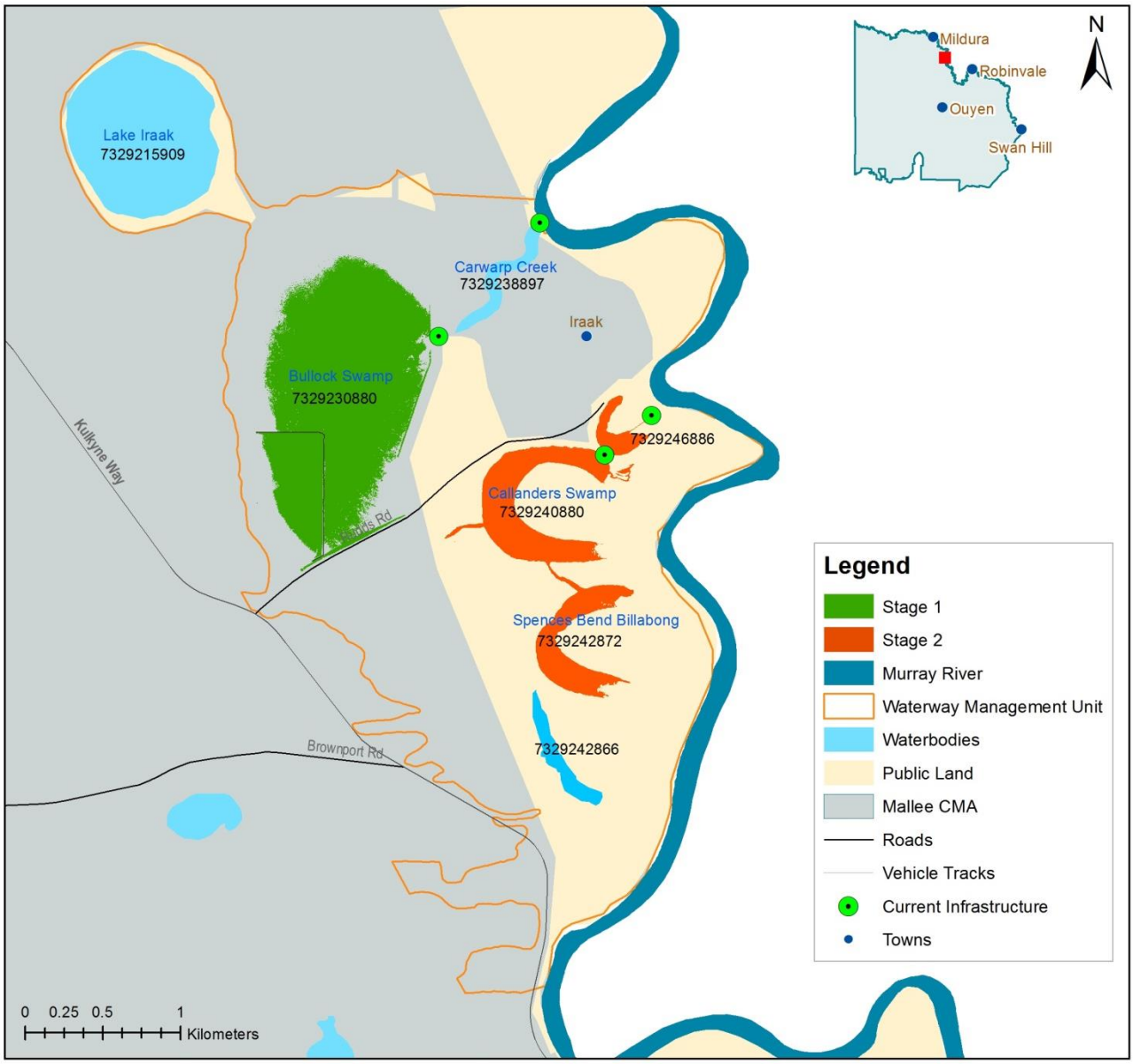


Figure 5 – Target areas shown are included in Stage 1 and 2 for the Spence's Bend EWMP

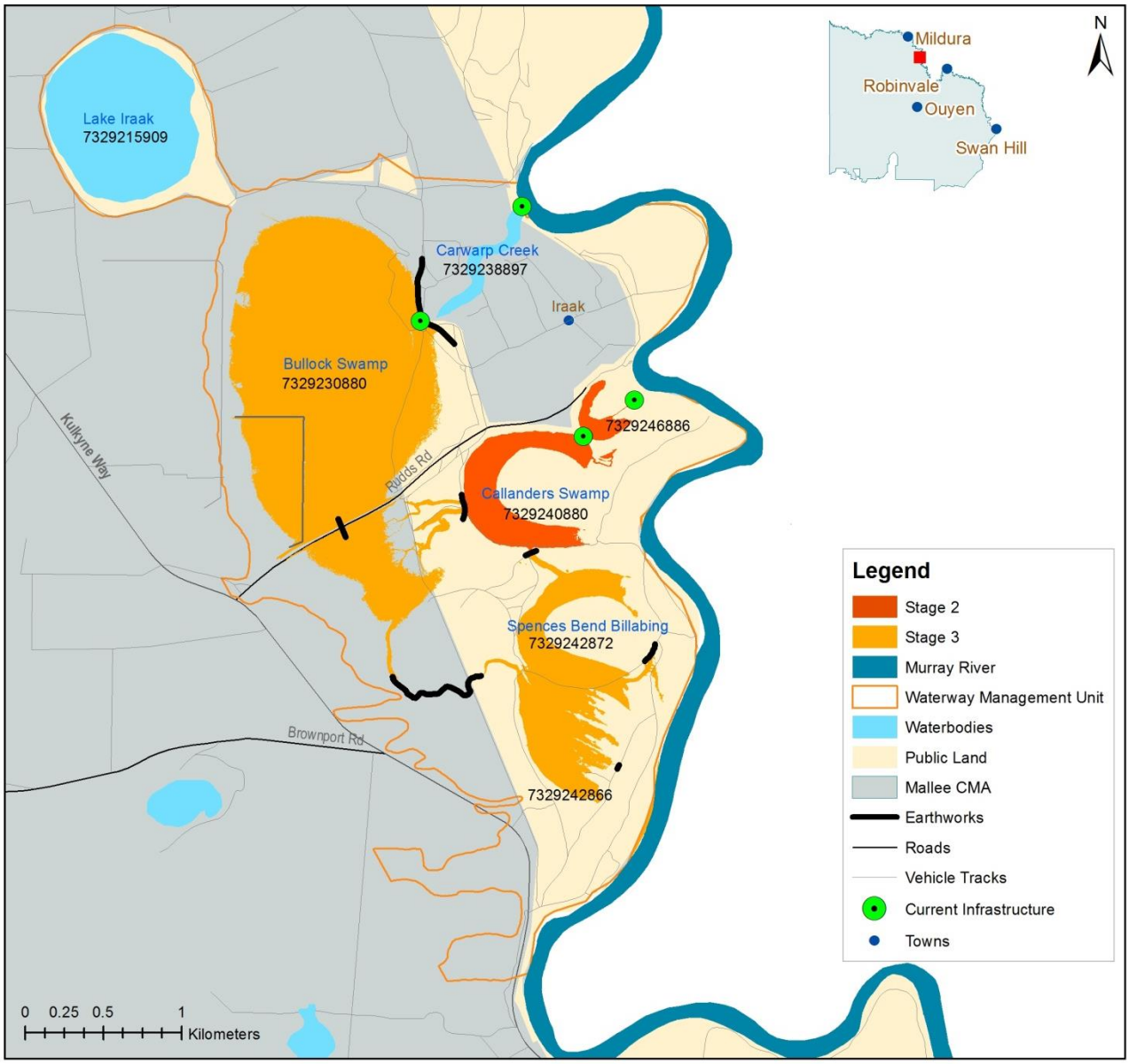


Figure 6 – Target areas shown are included in Stage 2 and 3 for the Spence's Bend EWMP

Overview of the Watering Proposal and Inundation Stages

The Spence's Bend EWMP proposes a staged implementation of environmental watering. The area inundated following implementation of the three stages of the EWMP is the target area for the EWMP.

Stage 1 and 2 (Figure 5) can be achieved using existing infrastructure, whereas Stage 3 (Figure 6) requires extensive works. Infrastructure recommendations are discussed fully in the Environmental Water Delivery Infrastructure section of this document.

Stage 1

Stage 1 (Figure 5) involves the inundation of approximately 140 ha of Bullock Swamp north of Rudds Road, requiring approximately 312 ML of environmental water. This will be the option adopted in the early phases of environmental water delivery to Spence's Bend.

Stage 2

The wetlands involved in Stage 2 (Figures 5 and 6) include Spence's Bend Billabong, Callander's Swamp and wetland #7329 238897. This stage will inundate an area of approximately 53 ha and require

approximately 650 ML of environmental water. These wetlands are the first to receive inflows under high Murray River levels, although their connection to the river is regulated. These wetlands have received environmental water in the past and in mid-2014 were in a drying phase. Environmental water may be delivered to these sites again in the future under Stage 2.

Stage 3

The inundation extent for Stage 3 (Figure 6) includes Spence's Bend Billabong, wetland #7329 246866 and Bullock Swamp south and north. This stage aims to restore connectivity between all the wetlands and provide major inundation of the target area. This may be achieved by connecting the northern and southern sections of Bullock Swamp via a regulated culvert under Rudds Road. This would allow through-flows between Bullock Swamp north and south and on to the wetlands within the Murray River Park. This would provide the opportunity for return flows back to the Murray River from Bullock Swamp north to aid in rehabilitation of the Swamp. This stage would inundate approximately 306 ha and require approximately 2486 ML of environmental water.

Combining Stage 2 and 3 to inundate all wetlands in the target area at once would inundate an area of approximately 341 ha and require approximately 2949 ML of environmental water.

Stage 4 (Figure 15) – Murray Hardyhead introduction – Bullock Swamp North and South

If Bullock Swamp is selected as a site for reintroduction of Murray Hardyhead, and appropriate works are undertaken to improve connectivity between north and south Bullock Swamp, the Swamp should be inundated every year, with an optimal duration of 6 months to support the semi-permanent saline wetland conditions (Ecological Associates, 2007b).

Specific Assessment of Salinity Risk

The Bullock Swamp area was part of a *Preliminary Salinity Impact Assessment for Mallee Environmental Water Projects* study (SKM, 2013) on behalf of the Mallee CMA. The four stages discussed above were provided to SKM for this purpose resulting in the salinity impacts at Morgan in South Australia in the Bullock Swamp region to be between 0.002 EC (Stage 2) and 0.005 EC (Stage 3) and negligible for Stage 1 (SKM, 2013). According to the MDBA's Basin Salinity Management Strategy Operational Protocol, a significant effect is a change in the average daily salinity at Morgan of at least 0.1 EC over a 100 year timeframe.

Australian Water Environments Pty. Ltd. (2014) undertook a follow up salinity impact assessment in 2014. The objective of the assessment was to determine the salinity impact at Morgans from environmental watering activities associated with the proposed watering regime.

The study identified that the key salt mobilisation processes likely to be triggered by environmental watering included:

- Salt wash-off from the bed of Bullock Swamp;
- Leaching of salt and recharge of the groundwater system;
- Evapoconcentration of surface water held on the floodplain.

Bullock Swamp is estimated to store 17 tonnes/hectare/meters of salt in the unsaturated soil zone (Australian Water Environments, 2014). The revised preliminary impact assessment (Australian Water Environments, 2014) suggests that holding water on the floodplain produces a lower EC impact at Morgan than holding and releasing water to the River (although both are likely to be unaccountable actions). The advantage of releasing water to the River is that some of the salt stored on the Bullock Swamp floodplain will be removed from the system. The follow up study concluded that under all four stages and for both options the maximum EC Impact at Morgan (1 in 3 year frequency) is 0.006 EC (if water is held within Bullock Swamp) and 0.076 EC if water is held in Bullock Swamp and then released to the Murray River. Neither value is an accountable salinity impact at Morgan.

Environmental Water Sources

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

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

Environmental Water for the study site may be sourced from the water entitlements and their agencies listed in Table 3 and further explained in the Regional Context Document (North, 2014). Recent environmental watering which has occurred at the Spence's Bend site is outlined in the Environmental Watering section.

Table 3 - Summary of environmental water sources available to Spence's Bend WMU Sub-Unit

Water Entitlement*	Responsible Agency
Murray River Unregulated Flows (RMUF)	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	Mallee CMA

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

Related Agreements, Policy, Plans and Activities

There are a range of international treaties, conventions and initiatives, as well as National and State Acts, policies and strategies that determine management of the target area. Those with particular relevance to the site and the management of its environmental values are listed in Table 4. For the functions and major elements of each refer to the Regional Context Document (North, 2014).

Table 4- Legislation, agreements, convention and listings relevant to the target area

Legislation, Agreement or Convention	Jurisdiction
China-Australia Migratory Bird Agreement (CAMBA)	International
Environment Protection and Biodiversity Conservation Act (EPBC)	National
Flora and Fauna Guarantee Act (FFG)	State
Department of Environment, Land, Water and Planning advisory lists (DELWP)	State

Spence's Bend has been included in several large-scale investigations. These include Salinity Management Plans, Flow studies and the Land Conservation Council (LCC) review, as well as the investigation into River

Red Gums by the Victorian Environmental Assessment Council (VEAC) in 2008, which resulted in part of the area being changed from State Park to a Regional Park in 2010.

In 1998, the Sunraysia Rural Water Authority, commissioned *a Feasibility study to rehabilitate Bullock Swamp* (SKM, 1998). This study focused on the groundwater and surface water interactions, the health of River Red Gums and options for rehabilitation.

In 2002 SKM developed a Management plan for Bullock Swamp (SKM, 2002) . The management plan set objectives for the wetland but was also based on LCC recommendations for the surrounding public land. These were:

1. Restore water-dependent flora and fauna values;
2. Ensure a coordinated management approach with land holders adjacent to the wetland;
3. Gain agreement from all management parties to manage the wetland in an adaptive manner; and.
4. Promote a community understanding of the ecological processes associated with the wetland.

In 2007, the Mallee CMA engaged consultants (Ecological Associates) to investigate water management options for the floodplain of the Murray River from Robinvale to Wallpolla Island (Ecological Associates, 2007b). This investigation proposed infrastructure to enable more frequent inundation of the target area in Spence's Bend which is outlined as part of this plan.

The Mallee Waterway Strategy applies a framework for targeting the delivery of management activities in the Mallee Region, including for Spence's Bend. These management activities include options for pest plant and animal control, rubbish removal and earthworks.

DELWP, Parks Victoria and the Mallee CMA have invested significant resources into the area in recent years in both environmental watering in 2005 and 2006 and complementary on ground works such as track upgrading, pest plant and animal control, and improved signage to decrease recreational pressures on the floodplain.

The Bullock Swamp area was part of a '*Preliminary Salinity Impact Assessment for Mallee Environmental Water Projects'* study (SKM, 2013) on behalf of the Mallee CMA. The outcomes from this project are discussed in the Managing Risks to Achieving Objectives section.

Bullock Swamp is one of a number of saline wetlands in the Mallee CMA region that are being investigated for their potential to support translocated populations of Murray Hardy Head (*Craterocephalus fluviatilis), listed under the* the '*Environment Protection and Biodiversity Conservation Act'1988*. A National Recovery Plan for the Murray Hardyhead aims to identify threats to the species and determine recovery objectives and actions to ensure the long-term survival of Murray Hardyhead (Backhouse, Lyon and Cant, 2008). Any activities involving Murray Hardyhead at Bullock Swamp will be undertaken in line with this Recovery Plan.

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.

The target area within Spence's Bend is located on the Victorian floodplain of the Murray River (954.5 km to 962 km) between river gauges Euston (#414203C) and downstream Mildura Weir (#414216A). Since there are no major tributaries or losses from the Murray River between Robinvale and Walpola, the hydrology can broadly be described in terms of flow passing Euston Weir (Ecological Associates, 2007b).

Wetland Hydrology, Water Management and Delivery

Pre-regulation

Prior to regulation of the Murray River flowing past Spence's Bend, the floodplain experienced late winter to spring flood events, which the ecology of the floodplain had adapted to (SKM, 2002).

Under natural conditions Bullock Swamp filled from the Murray River first through Carwarp Creek (at 62,000 ML/day at Mildura), then Callander's Swamp to the east (at 86,000 ML/day at Mildura) and finally low lying areas to the south (at flows of 125,000 ML/day) (SKM, 2002).

Post-regulation

With the effects of major storages and river regulation on the Murray River, the frequency, duration and magnitude of most flood events have decreased compared to natural conditions as shown in Figure 7. Since 1922, 13 weirs and locks across the Murray River have been constructed and the hydrology of the region has been altered significantly. River regulation and increased consumptive water use have reduced overbank flows that are important for water dependent flora and fauna species. Floods of 15,000 ML/day are most affected and occur less often than pre regulation (Figure 7). Floods generated by flows less than 90,000 ML/day are of shorter duration than under pre-regulation conditions (Figure 7). The reduction in duration and frequency of events has helped increased the interval between events with flows above 10,000 ML/day (Figure 7).

A comparison of daily discharge by month for the pre-regulation and post-regulation (current) conditions is reproduced from Ecological Associates (2007b) in Figure 8. On top of river regulation, a decade of drought has put extensive additional pressure on the river and the floodplain system, leading to a decline in river and floodplain health (Sunraysia Environmental 2008). The flooding regime has also been affected by local works such as the construction of levees, regulators and other earthworks, which prevent or reduce inflows to flood-dependent ecosystems (Ecological Associates, 2007b).

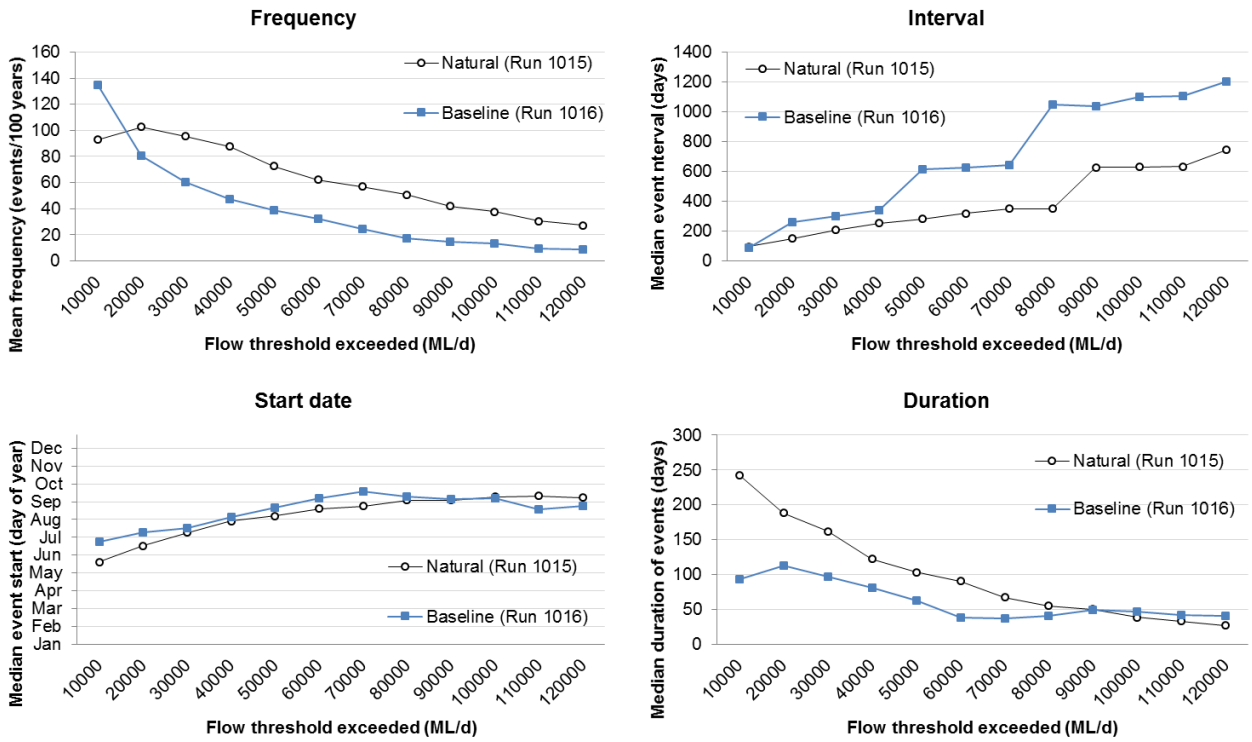


Figure 7. Comparison of Natural (pre-regulation) and Baseline Modelled Flow (post-regulation) scenarios for Euston Downstream (Gippel, 2014).

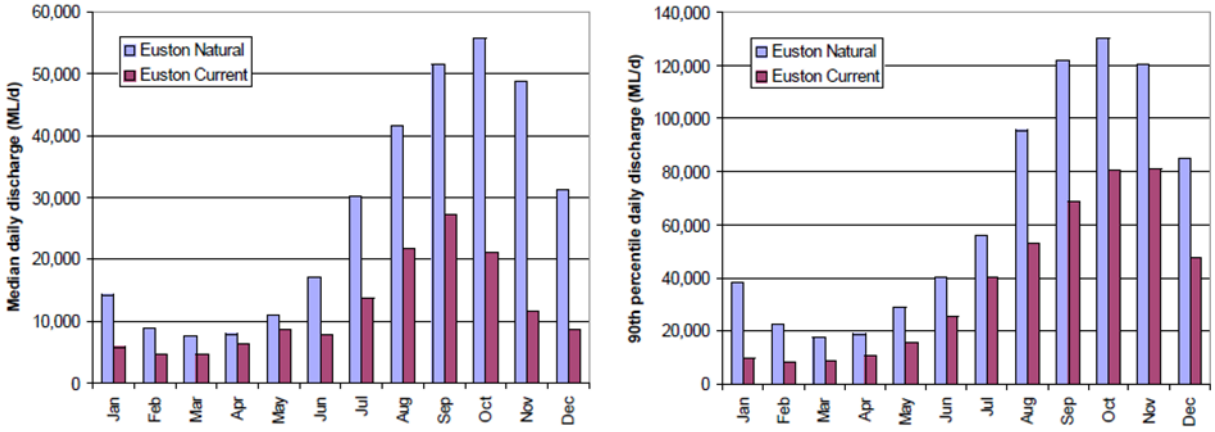


Figure 8. Distribution of median flows and 90th percentile flows for each month in the Murray River through Euston Weir for natural (pre-regulation) and current (post-regulation) conditions Source: derived from MDBC MSM-Bigmod 109-year data (Ecological Associates, 2007b).

Changes to frequency of wetland inundation at Spence's Bend

The commence to flow (ctf) rates measured in ML/day downstream of Euston Weir or upstream of Mildura weir for the wetlands within Spence's Bend are:

- 8,000 - 19,300 (wetlands #7329 246886 and #7329 240880)
- 19,300 - 37,900 (wetlands Callander's Swamp and Spence's Bend Billabong)
- 40,000 - Bullock Swamp south
- 140,000 - Bullock Swamp north (with current infrastructure in place)

Spells analysis undertaken by Gippel (2014) was consulted to better understand the frequency of inundation of the Spence's Bend wetlands under post-regulation conditions. The percentage of years with the threshold event from pre-regulation to post-regulation have significantly reduced for all thresholds above 8,000 ML/day, and the durations of these events are also significantly reduced for all flow thresholds (Table 5).

Table 5 - Modelled natural (pre-regulation) and baseline (post-regulation) flows for flow thresholds between 10,000 and 140,000 ML/day downstream of Euston gauge

Natural (N)/ Baseline (B)	Threshold ML/d	Frequency Mean (/10yrs)	Median Interval in days (50% of events are less than)	Median Duration in days (50% of events are shorter than)	Median Event Start date	Percentage of years with Event
N	8,000	9.3	96	243	1st Sept	100%
B	8,000	13.51	91	93	4th April	99%
N	19,300	10.26	149	189	23rd June	98%
B	19,300	8.07	263	113	15th July	77%
N	37,900	8.77	253	122	4th Aug	87%
B	37,900	4.74	341	81	12th Aug	46%
N	140,000	1.75	926	29	15th Sept	16%
B	140,000	0.61	5710	62	26th Aug	5%

Bullock Swamp also received inflows from the Channel Sands aquifer in the past (SKM, 2002), however this is no longer the case. Groundwater monitoring undertaken in 2012 indicated that groundwater levels in the Channel Sands aquifer were between 36.5 and 37.6m AHD at Bullock Swamp, compared with 38.3m AHD for the bed of Bullock Swamp (as determined by LiDAR). Linke (1990) in (Barling and Linke, 1993) suggest that the salinity of the regional groundwater mound in the Channel Sands is approximately 50,000 EC. These results show that groundwater was not connected to Bullock Swamp at that time. However, it is expected that once Bullock Swamp is refilled, it will recharge the shallow aquifer (SKM, 2013).

There is also evidence of irrigation leakage or spills from the irrigation channel on the western side of Bullock Swamp at five or more points.

Bullock Swamp Infrastructure

In addition to the effects of river regulation, the water regime of Bullock Swamp has been affected by several structures (SKM, 2002). These structures are shown in Figure 9 and their impact on hydrology are summarised in Table 6.

.

Table 6 - Bullock Swamp Hydrological Impacts

Structure	Impact
2 m high levee dividing the Swamp in two (Rudds Rd)	Reduced flooding frequency Reduced flooding duration
Regulating structures on Carwarp Creek	Reduced flooding frequency Reduced flooding duration
Internal levees on the bed of the wetland	Increased ponding time Water logging

Bullock Swamp has been divided into a northern section and southern section by a 200m long, 2m high and 3m wide road levee (Rudds Road). Barling and Linke (1993, cited in SKM 2002) state that water can now only flow between the northern and southern sections of the Swamp when Murray River flows exceed 180,000 ML/d at Mildura (average recurrence interval (ARI) of 16.7 years) and water overtops Rudds Road. They also state that although a culvert was constructed under Rudds Road when it was first built it is thought that it has silted up over time and no longer allows through-flow of water. The exact location of this culvert is unknown. Effort has been made to locate this but has not been found.

A regulating structure on Carwarp Creek near the Murray River is in place so that irrigators can pump from the Murray River to the creek to irrigate their properties (SKM, 2013). A levee was later constructed between Carwarp Creek and Bullock Swamp to protect the water quality of the Carwarp Creek from becoming salinized (SKM, 2002). Before this levee was put in place, when floodwaters receded from Bullock Swamp, groundwater and drainage water was carried back through the creek increasing the salinity of supply water (SKM, 2002). Bullock Swamp now only receives inflows through Carwarp Creek when the levee is over-topped by Murray River at flows above 140,000 ML/d (SKM, 2002).

There is also an internal levee within the northern section of Bullock Swamp that forms a pond which was used up until the mid-1990's for irrigation drainage evaporation. Although the wetland no longer receives irrigation drainage, it is suspected that there is some leakage to the Swamp from the irrigation channel that runs along its western and northern side. There are patches of lush vegetation at points adjacent to this channel that are not found anywhere else within the Swamp (SKM, 2002).

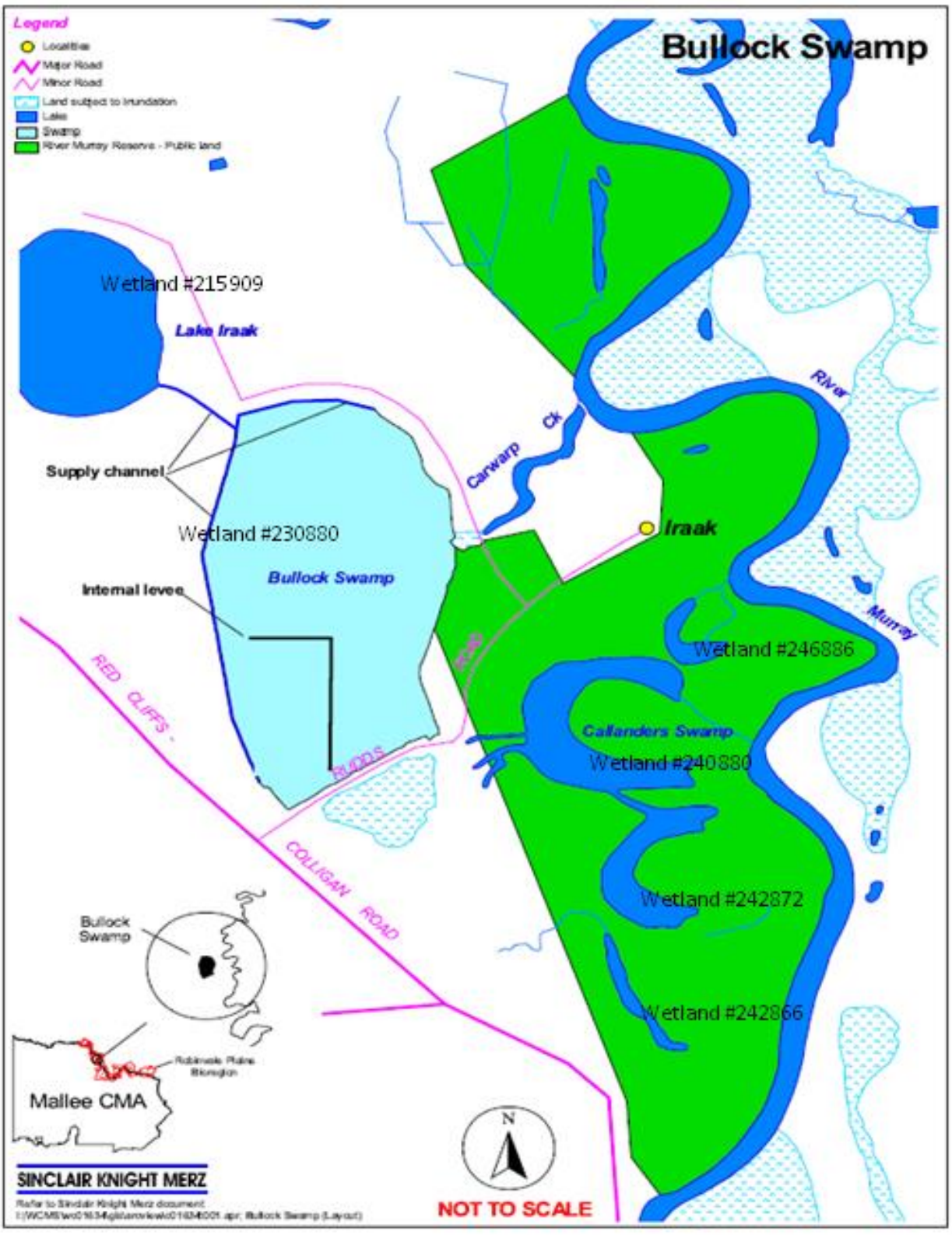


Figure 9 - Location of current structures on Bullock Swamp. Source SKM 2002, Note that wetland numbers shown in this figure have been updated.

Other wetlands

Wetland #7329 246886 receives water from the Murray River via a regulated channel. A further channel links this to Callander's Swamp and is regulated to provide and control flows at low river levels. If flows allow, water continues to spill to Spence's Bend Billabong and Bullock Swamp.

At higher river flows, water enters the northern section of Bullock Swamp from upstream and general floodplain inundation occurs. Wetland #7329 242866 is isolated from the other wetlands by a sandy ridge and is thought to fill by an independent effluent from the Murray River or by spill from Bullock Swamp (Ecological Associates, 2007b).

> *"This section of the Murray River is one of the longest free-flowing sections in a highly regulated waterway. This negates the possibility of manipulating weir pool levels to facilitate inundation of the target area and restricts control of environmental watering events to pumping from the river onto the floodplain and controlling water height on the floodplain with small levees, regulators and culverts"* (SKM, 2002).

Previous Environmental Watering

Environmental watering occurred at Spence's Bend during the Millennium Drought (mid 1990's to early 2010/11), in 2005 and 2006. The purpose of the emergency watering program was to address the prolonged dry conditions that had resulted in a drastic decline in River Red Gum health on the Murray River floodplain. The water for these events was from various sources as outlined in Table 7.

Table 7 - A summary of environmental watering at Spence's Bend

Water year	Time of inflow	Inflow source	Total volume (ML)	Area (ha) Inundated
2005	Spring	Environmental Water Allocation (EWA) / Murray River Unregulated Flow (RMUF)	640	65
2006	Autumn	Donations	955	65
2014	May – Dec	CEWH/VEWH	687	150

The watering took place in spring 2005 with a second event in autumn 2006. These events filled wetland #7329 246886, Callander's Swamp (#240880) and Spence's Bend Billabong (#242872) (Figure 10). This delivery of environmental water was effective in improving the health of River Red Gum trees fringing the wetlands. Benefits of these watering events would have extended to other flora and provided drought refuge for waterbirds, frogs, fish and turtles. The extent of emergency watering was limited by current infrastructure within the target area.

The purpose of the environmental watering has evolved from emergency response to long term sustainability of the system. The three horseshoe billabongs received further inundation during the floods of 2010/2011.

Bullock Swamp north was watered during 2014, with 523 ML delivered between May and August 2014 and an additional 156 ML delivered in the months after that (Australian Water Environments, 2014).

Bullock Swamp south and wetland #7329242866 were not inundated during the environmental watering undertaken to date. Infrastructure is not in place to provide for this.

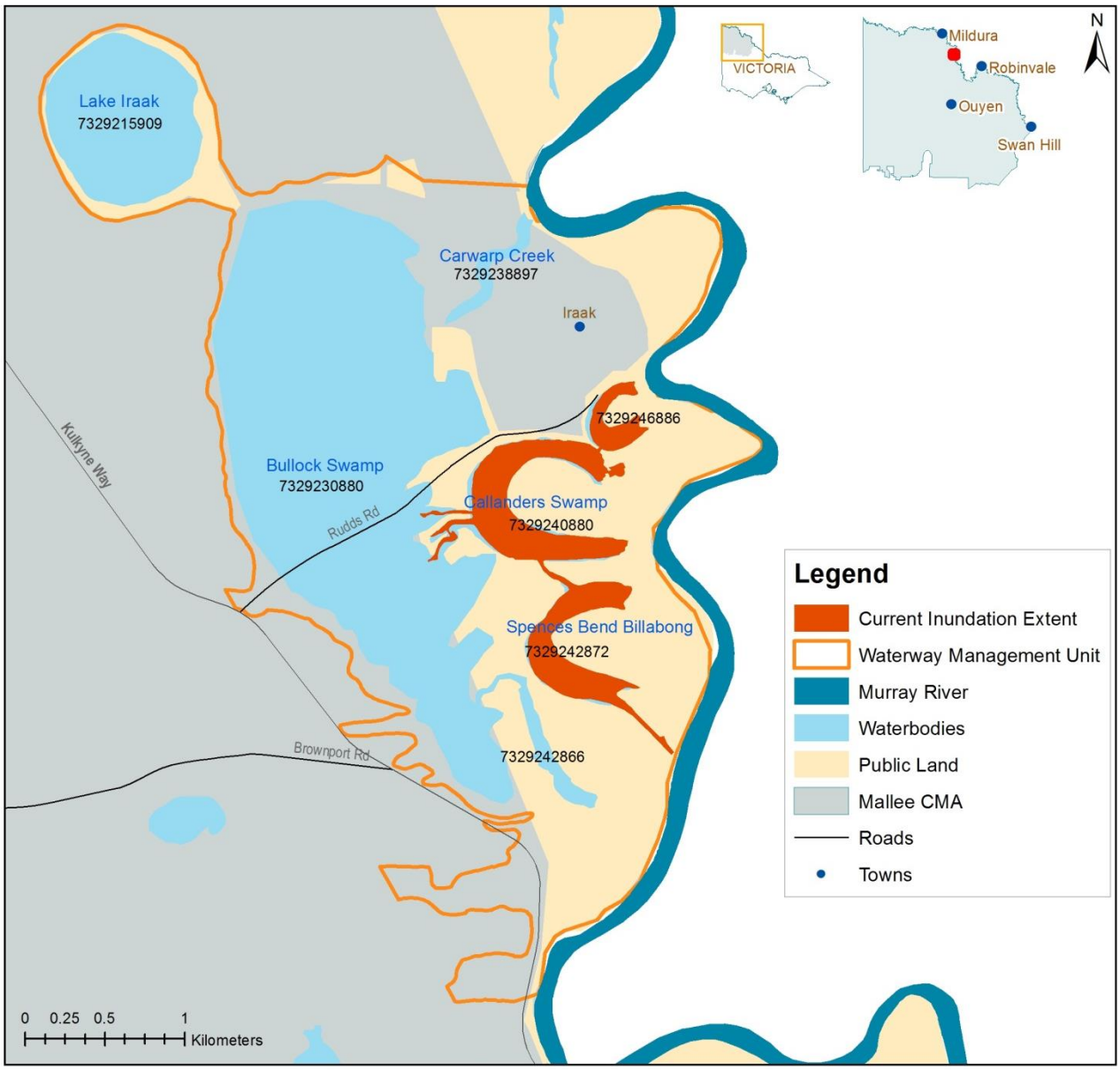


Figure 10 – Current environmental water inundation extent at Spence's Bend WMU Sub-Unit from 2005/2006

Water Dependent Values

Environmental Values

Listings and Significance

Fauna

Of special interest and responsibility are the eight water dependent species listed in legislation, agreements or conventions, as shown in Table 8. A full list of all fauna previously recorded at Spencer's Bend is provided in Appendix 1.

Table 8 - Listed fauna recorded at the site

Common name	Scientific name	Type	International agreements	EPBC status	FFG status	DEPI status
Caspian Tern	*Hydroprogne caspia*	B	CAMBA	NL	L	NL
Intermediate Egret	*Ardea intermedia*	B	NL	NL	L	CR
Eastern Great Egret	*Ardea modesta*	B	NL	NL	L	V
Hardhead	*Aythya australis*	B	NL	NL	NL	V
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	B	CAMBA	NL	L	V
Regent Parrot*	*Polytelis anthopeplus monarchoides*	B	NL	V	L	V
Growling Grass Frog	*Litoria ranformis*	A		VU	L	
Golden Perch	*Macquaria ambigua*	F		NL	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

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

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

The six bird species are considered water-dependent because they forage or nest in or over water, or require flooding to trigger breeding and fledging. The list includes the Regent Parrot, (*Polytelis anthopeplus monarchoides)* which is indirectly dependent on water as they require riparian trees for nesting habitat.

The Eastern Regent Parrot is listed as nationally vulnerable under the *EPBC Act*, with estimates of only 2,900 birds left in the wild. This species has quite specific habitat requirements. It breeds almost exclusively in River Red Gum (*Eucalyptus camaldulensis)* forest and woodland, typically in large, old and healthy hollow-bearing trees close to water. They require trees that are a minimum of 160 years old (Baker-Gabb and Hurley, 2011). However, Regent Parrots have also been known to breed in Black Box (*Eucalyptus largiflorens)*. They mostly feed in large blocks of intact Mallee woodlands usually within 5-10km (maximum

20km) of nest sites, but also consume flower buds of River Red Gum, Black Box and Buloke (*Allocasuarina leuhmanii)* (Baker-Gabb and Hurley, 2011). Eastern Regent Parrots are reluctant to fly through open areas and require corridors of vegetation between nesting and foraging sites. Regent Parrot breeding has previously been recorded along the Spence's Bend section of the Murray River and a nest site was identified within this WMU Sub-Unit in a study which ran from 2001 to 2005 (Webster and Belchar, 2005).

The Hardhead (*Aythya australis)* uses dense shrubby vegetation such as Lignum for nesting, and breeding is stimulated by flooding and season. Rogers & Ralph (2011) suggest that breeding primarily occurs between August and December. The Hardhead lives for approximately three to four years in the wild, therefore conditions suitable for breeding should occur every second year to maintain numbers of breeding adults. Although information on breeding is limited, it is estimated that fledging occurs at two to three months suggesting flooding should last for four to six months. Food resources are more abundant for Hardhead when a flood follows a period of wetland drying, suggesting that inter-flood drying for a few months may increase breeding success of the Hardhead (Rogers and Ralph, 2011).

Two Egret species recorded in the target area are the Intermediate Egret (*Ardea intermedia)* and the Eastern Great Egret (*Ardea modesta)*. Egrets mainly forage in shallow freshwater wetlands with emergent vegetation and use overhanging trees for nesting, with River Red Gum being their preferred tree. Egrets require shallow water with dense aquatic vegetation for foraging and feed mainly on fish but also consume shrimp, crayfish, frogs and insects (Rogers and Ralph, 2011). Draining of wetlands for agriculture is the main cause of habitat loss for Egrets in Victoria (DSE, 2001).

The Growling Grass Frog (*Litoria ranformis)* 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). Breeding is triggered by flooding or a significant rise in water levels in late winter/spring (SKM, 2009).

Golden Perch (*Macquaria ambigua)* are usually found in warm, turbid and slow flowing waters in lowland rivers, including backwaters, billabongs and anabranches (Treadwell and Hardwick, 2003), such as those found within Spence's Bend. Strong recruitment of Golden Perch is linked to rising flows in spring (Mallen-Cooper and Stuart, 2003). Golden Perch undertake significant migration both upstream and downstream in spring.

Bullock Swamp has been identified as a potential site for reintroduction of Murray Hardyhead, if appropriate habitat conditions are provided. Adult Murray Hardyhead spawn in stands of *Ruppia spp.* in saline lakes (Raadik and Fairbrother, 1999; Backhouse, Lyon and Cant, 2008). While adults may be relatively salt-tolerant, the early life stages, particular eggs and fry, may be more sensitive to high salinity levels. Salinity tolerance also varies between populations ((Bill Dixon DSE ARI unpub. data):(Backhouse, Lyon and Cant, 2008)).

Vegetation Communities

Twelve ecological vegetation classes (EVC's) occur within the WMU Sub-Unit as shown in 11. Two of these are Vulnerable within the Robinvale Plains bioregion: Lignum Swamp (#104) and Shallow Freshwater Marsh (#200). The bioregional conservation status of all water-dependent EVCs in the target area is shown in Table 9.

Note that the bioregional conservation status of the wetland EVCs in this report are based on expert advice and have not yet been formally approved by DELWP.

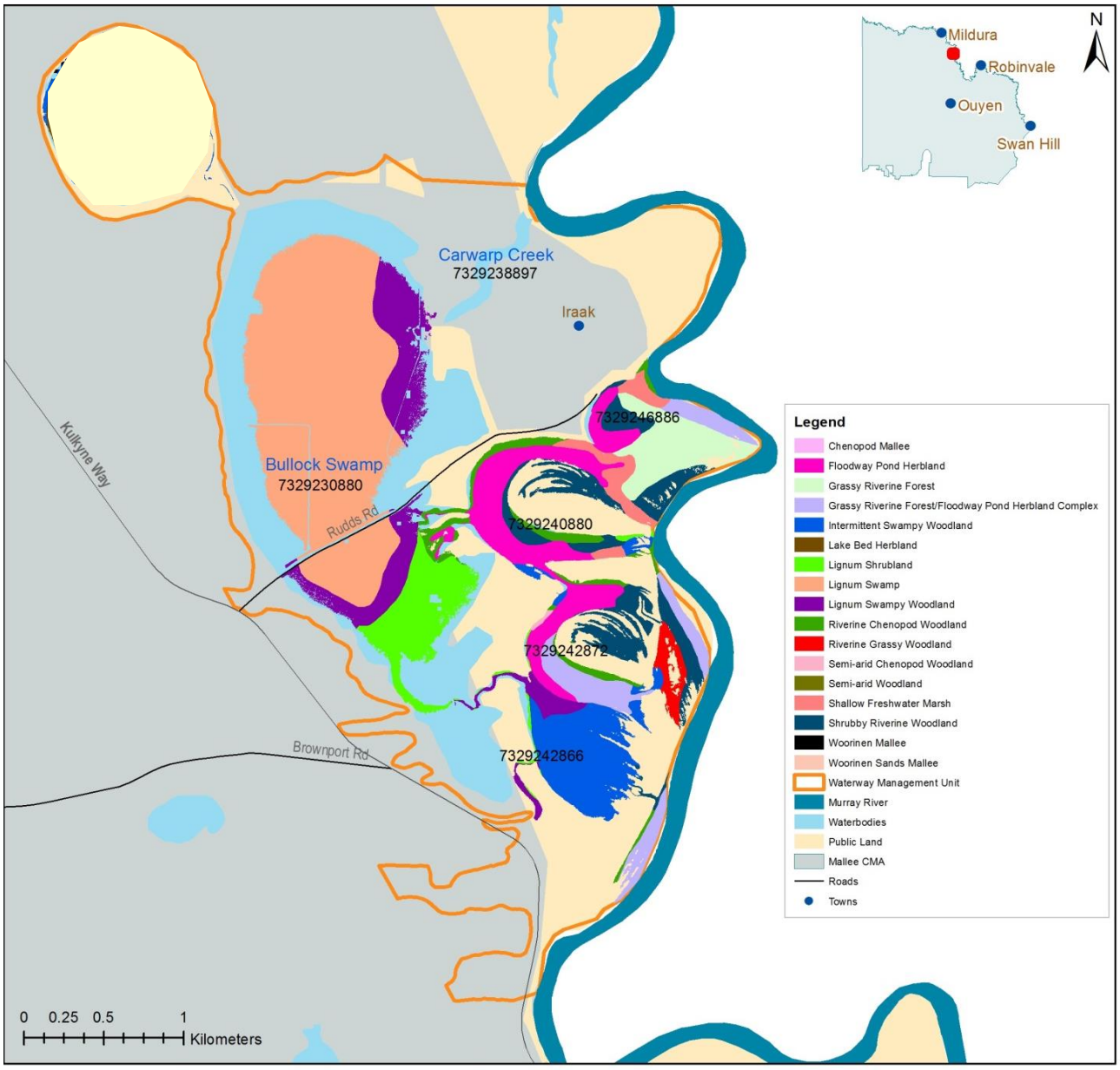


Figure 61 - EVCs in the target area of Spence's Bend

Table 9 - Bioregional conservation status of water dependent EVCs in the target area of Spence's Bend

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

Lignum Swamp covers the majority of Bullock Swamp. This typically treeless EVC is widespread in low rainfall areas and is subject to infrequent inundation (DSE, 2005). This EVC is dominated by Lignum, (*Muehlenbeckia florulenta)*, which becomes an extensive aquatic habitat for fish, reptiles and macroinvertebrates when inundated. It is also used as a nesting site by waterbirds, and as a feeding area by raptors, owls, and predatory reptiles (Ecological Associates, 2007a).

Lignum Swampy Woodland is found along the eastern edge of Bullock Swamp north and around the southern section of the Swamp. Lignum dominates this EVC but it also supports eucalypt or acacia woodland with River Red Gum and Black Box being the dominant trees species. At Bullock Swamp these woodlands also support small stands of the threatened species Buloke (*Allocasuarina leuhmannii)* and Swamp Sheoak (*Casuarina obesa)*. Black Box woodlands provide habitat links to the surrounding Mallee landscape in this region. They are rich in bird diversity, with both riverine and woodland species (Ecological Associates, 2007a). Both Lignum EVC's would have experienced a flooding event once in 2-8 years under natural conditions, with a critical interval of 15 years between events. The recommended duration of ponding for Lignum Swamp is 2-6 months and 2-4 months for Lignum Swampy Woodland (VEAC, 2008).

The majority of the wetland bed at Spence's Bend Billabong, Callander's Swamp and surrounding wetlands is covered by Floodway Pond Herbland. This threatened wetland EVC is dependent on a regular wetting and

drying cycle, characteristic of semi-permanent wetlands. Under the appropriate water regime this EVC supports aquatic herbs and emergent sedges which form important habitat for fish, frogs and waterbirds. Under natural conditions this wetland EVC would have flooded 6-9 years in every ten, with duration of 4-10 months ponding and a critical interval of three years between events (VEAC, 2008).

The remaining section of Bullock Swamp south of Rudds Road and wetland #7329 242866 are dominated by various woodland EVC's with River Red Gum and Black Box as the dominant tree species.

For a full list of EVCs within Spencer's Bend and details on each see Appendix 2.

Flora

A full list of flora recorded at the Spence's Bend can be found in Appendix 1. A total of 18 water dependent flora species listed in the various threatened species acts and agreements have been recorded in Spence's Bend ,with a further five species typical of damp habitats beside waterbodies. This list covers a range of growth forms from shrubby trees (Swamp Sheoak), to sedges (Flat Spike-sedge), small herbs (Jerry-jerry) and aquatic plants (Slender Water Ribbons). SKM (2002) also noted the presence at Bullock Swamp of the flood dependent Annual Lagoon Spurge (*Phyllanthus lacunellus)*, listed as rare in Victoria. The majority of the listed species (Table 10) occur in EVC's dominated by Lignum, Black Box and River Red Gum and management will be directed towards these species, whose water requirements are well known.

Table 10 - Listed water dependent flora species recorded at Spencer's Bend

Common Name	Scientific Name	EPBC Status	FFG Status	DEPI Status	EVC Listing Species
Jerry-jerry	*Ammannia multiflora*	NL	NL	V	808
Twin-leaf Bedstraw	*Asperula gemella*	NL	NL	R	823
Baldoo	*Atriplex lindleyi* subsp. *conduplicata*	NL	NL	R	103
Mealy Saltbush	*Atriplex pseudocampanulata*	NL	NL	R	811
Small Water-fire	*Bergia trimera*	NL	NL	V	107
Swamp Sheoak	*Casuarina obesa*	NL	L	E	
Flat Spike-sedge	*Eleocharis plana*	NL	NL	V	103
Tall Nut-heads	*Epaltes cunninghamii*	NL	NL	V	103, 813
Cane Grass	*Eragrostis australasica*	NL	NL	V	104, 808
Purple Love-grass	*Eragrostis lacunaria*	NL	NL	V	103, 813
Bristly Love-grass	*Eragrostis setifolia*	NL	NL	V	
Dwarf Brooklime	*Gratiola pumilo*	NL	NL	R	
Warty Peppercress	*Lepidium papillosum*	NL	NL	PK	103, 808
Woolly Minuria	*Minuria denticulata*	NL	NL	R	808
Smooth Minuria	*Minuria integerrima*	NL	NL	R	808
Spiny Lignum	*Muehlenbeckia horrida* subsp. *horrida*	NL	NL	R	813
Slender Water-ribbons	*Triglochin dubia*	NL	NL	R	823
Coral Saltbush*	*Atriplex papillata*	NL	NL	R	
Woolly Mantle*	*Eriochlamys behrii s.s.*	NL	NL	R	
Leafy Sea-heath*	*Frankenia foliosa*	NL	NL	R	
Native Peppercress*	*Lepidium pseudohyssopifolium*	NL	NL	PK	818, 103, 813, 106, 295, 811

Common Name	Scientific Name	EPBC Status	FFG Status	DEPI Status	EVC Listing Species
Goat Head*	*Malacocera tricornis*	NL	NL	R	103, 808
Bush Minuria*	*Minuria cunninghamii*	NL	NL	R	
Twiggy Sida*	*Sida intricata*	NL	NL	V	107

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

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

***Possibly water dependent, found around lakes and watercourses, and could potentially be found around wetlands.**

Lignum EVC's dominate Bullock Swamp and Tangled Lignum has particular ecological value as waterbird breeding habitat (Rogers and Ralph, 2011) making it especially significant at this site. Wetland birds that breed over water, such as Egrets, use flooded Lignum shrublands (Ecological Associates, 2007a) for resting and the Hardhead Duck uses Lignum for nesting (Rogers and Ralph, 2011).

Bullock Swamp is fringed by Black Box communities of degraded health (Ecological Associates, 2007b). Black Box occurs in the less frequently flooded, more elevated areas of the floodplain and is found in the Lignum Swampy Woodland EVC which fringes Bullock Swamp. Black Box communities are extensive around the Spence's Bend Billabong and Callander's Swamp. Black Box provides essential habitat and foraging opportunities for a range of species including mammals and reptiles and supports a high proportion of ground foraging and hollow-nesting birds. Black Box Woodlands are particularly important to the endangered Regent Parrot which has been recorded using Black Box hollows for breeding (Baker-Gabb and Hurley, 2011). These woodlands are also an important connection to surrounding Mallee landscape, allowing movement of fauna between these landscapes (Ecological Associates, 2007a). Black Box can tolerate a range of conditions from wet to dry and saline to fresh (Roberts and Marston, 2011). However, under extended periods of dry conditions trees will suffer a decline in health and eventually death (Ecological Associates, 2007a).

River Red Gum woodlands are found around the Spence's Bend Billabong and Callander's Swamp area. They provide extensive habitat for a range of fauna, and waterbirds such as the Intermediate Egret which use these trees for nesting. However, trees in poor condition contribute little to the function and productivity of the ecosystem and the quality of woodland habitat is greatly reduced (Roberts and Marston, 2011). Briggs, 1997, cited in (DSE, 2001) states that Egrets do not breed in dead River Red Gums. River Red Gums also deposit organic woody debris to wetlands which provide structural habitat features for wetland fauna such as perching sites for waterbirds and snags for fish (Ecological Associates, 2007b).

The Lignum Swampy Woodland EVC which surrounds Bullock Swamp also supports some small stands of Buloke and Swamp Sheoak. Buloke Woodlands are listed as threatened under the Victorian FFG Act and endangered under the federal EPBC Act. These woodlands provide habitat for many native flora and fauna species including the near threatened brown Treecreeper, (*Climacteris picumnus victoriae)* (Cheal, Lucas and Macaulay, 2011), which has been recorded at this site.

Swamp Sheoak populations are very limited, with nine extant natural populations known in Victoria. This species is found in low-lying Swampy flats, river banks and along the perimeter of salt lakes (DSE, 2003).

Swamp Sheoak is nitrogen-fixing and has great potential in rehabilitating saline sites as it is one of the most salt tolerant native trees in Australia (Flora Bank, 2014). Swamp Sheoak is found in Lignum Swampy Woodland vegetation amongst Black Box trees along the wetland edge at Bullock Swamp. This small stand of trees was planted at Bullock Swamp as part of a plan to set up satellite populations of the naturally-occurring Karadoc Swamp population nearby which has suffered significant decline (Jaensch, S. pers. comm., 29th January). These trees would receive environmental water under Stage 3 of the proposed watering plan for Spence's Bend WMU Sub-Unit.

Significance

The Spence's Bend target area consists of a forested floodplain area with several wetlands, ranging from deep to shallow freshwater and semi-permanent saline systems. These provide habitat for a large range of fauna, notably waterbirds, fish and frogs, which will benefit from the wetlands in the target area receiving water on a more regular basis.

Waterbirds

Spence's Bend supports a diverse range of waterbirds (32 species) including the listed species in Table 8. Waterbird diversity and abundance are influenced by wetland habitat diversity, with different species and feeding guilds, as described in Table 11, using different habitats for breeding and foraging (Haig et al. 1998 cited in MDBA 2009). Water depth in particular influences waterbird diversity due to the specific feeding behaviours of different species (Bancroft, Gawlik, & Rutchey, 2002). Managing wetlands to provide diverse habitats such as variable water depth, mud flats, inundated vegetation and areas of deep water increases the likelihood of waterbird diversity (Taft, Colwell, Isola, & Safran, 2002).

Under flooding of adequate duration wetlands and floodplains provide breeding habitat for waterbirds. Flooded Lignum, Black Box and River Red Gum are all used by waterbirds for breeding and nesting (Ecological Associates, 2007b).

Table 11 - Waterbird functional feeding groups (Roshier, Robertston and Kingsford, 2002) and their resource use

Waterbird Group	Food Resource	Habitat Use	Breeding Strategy	Number of Waterbird Species found at Spence's Bend
Dabbling and Diving Ducks (Chestnut teal, Pink-eared duck, Freckled duck	Generalists; plankton, small invertebrates, plant material	Shallow Water (Dabblers),	Solitary	4
Grazing Waterfowl Shellduck, Wood Duck)	Plant material, seeds, invertebrates	Shallow Water, littoral zone	Colonial or solitary	2
Fish Eaters (Pelican, Cormorants, Grebes, Darter, Egret, Heron, Tern)	Fish	Open and deep water	Colonial	15
Small Waders (Stilt, Plovers, Dotterels)	Small invertebrates, seeds	Littoral zone, mudflats	Solitary	4
Large Waders (Ibis, Brolga)	Macroinvertebrates, fish, amphibians	Littoral zone	Colonial or solitary	4
Deep Water Forages (Black Swan and Hardhead)	Plant material, some molluscs and invertebrates	Open deep water, Shallow water, Littoral zone, mudflats	Colonial or solitary	2
Shoreline Foragers (Lapwings, Hens)	Plant material, seeds, invertebrates,	Littoral zone, mudflats	Solitary or small groups	1

Spence's Bend supports another four species of native frog which are not listed; this diversity is of significant ecological value. Frogs are considered to be good indicators of environmental health and may act as 'sentinel' species for secondary salinisation (DSE, 2006). Like most flood dependent species, frogs respond to the timing, duration and frequency of flooding, with the timing of inundation being the most significant factor. Close proximity to permanent waterbodies and drought refuges (such as grass or sedge tussocks, fallen logs) are also important for frogs. Aquatic vegetation complexity is important for many species,

particularly at tadpole stage, and can drive occupancy patterns and recruitment success (Tarr and Babbit, 2002; Rogers and Ralph, 2011).

A study (DSE, 2006) found that salinity levels up to 3000 EC did not limit amphibian occupancy but amphibian diversity declined significantly between 3000 and 6000 EC.

Although no species records can be found in fauna databases, freshwater turtles are known to breed along Carwarp Creek and probably occur at other wetlands throughout the Spence's Bend target area. Female turtles excavate nest holes on the sandy banks or lighter soils along the creek, lay their eggs and bury the nest, and leave the eggs to incubate unattended (CSIRO, 2004). These nests are heavily predated by foxes along Carwarp Creek and options to better protect nest sites are being investigated.

Three species of turtles occur in the Mallee region; the Eastern Long-necked Turtle (*Chelodina longicollis*), the Murray River Turtle (*Emydura macquarii*) and the FFG listed Broad-shelled Turtle (*Chelodina expansa*) (Ho et al., 2004). It is possible that all three species occur and breed along Carwarp Creek and may do so elsewhere in the target area (Ellis, I., pers. comm., 20th February 2014). The Murray River Turtle is listed as data deficient in Victoria and presumed to be threatened, while *the* Broad-shelled Turtle is listed as endangered in Victoria as well as being listed in the FFG Act. Although the Eastern Long-necked Turtle is considered common, it has been reported that this species suffered the greatest decline of all three species (91%) in a study investigating freshwater turtle decline in the Murray-Darling Basin in response to long-term decline in river flow and floodplain inundation (Chessman, 2011). Thompson (1983, cited in CSIRO 2004), in his study of turtle nests along the Murray River found that 96% of the nests of these three species had been predated, mainly by foxes. Declining water availability, as well as egg predation, are major threats to freshwater turtles and the presence and breeding of turtles within Spence's Bend gives significant ecological value to the area.

Bullock Swamp is listed as a high value wetland (ranked 10) in the Mallee Wetland Strategy 2006-2011 based on an analysis of rare or threatened species, wetland rarity and type and bioregional location (Mallee CMA, 2006). Ecological Associates (2007b) suggest that the intermediate wetland depths present in the wetlands between Bullock Swamp and the Murray River support dense stands of semi-emergent macrophytes, and that these are highly productive wetland habitats, providing shelter and food for macroinvertebrates, tadpoles and small fish. Waterfowl and dabbling ducks will also graze on semi-emergent macrophytes (Ecological Associates, 2007b).

Bullock Swamp is a semi-permanent saline marsh. Saline marshes provide habitat for crustaceans which attract dabbling ducks such as Hardhead, (*Aythya australis)* (Ecological Associates, 2007b). Ecological Associates (2007b) also states that saline marshes also support salt-tolerant fish and can provide habitat for significant species such as Murray Hardyhead (*Craterocephalus fluviatilis)*. Saline wetlands such as these are known to have beds of the aquatic macrophyte *Ruppia* spp. which is important for Murray Hardyhead (Backhouse, Lyon and Cant, 2008). The Caspian Tern (*Hydroprogne caspia),* which also inhabits saline and brackish lakes has been recorded at the site.

Spence's Bend is also of environmental significance due to the presence of the remaining vegetation in a largely cleared landscape (SKM, 2002).

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, developed by Andrew Corrick from the Arthur Rylah Institute. Mapping was undertaken from 1981 using 1:25,000 colour aerial photographs, along with field checking. This database is commonly known as the 1994 wetland layer and contains the following information:

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

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

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

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

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

Spence's Bend target area contains seven wetlands. They have been classified using the Corrick-Norman wetland classification system as Deep Freshwater Marsh, Permanent Open Freshwater, Shallow Freshwater Marsh and Semi-permanent saline (Table 122).

Based on a comparison of the geospatial wetland layers (1788 and 1994), Deep Freshwater Marshes are the most depleted (-70% change) type of wetland in Victoria, second most (-45% change) in the Mallee CMA region and second most (-37% change) in the Robinvale Plains Bioregion. This makes Spence's Bend Billabong, which is a Deep Freshwater Marsh, significant in the region.

Shallow freshwater marshes have also undergone significant reductions in Victoria (-60%), but this is not reflected in the Mallee CMA region or Robinvale Plains Bioregion where they have actually increased in area (Table 122). Permanent open freshwater wetlands have only experienced minimal changes and in the Mallee CMA region have actually increased in area (4%). Semi-permanent saline wetlands have decreased slightly across Victoria (-7%) but increased in the Mallee CMA and Robinvale Plains bioregion.

The 1994 Wetland layer has been further refined and updated with some minor changes being recorded. This EWMP uses the unique wetland identification numbers from the 2015 wetland layer.

Table 122 - Changes in area of the wetlands in the target area by Corrick classification Source: DELWP Biodiversity interactive maps, Mallee Wetland Strategy

Corrick Category	No of Wetlands in target area	Total area (ha)	Percentage change in wetland area from 1788 to 1994		
			% Change in area in Victoria	Change in area In Mallee CMA	Change in Robinvale Plains Bioregion
Deep Freshwater Marsh	1	16.65	-70	-45	-37
Permanent Open Freshwater	3	42.56	-6	5	-1
Shallow Freshwater Marsh	1	8.17	-60	-6	-4
Semi-permanent saline	2	452.22	-7	9	100

Ecosystem Functions

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

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

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

Spence's Bend contains a floodplain wetland complex of seven wetlands (five of which are the focus of environmental watering) which are categorised as Deep Freshwater Marsh, Permanent Open Freshwater, Semi-permanent Saline and Shallow Freshwater Marsh. Altered water regimes in the target area due to river regulation and dry conditions have seen a decrease in the frequency of inundation in these floodplain wetlands and therefore a decrease in the ability for these wetlands to perform these valuable ecosystem functions.

Social Values

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.

Cultural Heritage

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

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

Surveyed sites include middens, earth features, scarred trees, Aboriginal mounds and surface scatters. Surface scatters in this area may consist of chipped stone artefacts, animal bones, shell, charcoal, hearth stones, clay balls and ochre. A search of the DELWP GeoVic Database shows that most areas in the WMU around the Murray River and the wetlands are areas of Cultural Heritage Sensitivity. The database lists one shell midden and two artefact scatters within the WMU, but these are not near the target area. As is the case for most of the Murray River floodplain and beyond, it is recognised that waterways and floodplains are highly significant for the Indigenous culture but the true extent of the number and types of sites present is still unknown. A contingency plan (Appendix 3) is in place should any further evidence of cultural heritage sites be discovered during site visits or works.

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

Aboriginal people continue to have a connection to this country. There is no Registered Aboriginal Party (RAP) that covers this area. The land council, and other Aboriginal community members, continue to value this country through traditional laws and customs.

European heritage reflects the pioneering history of the area. The town of Iraak, along with nearby Colignan and Nangiloc, were set up as soldier settlement farming areas after the first World War (Noelker Consulting, 2008). Dry land farming was the most prominent form of farming undertaken by these settlers. By the 1920's the area relied on irrigation as river frontage land was leased and primarily used for vegetable farming (Nangiloc/Colignan and District Community, 2014).

There is significant local community value associated with Carwarp Creek. It is used as a supply of domestic and irrigation water and holds strong aesthetic value (SKM, 2002).

Recreation

The region is popular for swimming, camping, fishing, boating, four wheel driving, picnicking, barbequing, trail bike riding, horse riding and walking and these uses will continue in the park.

Economic Values

Spence's Bend has been used for grazing, irrigation and irrigation drainage water disposal (still occurring in Lake Iraak). There is evidence that timber harvesting has occurred at some stage in the past (SKM, 2002) as shown in Figure 72.

Figure 72 - Evidence of historical timber harvesting in Bullock Swamp North

Significance

The environmental, social and economic values outlined indicate the significance of this site. While these values do not constitute Spence's Bend being a unique or pristine site, the riparian and floodplain communities of the Murray River are important to the functioning of the river system and its sustainability. Bullock Swamp is considered to be a high value wetland in the Mallee Wetland Strategy (2006). This semi-permanent saline marsh has the potential to support habitat for the salt-tolerant aquatic macrophyte *Ruppia*, which would provide habitat for translocation of the critically endangered Murray hardyhead (Ecological Associates, 2007b). Saline marshes also provide excellent habitat for some species of migratory wading birds (Ecological Associates, 2007b). Waterbirds such as Ibis and Spoonbill may nest in the Lignum Shrublands. The Deep freshwater marsh, Permanent open freshwater and Shallow freshwater marsh that exist between Bullock Swamp and the Murray River will support dense semi-emergent macrophytes, providing habitat for frogs, macroinvertebrates, small fish and waterfowl (Ecological Associates, 2007b).

The relatively high number of frogs and waterbirds, and the relatively long list of listed water-dependent plant species show that the area is rich in biodiversity, and is providing habitat for listed flora and fauna species such as Swamp Sheoak, the Regent Parrot and the Eastern Great Egret. The social and cultural values associated with Spence's Bend are important to local communities of the area. The values contained within Spence's Bend and specifically the target area for this plan makes this area a priority for protection and enhancement through environmental water management. Of particular significance are the Lignum, River Red Gum and Black Box communities which line the temporary wetlands and creeks throughout the target area. These communities provide habitat and feeding opportunities for many of the listed fauna species found in the target area and form the basis for the functioning ecological system. They are the primary focus of this plan.

Ecological Condition and Threats

Current Condition

In the early 2000's, the Black Box and Lignum woodlands around Bullock Swamp were very degraded due to surface salting as a result of past drainage disposal, high groundwater and altered flood regimes. In the northern section of the Swamp areas of bare salt-encrusted ground were evident due to surface seepage (SKM, 2002). Recent reduction in groundwater levels, due to increased irrigation efficiency and prolonged dry conditions mean that groundwater discharge is not currently a problem. Infrequent flooding remains the greatest threat to the maintenance and improvement of the ecology within Bullock Swamp. Levees divide the wetland and reduce connectivity of habitats.

During site visits by SKM in (2002) it was reported that Lignum in the northern section of Bullock Swamp wetland was severely degraded but relatively healthy in the southern section. There was also evidence of regeneration of some River Red Gums and possibly Black Box, with a mix of both living and dead River Red Gums (SKM, 2002). During this time the vegetation around Spence's Bend Billabong and Callander's Swamp in the Murray River Park was in better condition.

Sunraysia Environmental on behalf of the Mallee CMA undertook a baseline 'Index of Wetland Condition assessment during April 2014. A total of five sites were assessed which was limited to the section of Bullock Swamp north of Rudds Road. This assessment indicated Bullock Swamp to be in moderate condition overall with a total score of 5 (Table 133). Factors including the wetland only receiving water intermittently, reduced wetland connectivity and size and saline groundwater had impacted on flora composition and health. The majority of the Lignum has disappeared, and the Black Box overstorey has poor canopy health. Photo point monitoring has been undertaken during this assessment to capture condition before and after watering (Figure 83).

Table 133 - Index of Wetland Condition Assessment Bullock Swamp north, 2014

Sub Index	Score	Weighting	Weight Adjusted Score	Condition Category
Wetland Catchment	10.5	0.26	2.73	Moderate
Physical Form	11	0.08	0.88	Moderate
Hydrology	5	0.31	1.55	Poor
Water Properties	12	0.47	5.64	Moderate
Soils	20	0.07	1.40	Excellent
Biota	9.57	0.73	6.99	Moderate
Sub Total	68		19.19	
Total Score			5	Moderate

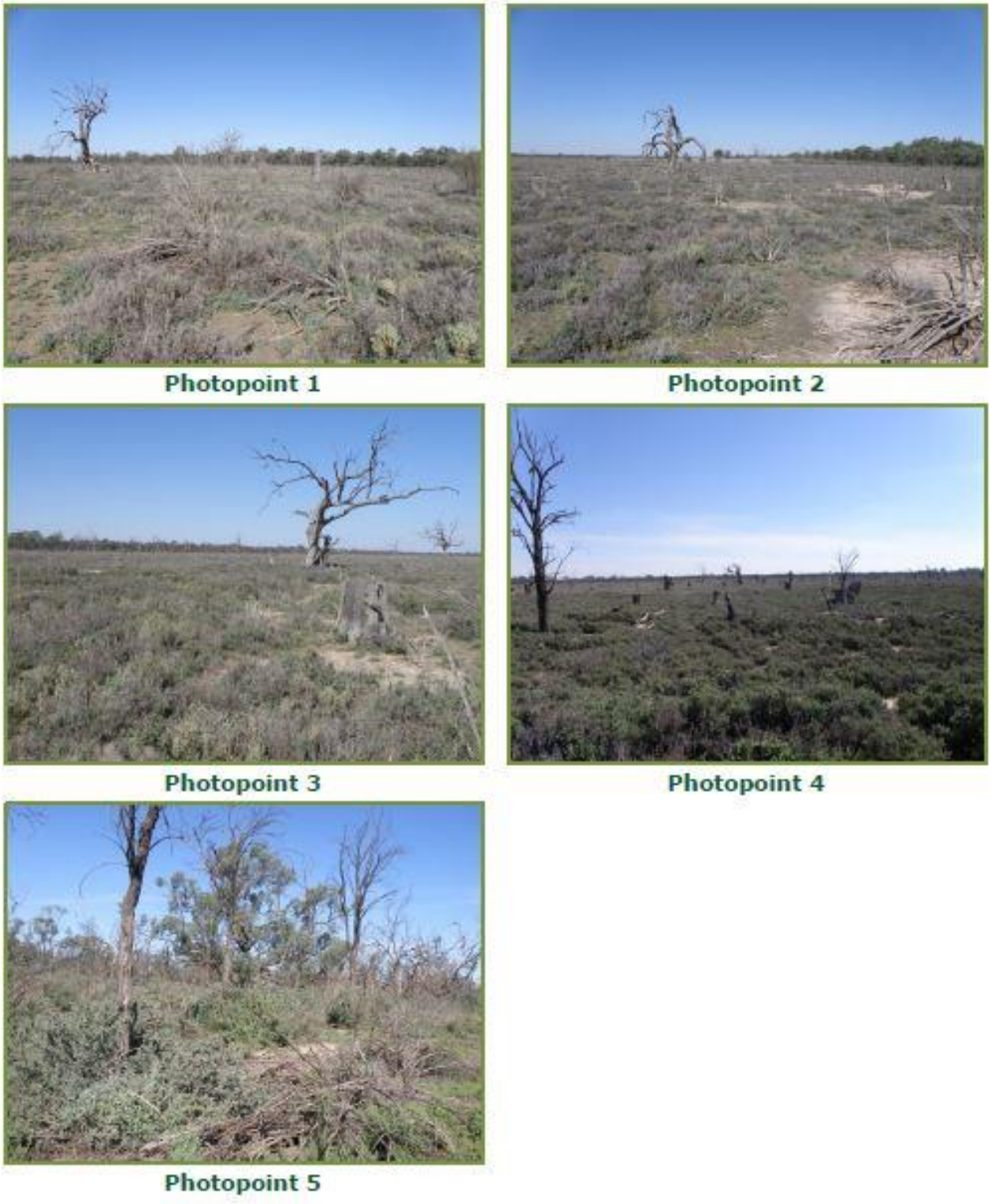


Figure 83 – Photo points taken during IWC Assessment (Sunraysia Environmental, 2014)

Condition Trajectory

Condition of wetlands within the target area will continue to decline without regular and well planned environmental watering targeting appropriate objectives. Conditions within Bullock Swamp north, which is the most impacted under post-regulation conditions, are the most highly impacted, although all wetlands in the target area are impacted by reduced flooding frequency and duration.

The reduced flooding duration and frequency will continue to impact the ecology of the wetlands through:

- reduced organic matter recruitment;
- reduced connectivity for movement of organic matter, fish and transport of salt;
- reduced suitable nesting and roosting sites for waterbird species who rely on flooded shrub land and forest; and
- limited food sources for all waterbird types, reptiles and amphibians through reduced recruitment of terrestrial and aquatic invertebrates and reduced extent of emergent and submergent marcrophytes

Water Related Threats

Threats to the ecological water-dependent values are the result of factors such as human intervention and climate, and include:

- Changed water regime;
- Loss or reduction of wetland connectivity;
- Water quality; and
- Introduction/increase of exotic flora and fauna.

A qualitative assessment of current and future threats to Bullock Swamp was undertaken by SKM (2002). Those that were assessed as high priorities to address were:

- Modified water regimes (northern section);
- Increased groundwater levels (northern and southern sections);
- Increasing salinity (northern and southern sections); and
- Reduced Regent Parrot habitat (northern and southern sections).

River Regulation

The regulation of the Murray River has seen the water regime altered through the Spence's Bend section. Flow events of the magnitude required allowing flows into the creeks and wetlands of the floodplain are less frequent and of shorter duration. Combined with dry conditions over the last decade, this has affected the vigour of vegetation and placed trees under stress, affecting the productivity and functioning of the floodplain ecosystem.

The lack of floodwater to the northern section of Bullock Swamp is believed to be partially responsible for the degradation of vegetation (Predebon, 1990). Carwarp Creek is now permanently inundated to maintain amenity and supply of irrigation water. The structures in place to achieve this create a barrier to fish passage and prevent more frequent inundation of Bullock Swamp north. Invasive species which favour permanent inundation, such as carp, may thrive, contributing further to the decline of native biodiversity (Mallee CMA, 2012).

Irrigation and Drainage Water

In the past Bullock Swamp south received irrigation drainage water with electrical conductivities in the order of 2000 to 3000 EC but this ceased with the implementation of the Nangiloc-Colignan Salinity Management Plan in the early 1990's.

Bullock Swamp continues to be subject to seepage from an irrigation channel on its western edge (SKM, 1998). Carwarp Creek, the effluent between the Murray River and Bullock Swamp is now blocked at both ends to contain water pumped from the river for relifting by pumps along the creek. The use of wetlands for irrigation drainage can lead to a rise in groundwater tables and salinity, waterlogging and increased nutrient loads. Increases in nutrient load can, in turn, lead to algal blooms. The health of native vegetation may decline and an increase in invasive species may occur (Mallee CMA, 2006).

Groundwater and Salinity

The Bullock Swamp is a naturally semi-permanent saline wetland, and the ecology of the system is somewhat adapted to this environment. The floodplain is characterised by a shallow, saline water table that is within 5 m of the ground surface and may be within a metre of the ground surface below the bed of the Swamp itself. Bullock Swamp behaves as a groundwater discharge feature when empty, with salt moving upwards into the unsaturated zone due to evaporation. This, coupled with the location of the Swamp on high terrace floodplain that is infrequently flooded, suggests the potential for high salt concentrations within the unsaturated zone. Historical use of the site as a disposal point for saline drainage water may have also contributed to this.

A recent study undertaken by Australian Water Ecosystems (2014) on groundwater monitoring has indicated that since inception of the Nangiloc-Colignan Salinity Management Plan in 1991 the groundwater table within the Nangiloc-Colignan irrigation district has been variable with a decline in groundwater levels between 1992 and 2009, and an increase in the mound following a period of high river fow and rainfall between 2009 and 2013. Within the Nangiloc-Colignan district, irrigation occurs on the floodplain whereas districts of Merbein, Mildura, Red Cliffs and Robinvale occurs on the highland. This means that groundwater levels in the Nangiloc-Colignan district are more responsive to changes in river level and flood events.

Inundation of the Swamp may mobilise salts stored in the unsaturated zone through salt wash-off from the surface. Bullock Swamp is also likely to behave as a recharge feature when filled, mobilising salts in the unsaturated zone via infiltration through the Swamp bed and subsequent groundwater mounding. This process may flush salts from the top of the soils profile initially but may require multiple watering events to be maintained. The current management of Carwarp Creek is resulting in relatively fresh groundwater to the River Red Gums lining this section of the creek. Salinity of Bullock Swamp should be carefully monitored to ensure that objectives are not compromised by watering effects on the salinity levels.

Introduced Species

Common Carp (*Cyprinus carpio)* are prevalent in Carwarp Creek and may be present in other wetlands at Spencer's Bend. Carp have been found to contribute to the loss of aquatic vegetation and increased turbidity, resulting in loss of habitat for waterfowl (Purdey and Loyn, 2008) and native fish species. This species also competes with the native fish for habitat and food as well as having a detrimental effect on water quality (Mallee CMA, 2003).

The Red Fox (*Vulpes vulpes)*, is a significant threat to freshwater turtle breeding along Carwarp Creek. Turtle nest predation by foxes is very high. Although the fox is not a water related threat, it is having a substantial impact on a water dependent ecological value at the site.

Agricultural and other weeds are an ongoing threat and management issue along the Murray River floodplain. These may pose a threat when water is applied as increased water availability can cause weeds to thrive and displace native vegetation. A list of exotic flora species identified at Spence's Bend is given in Appendix 1.

Management Objectives

Management Goal

To provide a water regime that reflects natural inundation seasonality and duration, that will maintain and promote the mosaic of available habitats through the Spence's Bend target area.

Implementation of environmental water will happen in three stages, with the management goal referring to the outcomes expected by implementing all three stages.

Ecological Objectives

Ecological objectives represent the desired ecological outcomes of the site based on the management goal to do with key values outlined in the Water Dependent Values section. In line with the draft policy Victorian Waterway Management Strategy (VWMS) the ecological objectives are expressed as the target condition or functionality for each key value. The ecological objectives at this site are centred on reducing salt loads in Bullock Swamp, maintaining and improving the health of Lignum, Black Box and River Red Gum communities and reinstating wetland connectivity (Table 14).

Table 144 - Ecological objectives for the Spence's Bend target area

Ecological objective	Justification (value based)	Stage/ Site
Improve Swamp and woodland diversity and productivity to meet EVC benchmarks for Lignum Swamp (104) and Lignum Swampy Woodland (823) Communities in Bullock Swamp north	Lignum and Black Box communities are in a severely degraded state at Bullock Swamp. In a healthy state these flora species provide important habitat and feeding opportunities for listed species found in the target area, particularly waterbirds that breed over Lignum and hollow-dependent species that utilise Black Box.	Stage 1 – Bullock Swamp North
Increase woodland and shrubland diversity and productivity (including tree health) to meet EVC benchmarks for EVCs 103, 810, 818, 811, 813	River Red Gums are a keystone species and their health is essential to maintaining a functioning floodplain and river system. They provide essential breeding habitat for waterbirds and for hollow-dependent species such as the Regent Parrot	Stage 2 – Spence's Bend Billabong, Callanders Swamp and wetland #7329 246886
Maintain and Improve woodland, shrubland and Swamp diversity and productivity (including tree health) to meet EVC benchmarks for EVCs 103, 104, 808, 810, 811, 813, 818, 823	Lignum, Black Box and River Red Gum are keystone species and their health is essential to maintaining a functioning floodplain and river system. They provide breeding and feeding habitat for floodplain fauna, particularly waterbirds and hollow-dependent species such as the Regent Parrot.	Stage 3 – Spence's Bend Billabong, wetland # 7329242866 and Bullock Swamp south
Improve semi-permanent saline marsh habitat for Murray Hardyhead reintroduction	Murray Hardyhead occurs in open-water and amongst aquatic plants and macrophytes. *Ruppia* appears to be a key aquatic species in saline lakes where the Murray Hardyhead occurs (J.McGuckin pers. comm. cited in (Backhouse, Lyon and Cant, 2008).	Stage 3 – Bullock Swamp

Ecological objective	Justification (value based)	Stage/ Site
Reinstate seasonal connectivity between all wetlands in the target area	Connectivity between wetlands and to rivers is important for flow, water quality and energy and nutrient dynamics. Connectivity also facilitates breeding, maintenance, diversity and movement of aquatic plant and animal populations. This connectivity will also be important for movement of native fish, frogs and turtles between wetlands and the river (Amezaga, Santamaria and Green, 2001; MDBC, 2001).	Stage 3 - All
Increase aquatic macrophyte (submerged and emergent) diversity and area	Macrophytes provide habitat for a range of species including shelter from predators, nesting sites and a source of organic matter	All
Increase dissolved organic matter, particulate matter and macroinvertebrate productivity	The release of energy and nutrients greatly increases productivity which increases bacteria and invertebrates. Providing food for large aquatic animals. (Ecological Associates, 2013)	All
Improve or maintain water quality (particularly salinity) to meet standards for each wetland type and key species.	The flora and fauna which in habitat each wetland type have salinity tolerances for various stages in their lifecycle. In some cases, water quality conditions, such as temperature or dissolved oxygen (DO) may trigger responses such as spawning or migration off the floodplain.	All

The ecological objectives focus on wetland health and ecological vegetation communities with the dominant species of Lignum, Black Box and River Red Gum, representing the ecological communities that meet habitat and feeding requirements of many of the fauna species present in the target area. Many of the listed flora species found in the target area occur in EVC's dominated by these species. Attainment of the ecological objectives is anticipated to have wider benefits for the target area and is expected to result in:

- Improving understorey productivity;
- Reinstating submerged and semi emergent aquatic macrophytes;
- Improving nesting opportunities for waterbirds and the Regent Parrot in flooded trees lining billabong; and
- Providing a refuge for turtles, frogs, large fish species and possibly Murray Hardyhead in the future.

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

Hydrological Objectives

Hydrological objectives describe the components of the water regime required to achieve the ecological objectives for the target area. The hydrological requirements to achieve each of these objectives are presented in Table 5.

River Red Gum stands are found in woodland EVC's within the target area. River Red Gum Woodlands require flooding every two to four years with durations of two to four months. Flood events may differ and a

variance in ponding duration around the mean requirement for this species is encouraged. Although the timing of flooding is not vital for River Red Gum, spring-summer flooding encourages greater growth. Timing is important for understorey plant communities however. The critical interval for River Red Gum woodlands is five to seven years to prevent deterioration of tree condition (Roberts and Marston, 2011).

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

Lignum can tolerate a wide range of wet and dry conditions as well as moderate salinity levels. Flood requirements vary with frequencies of one to three years needed to maintain large shrubs with vigorous canopy and flooding every three to five years for maintenance of healthy shrubs. Intervals of seven to ten years can be tolerated by small shrubs but growth will decline and plants in this state do not accommodate nesting by birds. Durations of three to seven months sustain vigorous canopy, but continuous flooding is detrimental. Although timing of flooding is not crucial for Lignum, following natural seasonality is encouraged to provide for understorey and wetland plants (Roberts and Marston, 2011). Longer durations of flooding would be required for specific species of colonial waterbirds, who will abandon nests as flooding recedes. Specific objectives have not been set at this site for these species.

Semi-permanent saline marshes such as Bullock Swamp require inundation one to six months with a minimum frequency of one in ten years and a maximum frequency of every year (Ecological Associates, 2007b). Promotion of semi-emergent macrophytes can be managed with inundation at a depth up to a metre, with duration of one to twelve months. Events should occur with a minimum frequency of every two years and a maximum frequency of every year (Ecological Associates, 2007b).

Table 15 - Hydrological objectives for the Spence's bend target area

Ecological objective	Water management area	Hydrological Objectives								
		Mean frequency of events (Number per 10 years)			Tolerable interval between events (years)		Duration of ponding (months)			Preferred timing of inflows
		Min	Opt	Max	Min	Max	Min	Opt	Max	
Improve Swamp and woodland diversity and productivity to meet EVC benchmarks for Lignum Swamp (104) and Lignum Swampy Woodland (823) Communities in Bullock Swamp north	Wetland / Floodplain	3	5	10	1	7	3	5	7	Winter/Spring
Increase woodland and shrubland diversity and productivity (including tree health) to meet EVC benchmarks for EVCs 103, 810, 818, 811, 813 **Maintain and Improve** woodland, shrubland and Swamp diversity and productivity (including tree health) to meet EVC benchmarks for EVCs 103, 104, 808, 810, 811, 813, 818, 823 (Focus of this hydrological objective is River Red Gum)		2	3	7	1	7	2	3	8	Spring/Summer
Increase woodland and shrubland diversity and productivity (including tree health) to meet EVC benchmarks for EVCs 103, 810, 818, 811, 813 **Maintain and Improve** woodland, shrubland and Swamp diversity and productivity (including tree health) to meet EVC benchmarks for EVCs 103, 104, 808, 810, 811, 813, 818, 823 (Focus of this hydrological objective is Black Box)		2	3	3	3	10	2	4	6	Winter/Spring
Reinstate seasonal connectivity between all wetlands in the target area**										
Increase aquatic macrophyte diversity and area in the Freshwater marsh habitats		2	5	10	0		1	6	12	Winter/Spring
Increase dissolved organic matter, particulate matter and macroinvertebrate productivity**										
Improve semi-permanent saline marsh habitat for Murray Hardyhead reintroduction		5	10	10	1	1	1	6	8	Winter/Spring
Improve or maintain water quality (particularly salinity) to meet standards for each wetland type and key species**										

* Due to the inter-annual variability of these estimates (particularly the climatic conditions), determination of the predicted volume requirements in any given year will need to be undertaken by the environmental water manager when watering is planned. **Ecological objective met by other hydrological objectives

Staged implementation of the watering regime at Spence's Bend target area

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

The optimal, minimum and maximum watering regimes for each Stage are described below. The extent of the target area inundated is also presented and is also shown in Figure 94 and Figure 105. Due to the inter-annual variability of these estimates (particularly the climatic conditions), determination of the predicted volume requirements in any given year will need to be undertaken by the environmental water manager when watering is planned.

Stage 1- Bullock Swamp north

Stage 1 (Figure 14) involves the inundation of approximately 140 ha of Bullock Swamp north of Rudds Road, requiring approximately 312 ML of environmental water. This will be the option adopted in the early phases of environmental water delivery to Spence's Bend. There are no infrastructure requirements for Stage 1.

Water Regime	Inundation area, duration and frequency
Minimum	Inundate Bullock Swamp north three times in ten years with a maximum interval of seven years between events. Maintain water in the wetland for three months to improve wetland function and the health of Lignum communities in the Swamp. In two inundation events out of three, bring the water level high enough to reach Black Box Woodlands fringing the Swamp and allow ponding for two months to maintain Black Box health.
Optimal	Inundate Bullock Swamp north five times in ten years with a maximum interval of seven years between events. Maintain water in the wetland for five months to improve wetland function and the health of Lignum communities in the Swamp. In three inundation events out of five, bring the water level high enough to reach Black Box Woodlands fringing the Swamp and allow ponding for four months to improve Black Box health.
Maximum	Inundate Bullock Swamp north ten times in ten years with a maximum interval of one year between events. Maintain water in the wetland for seven months to improve wetland function and the health of Lignum communities in the Swamp. In five inundation events out of ten, bring the water level high enough to reach Black Box Woodlands fringing the Swamp and allow ponding for six months to improve Black Box health.

Stage 2- Spence's Bend, Callander's Swamp and wetland #7329 246 886

The wetlands involved in Stage 2 (Figure 14) include Spence's Bend Billabong, Callander's Swamp and wetland #7329 238897. This stage will inundate an area of approximately 53 ha and require approximately 650 ML of environmental water. These wetlands are the first to receive inflows under high Murray River levels, although their connection to the river is regulated. These wetlands have received environmental water in the past and in mid-2014 were in a drying phase. Environmental water may be delivered to these sites again in the future under Stage 2 if they dry out completely.

Water Regime	Inundation area, duration and frequency
Minimum	Inundate the wetlands and fringing River Red Gum Woodlands two times in ten years with a maximum interval of seven years between events. Maintain water in the wetland for four months to maintain wetland function and on the floodplain for two months to maintain the health of River Red Gum communities.
Optimal	Inundate the wetlands and fringing River Red Gum Woodlands three times in ten years with a maximum interval of two years between events. Maintain water in the wetland for eight months and on the floodplain for eight months to improve the health of River Red Gum communities.
Maximum	Inundate the wetlands and fringing River Red Gum Woodlands seven times in ten years with a maximum interval of one year between events. Maintain water in the wetlands for twelve months and on the floodplain for eight months to improve the health of River Red Gum communities.

Stage 3- Spence's Bend Billabong, wetland # 7329242866 and Bullock Swamp south

The inundation extent for Stage 3 (Figure 16) includes Spence's Bend Billabong, wetland #7329 246866 and Bullock Swamp south and north. This stage aims to restore connectivity between all the wetlands and provide major inundation of the target area. This may be achieved by connecting the northern and southern sections of Bullock Swamp via a regulated culvert under Rudds Road. This would allow through-flows between Bullock Swamp north and south and on to the wetlands within the Murray River Park. This would provide the opportunity for return flows back to the Murray River from Bullock Swamp north to aid in rehabilitation of the Swamp. This stage would inundate approximately 306 ha and require approximately 2486 ML of environmental water.

Combining Stage 2 and 3 to inundate all wetlands in the target area at once would inundate an area of approximately 341 ha and require approximately 2949 ML of environmental water.

Water Regime	Inundation area, duration and frequency
Minimum	Inundate the target area two times in ten years with a maximum interval of seven years between events. Maintain ponding for three months to maintain Lignum, River Red Gum and Black Box communities.
Optimal	Inundate the target area five times in ten years with a maximum interval of three years between events. Maintain ponding for five months to improve Lignum, River Red Gum and Black Box communities.
Maximum	Inundate the wetlands and fringing Lignum and River Red Gum communities ten times in ten years with a maximum interval of one year between events. Extend the inundation area to include Black Box communities three times in ten years with a maximum interval of three year between events. Maintain ponding for eight months to improve Lignum, River Red Gum and Black Box communities.

Stage 4 – Murray Hardyhead reintroduction – Bullock Swamp North and South

If Bullock Swamp is pursued as a site for reintroduction of Murray Hardyhead (10 year+), and appropriate works are undertaken to improve connectivity between north and south Bullock Swamp, the Swamp should be inundated every year, with an optimal duration of 6 months to support the semi-permanent saline wetland conditions (Ecological Associates, 2007b). Inundation should occur over spring/summer as spawning is associated with increasing water temperature and day length. Murray Hardyhead need sufficient depth of water over *Ruppia spp.* beds to allow successful spawning and recruitment (King et al., 2009) in spring and summer (Cadwallader and Backhouse, 1983).

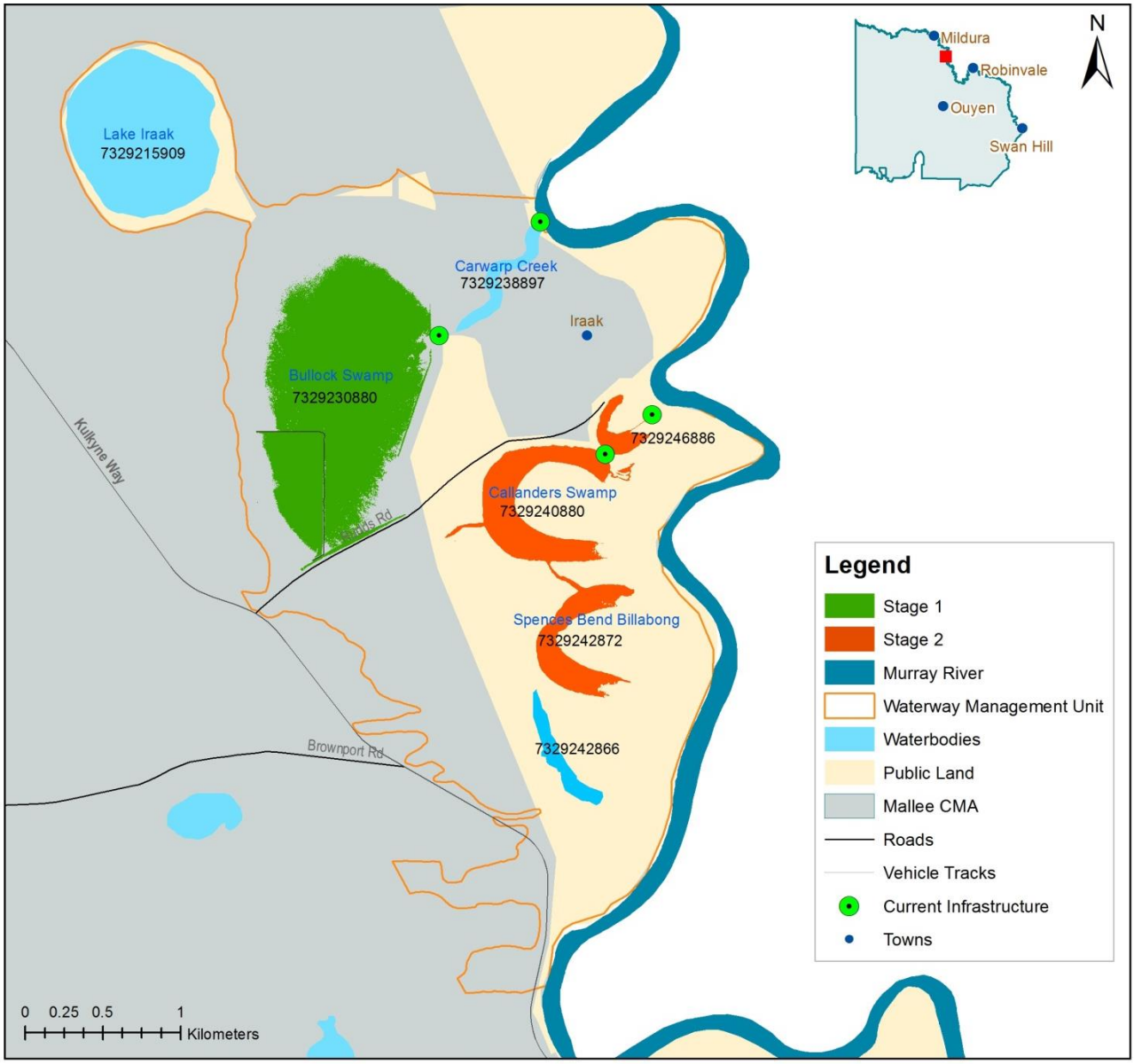


Figure 94. Inundation extent for Stages 1 and 2 of the Spence's Bend EWMP

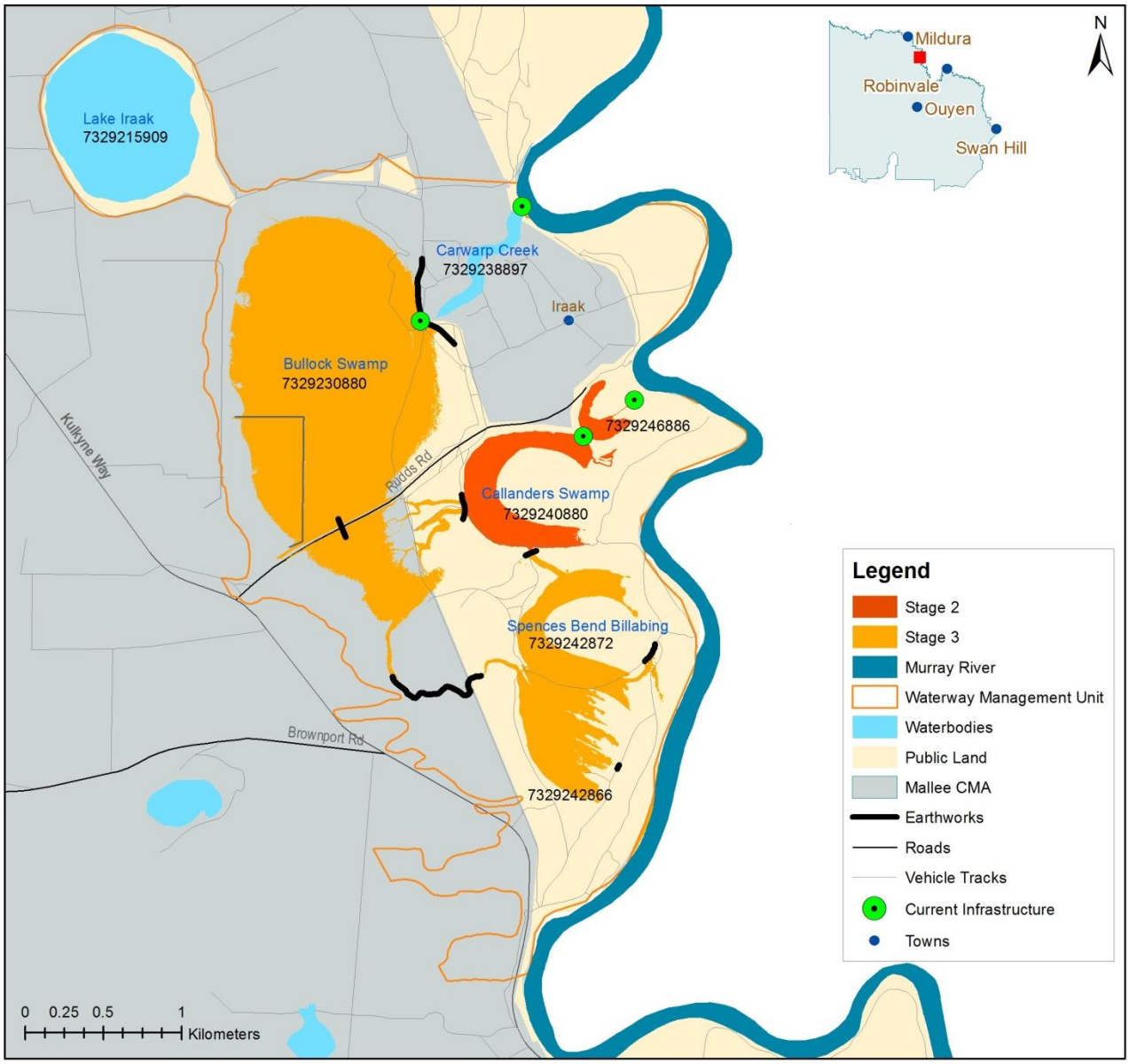


Figure 105. Inundation extent for Stages 3 and 4 of the Spence's Bend EWMP

Managing Risks to Achieving Objectives

Table 16. Assessment of risks to achieving the objectives of the Spence's Bend EWMP

Threat	Likelihood	Consequence	Risk – H, M, L (likelihood x consequence)	Management Measure	Residual Risk
Failure to meet ecological objectives	Possible	High	H	Monitoring program in place. Adaptive approach	Low
Species/communities or ecological processes have been overlooked in water regime due to lack of data	Unlikely	High	L	N/A	
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	N/A	
Groundwater recharge associated with wetting Bullock Swamp impacts ecological values or water users	Possible	Moderate	L	N/A	
Environmental watering program negatively affects cultural heritage sites	Unlikely	High	L	N/A	

Threat	Likelihood	Consequence	Risk – H, M, L (likelihood x consequence)	Management Measure	Residual Risk
Return flows to the Murray River have significant salinity impact	Possible	High	H	It is not proposed to return environmental water to the Murray River	Low
Infrastructure constructed or retrofitted to assist with implementation of Stages 2 & 3 impact environment e.g. creation of additional barriers	Unlikely	High	L	Appropriate designs in place and construction regimes in place	
Monitoring program is unable to detect improvements in short to medium term (Engagement risk)	Possible	High	M	Appropriate engagement with stakeholders confirming expected outcomes and timeframes	Low
Loss of relocated population of Murray Hardyhead population	Unlikely	Very High	M	Appropriate regulations in place to ensure all assessment is rigorous before reintroduction would occur.	Low

Environmental Water Delivery Infrastructure

Constraints

The existing arrangements limit the frequency and duration of inundation by flows at Spence's Bend. Current infrastructure (Figure 16) consists of:

- A regulator on wetland #7329 246886 is constructed out of bricks, framed by an iron structure and operated by drop boards. There are difficulties operating this structure in its current condition.
- A regulator on Callander's Swamp made of concrete with a 300 mm pipe and one way valve (therefore requiring no active operation). This structure is in fair to good condition.
- A road levee (Rudds Rd) across Bullock Swamp which prevents water from flowing from south into the northern section. There is a small culvert through Rudds Rd, which is believed to be silted up and does not let water past. The location of this culvert is unknown.
- Regulating structures on both ends of Carwarp Creek.

The most significant constraints to returning the Bullock Swamp system to a more natural water regime are the risks associated with salinity. These include:

- If Carwarp Creek was to be decommissioned, receding water from the northern section of the wetland to the Murray River may release high salt loads back to the Murray River (SKM 1998).
- If the levee between the wetland and the creek was modified to allow floodwaters to pass, receding floodwaters high in salt would enter the creek.
- There is limited mixing within the northern section of the wetland, meaning accumulated salt may be difficult to flush from the system.
- The desolation of the Rudds Rd culvert may allow saline water from the northern section to mix with the southern section. The southern section currently receives water from river flows and has more intact vegetation as a result.

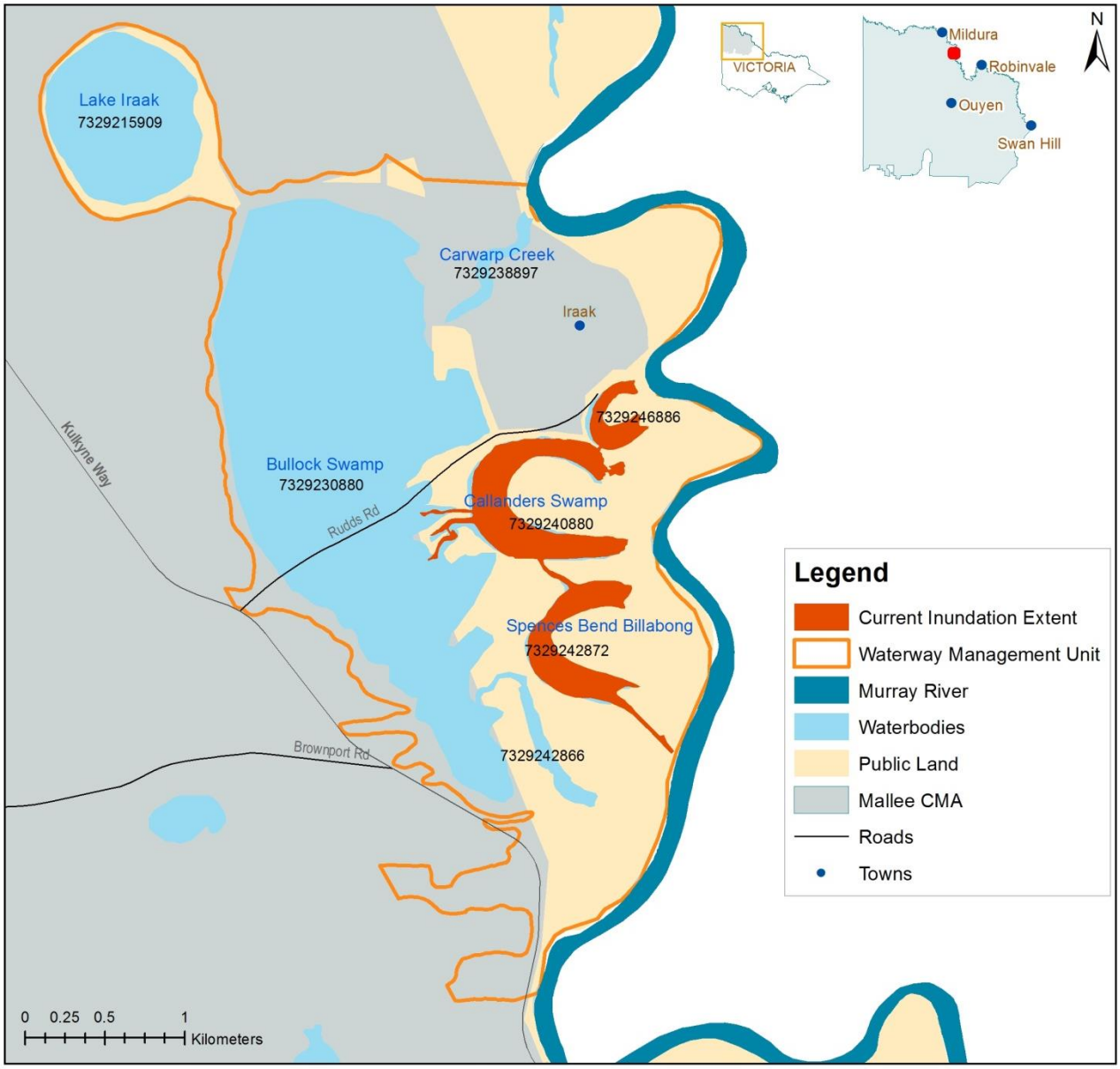


Figure 116 - Current inundation extent of Spence's Bend WMU Sub-Unit

Infrastructure or complementary works recommendations

In order to provide the environmental water delivery to the target area proposed in Stages 1 to 3 of this EWMP, some upgrades to infrastructure are required. Environmental water delivery within the entire target area will not be possible without the infrastructure upgrades, and the ecological objectives will not be achieved.

Ecological Associates (2007b) prioritised water management options for Spence's Bend. This included recommending a number of infrastructure upgrades. Subsequent to the Ecological Associates report, a feasibility assessment and concept design report was completed by Alluvium to further refine and prioritise the options (Alluvium, 2007). The reports recommended two infrastructure options for Spence's Bend. These two options have been developed to the concept designs stage consisting of:

- Upgrading existing regulators on wetland #7329 246886. A manually operated penstock type regulator that enables water to enter and recede. The regulator will enable watering to an elevation of 36.6 m AHD and inundate 55 ha during stage 3.

- Connect the Bullock Swamp north to the Bullock Swamp south through the installation of culverts in Rudds Rd. This would consist of three sets of 2 No.1500 x 1200 reinforced concrete box culverts. This would achieve an inundation extent of 200ha (Ecological Associates, 2007b) and provide hydraulic connection between Bullock Swamp North and South during stage 4.
- Construction of a regulator between Spence's Bend Billabong and Callander's Swamp to control flows. This would also provide the ability to direct water flow from Spence's Bend Billabong (once this has filled) to Bullock Swamp south, rather than into Callander's Swamp which can also fill through wetland #7329 246886 downstream during stage 2.
- Improve connectivity between Carwarp Creek & Bullock Swamp north during stage 3.
- Construction of levees on Spence's Bend Billabong flood runners (eastern side) to prevent flow back to the river during stage 3.
- Construction of a levee along the western boundary of Callander's Swamp to block flood runners from Bullock Swamp south. This would allow water to run from Bullock Swamp south under Rudds Road to fill Bullock Swamp north. Without this water may return to Callander's Swamp and back to the river without reaching Bullock Swamp north during stage 2.
- Deconstruction of a levee and grading across the flood runner between wetland #7329 242866 and Bullock Swamp south to allow through-flow during stage 4.
- In order to provide appropriate habitat connectivity for a reintroduction of Murray Hardyhead, a regulator would need to be installed under Rudds Road to allow ease of movement and management of water between Bullock Swamp South and North during stage 4.

The proposed works would significantly increase the volume and extent of water able to be delivered to the selected wetlands and reintroduce water to the northern end of Bullock Swamp. The function of these works depends on peak flows in river flow and would also require temporary pumping if this did not occur (EA 2007b).

Demonstrating Outcomes

Monitoring Priorities at the Site

Ongoing water quality monitoring should occur in each of the target area wetlands. This should include both baseline and event based monitoring, particularly focusing on salinity.

A small groundwater-monitoring program could also be implemented focusing on bores located around the perimeter of Bullock Swamp and adjacent Carwarp Creek. The collection of groundwater level and salinity data will help assess the groundwater response to watering and the level of connection between the Swamp and the floodplain aquifer. This will in turn improve assessments of leakage rates and mounding beneath the Swamp bed (Australian Water Environments, 2014).

Although not critical to the salt and water balance, a follow up soil sampling program is recommended at the conclusion of the environmental watering event. This would help to evaluate the success of watering relative to leaching salts from the upper soil profile.

Index of Wetland Condition assessments should be undertaken every five years at the site to monitor the health of the vegetation communities in response to the implementation of the EWMP.

Specific surveys of flora and fauna at the site would be beneficial, particularly studies focusing on the listed species identified within this plan.

Consultation

This Plan was developed in collaboration with key stakeholders namely Parks Victoria, the Latji Latji and Nyeri Nyeri Indigenous Communities, DELWP and local interest groups (Table 17). Parts of Bullock Swamp and Carwarp Creek are freehold and consultation with local landholders was required regarding the management of all wetlands and associated waterways.

Table 157 - Consultation undertaken as part of the development of the EWMP

Meeting Date	Stakeholders	Details
10 Sept 2012	Parks Victoria	Initial discussion to introduce concept of plan
12 Sept 2012 **28 Oct 2013**	Local residents	House calls to residents to begin consultation phase
12 Nov 2012	Local Landholders (including holders of environmental covenant over Bullock Swamp)	Informal gathering to discuss possibilities for environmental watering plan.
28 Nov 2013 **12 Dec 2013**	Nangiloc Irrigation Association (NIA)	Informal meeting & NIA AGM – discussed use of irrigation infrastructure for environmental water delivery to Bullock Swamp
TBA	Latji Latji, Nyeri Nyeri	Presentation and review of draft plan
2 March 2015 **12 February 2015**	Local landholders Local residents Aboriginal Reference Group Nagiloc Irrigation Association Mallee CMA – Land and Water Advisory Committee	Preparation for environmental watering event

Knowledge Gaps and Recommendations

This plan is based on the best information at the time of writing. In some cases this information is scarce or outdated. Further investigation and information collection will continue and the results of this further work will continue to build a better picture of the site and add rigor to future planning.

Knowledge Gaps

An Index of Wetland Condition assessment should be undertaken for each of the wetlands within the target area. This will establish baseline condition, as the basis for monitoring improvement over the long term for the target area.

Further assessment of the potential for Bullock Swamp as a site for reintroduction Murray Hardyhead.

Continue to build understanding of the optimal salinity conditions for Bullock Swamp, including the long term interactions with groundwater, irrigation and drainage.

Continue to investigate the best environmental option between returning environmental water to the river and retaining water in the wetlands following environmental watering of the target area.

Continue to investigate and better understand the water requirements of all values of the site, including understorey vegetation and aquatic macrophytes.

Continue to investigate and understand the range of species at the site, including surveys of vegetation, including aquatic macrophytes.

Recommendations

1. Landholder agreements should be signed outlining the proposed watering regimes and any inundation of private land. This would include land currently under covenant.
2. Prior to the infrastructure upgrades proposed in this EWMP it is recommended that agreements with stakeholders and landholders be developed. These agreements should included details of the roles in management of the infrastructure, financial responsibilities for the infrastructure etc.
3. Development of functional and detail designs for the infrastructure proposed in this EWMP that has undergone feasibility assessment and costing.
4. Undertake feasibility assessment and costing of the additional works identified by Mallee CMA which would benefit environmental watering at the target area.
5. Cultural and heritage assessments to be undertaken prior to any works being implemented.
6. Development of operating rules for structures and each wetland within the target area.

References

Alluvium, 2007. Feasibility Assessment and concept design: Water management options for the Murray River - Robinvale to Wallpolla Island: Stage 2.

Amezaga, J.M., Santamaria, L. and Green, A.J., 2001. Biotic wetlands connectivity - supporting a new approach for wetland policy. International Journal of Ecology, 23, pp.213–222.

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

Australian Water Environments, 2014. Salinity Impact Assessment for Mallee Environmental Watering Sites - Follow Up Salinity Impact Assessment Bullock Swamp. Report prepared for Mallee Catchment Management Authority.

Backhouse, G., Lyon, J. and Cant, B., 2008. National Recovery Plan for the Murray Hardyhead Crateroephalus fluviatilis. East Melbourne, Victoria: Department of Sustainability and Environment.

Baker-Gabb, D. and Hurley, V.., 2011. National Recovery Plan for the Regent Parrot (eastern sub speices) *Polytelis anthopeplus monarchoides*. Melbourne, Victoria: Department of Sustainability and Environment.

Barling, R. and Linke, G., 1993. Memorandum on the hydrology of Bullock Swamp. Memorandum to Janice Kelly - Project Officer for the Nangiloc-Colignan Salinity Management Plan.

Cadwallader, P. and Backhouse, G., 1983. A Guide to the Freshwater Fish of Victoria. Melbourne, Victoria: Victorian Government Printing Office.

Cheal, D., Lucas, A. and Macaulay, L., 2011. National Recovery Plan for Buloke Woodlands of Riverina and Murray-Darling Depression Bioregions. Melbourne, Victoria: Department of Sustainability and Environment.

Chessman, B.C., 2011. Decline of freshwater turtles associated with climatic drying in Australia's Murray-Darling Basin. Wildlife Research, 38, pp.664–671.

CSIRO, 2004. Water for a Healthy Country, Taxon Attribute Profiles, Chelidae. Available at: <http://www.cpbr.gov.au/cpbr/WfHC/Chelidae/index.html>.

DEPI, 2005. Index of Wetland Condition. Conceptual framework and selection of measures. East Melbourne, Victoria: Department of Environment and Primary Industries.

DNRE, 1997. Victoria's Biodversity- Our Living Wealth - Sustaining Our Living Wealth and Directions in Management. Melbourne, Victoria: Department of Natural Resources and Environment.

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

DSE, 2003. Action Statement; Swamp Sheoak *Casuarina obesa*. East Melbourne, Victoria: Department of Sustainability and Environment.

DSE, 2005. EVC Bioregion Benchmark for Vegetation Quality Assessment. Robinvale Plains Bioregion, EVC 104: Lignum Swamp. East Melbourne, Victoria: Department of Sustainability and Environment.

DSE, 2006. Wetlands biodiversity and salt: Frogs. East Melbourne, Victoria: Department of Sustainability and Environment.

Ecological Associates, 2007a. Feasibility investigation of options for Hattah Lakes, Final Report. Mildura, Victoria: Report prepared for Mallee Catchment Management Authority.

Ecological Associates, 2007b. Investigation of Water Management Options for the River Murray – Robinvale to Wallpolla Island: Final Report. Mildura, Victoria: Report prepared for Mallee Catchment Management Authority.

Ecological Associates, 2013. Locks 8 and 9 Weir Pool Manipulation Optimisation Plan- Analysis Report. Buronga: Ecological Associates.

Flora Bank, 2014. Casuarina obesa. Available at: <http://www.florabank.org.au/lucid/key/species%20navigator/media/html/Casuarina_obesa.htm>.

Gippel, C.J., 2014. Spells analysis of modelled flow for the River Murray from Swan Hill to the South Australian Border. Stockton: Fluvial Systems Pty Ltd, Stockton. Mallee CMA, November.

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

King, A., Ramsey, D., Baumgartner, L., Humphries, P., Jones, M. and Koehn, J., 2009. Environmental requirements for managing successful fish recruitment in the Murray River Valley - review of existing knowledge. Heidelberg, Victoria, Arthus Rylah Institute for Enviornmental Research: Department of Sustainability and Environment.

LCC, 1989. Mallee Area Review Final Recommendations. Melbourne, Victoria: Land Conservation Council.

Mallee CMA, 2003. Murray River Frontage Action Plan –Robinvale to Merbein Common. Mildura, Victoria: Mallee CMA.

Mallee CMA, 2006. Mallee River Health Strategy. Mildura, Victoria: Mallee CMA.

Mallee CMA, 2012. Kings Billabong Operating Plan. Mildura, Victoria: Mallee CMA.

Mallen-Cooper, M. and Stuart, I., 2003. Age, growth and non-flood recruitment of two potamodrous fishes in a large semi-arid/temperate river system. River Research and Applications, 19, pp.697–719.

MDBC, 2001. Rivers as Ecological Systems: The Murray-Darling Basin. Canberra, ACT: Murray-Darling Basin Commision.

Nangiloc/Colignan and District Community, 2014. History of Irrigation in the Nangiloc District. Available at: <http://nangiloc.vic.au/district/history-of-the-nangiloc-district/history-of-irrigation-in-the-nangiloc-district>.

Noelker Consulting, 2008. Nangiloc/Colignan and District Community Plan.

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

Predebon, S., 1990. Nangiloc Coliganan Salinity Management Plan. Nangiloc Colignan: the environment. Mildura, Victoria: Department of Conservation, Forest and Lands.

Purdey, D. and Loyn, R., 2008. Wetland use by Blue-billed Ducks Oxyura australis during Summer Waterfowl Counts in North-West Victoria, 1984-2008. Heidelberg, Victoria: Arthur Rylah Institute for Environmental Research.

Raadik, T. and Fairbrother, P., 1999. Cardross lakes aquatic fauna monitoring -November 1998. Department of Natural Resources and Environment.

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

Rogers, K. and Ralph, T.., 2011. Floodplain wetland biota in the Murray Darling Basin. In: Floodplain wetland biota in the Murray Darling Basin. Collingwood, Victoria: CSIRO Publishing, pp.17–82.

Roshier, D.A., Robertston, A.I. and Kingsford, R.T., 2002. Responses of waterbirds to flooding in an arid region of Australia and implications for conservation. Biological Conservation, (106), pp.399–411.

SKM, 1998. Feasibility study of rehabilitating Bullock Swamp. Report to Sunraysea Rural Water Authority.

SKM, 2002. Bullock Swamp Wetland Operational Plan. Final report for Mallee CMA.

SKM, 2009. Ecological Objectives for the Euston Weir. Department of Water and Energy, NSW.

SKM, 2013. Preliminary Salinity Impact Assessment for Mallee Environmental Water Projects: Wallpolla Floodplain; Bulloke Swamp; Hattah Lakes; Belsar & Yungera; Burra Creek, Nyah Forest, Vinifera. Mildura, Victoria: Final report for Mallee CMA3.

Sunrise 21, 2010. Mallee Irrigation Drainage. Volume 2. Colignan Region. Mildura, Victoria: Report prepared for Mallee Catchment Management Authority.

Tarr, T.L. and Babbit, K.J., 2002. Effects of habitat complexity and predator identity on predation of Rana clamitans larvae. Amphibia Reptilia, (23), pp.13–20.

Treadwell, S. and Hardwick, R., 2003. Review of habitat associations of native fish in the Murray-Darling Basin. Armidale, Victoria: SKM.

VEAC, 2008. River Red Gum Investigation. East Melbourne, Victoria: Victorian Enviornmental Assessment Council.

Webster, R. and Belchar, C., 2005. A Survey of Regent Parrot, Polytelis anthopeplus monarchoides, Breeding Colonies along the Murray River in Victoria. Deniliquin, NSW: Ecosurveys.

Abbreviations and Acronyms

ANCA Australian Nature Conservation Agency

AVIRA Aquatic Value Identification and Risk Assessment

CAMBA China-Australia Migratory Bird Agreement

CMAs Catchment Management Authorities

DEH Department of Environment and Heritage

DEPI Department of Environment and Primary Industries

DSE Department of Sustainability and Environment

EA Ecological Associates

EPBC Environment Protection and Biodiversity Conservation Act

EVC Ecological Vegetation Class

EWA Environmental Water Allocation

EWMP Environmental Water Management Plan

EWH Environmental Water Holder

EWR Environmental Water Reserve

FFG Flora and Fauna Guarantee Act

FSL Full Supply Level

G-MW Goulburn-Murray Water

MCMA Mallee Catchment Management Authority

MDBA Murray-Darling Basin Authority (formally Murray-Darling Basin Commission, MDBC)

Ramsar Global treaty adopted in the Iranian city of Ramsar in 1971 that focuses on the conservation of internationally important wetlands

RMUF Murray River Unregulated Flow

RRG River Red Gum

TLM The Living Murray Initiative

TSL Targeted Supply Level

VEAC Victorian Environmental Assessment Council

VEWH Victorian Environmental Water Holder

VWMS Victorian Waterway Management Strategy

WMU Waterway Management Unit

Appendix 1 – Flora and Fauna Species List

Flora Native

Scientific Name	Common Name	Records
Abutilon otocarpum	Desert Lantern	12
Acacia brachybotrya	Grey Mulga	2
Acacia colletioides	Wait-a-while	2
Acacia ligulata	Small Cooba	4
Acacia montana	Mallee Wattle	2
Acacia oswaldii	Umbrella Wattle	4
Acacia rigens	Nealie	2
Acacia stenophylla	Eumong	22
Acacia wilhelmiana	Dwarf Nealie	2
Actinobole uliginosum	Flannel Cudweed	10
Agrostis s.l. spp.	Bent/Blown Grass	3
Ajuga australis	Austral Bugle	3
Alectryon oleifolius subsp. canescens	Cattle Bush	6
Allocasuarina luehmannii	Bullock	4
Alternanthera denticulata s.l.	Lesser Joyweed	1
Alternanthera denticulata s.s.	Lesser Joyweed	5
Ammannia multiflora	Jerry-jerry	1
Amphibromus nervosus	Common Swamp Wallaby-grass	1
Amyema miquelii	Box Mistletoe	6
Amyema miraculosa subsp. boormanii	Fleshy Mistletoe	2
Aristida contorta	Sand Wire-grass	2

Scientific Name	Common Name	Records
Asperula gemella	Twin-leaf Bedstraw	2
Atriplex leptocarpa	Slender-fruit Saltbush	67
Atriplex lindleyi	Flat-top Saltbush	47
Atriplex lindleyi subsp. conduplicata	Baldoo	1
Atriplex lindleyi subsp. inflata	Corky Saltbush	34
Atriplex nummularia	Old-man Saltbush	1
Atriplex papillata	Coral Saltbush	11
Atriplex pseudocampanulata	Mealy Saltbush	1
Atriplex pumilio	Mat Saltbush	10
Atriplex semibaccata	Berry Saltbush	40
Atriplex spinibractea	Spiny-fruit Saltbush	3
Atriplex spp.	Saltbush	10
Atriplex vesicaria	Bladder Saltbush	3
Austrostipa drummondii	Cottony Spear-grass	4
Austrostipa elegantissima	Feather Spear-grass	5
Austrostipa nitida	Balcarra Spear-Grass	8
Austrostipa scabra	Rough Spear-grass	8
Austrostipa scabra subsp. falcata	Rough Spear-grass	18
Austrostipa spp.	Spear Grass	35
Bergia trimera	Small Water-fire	1
Beyeria opaca	Dark Turpentine-bush	1
Billardiera cymosa s.l.	Sweet Apple-berry	1
Bolboschoenus caldwellii	Salt Club-sedge	2

Scientific Name	Common Name	Records
Brachyscome ciliaris	Variable Daisy	15
Brachyscome ciliaris var. ciliaris	Variable Daisy	1
Brachyscome lineariloba	Hard-head Daisy	37
Bulbine semibarbata	Leek Lily	14
Calandrinia eremaea	Small Purslane	54
Calandrinia volubilis	Twining Purslane	1
Callitris gracilis subsp. murrayensis	Slender Cypress-pine	3
Calocephalus sonderi	Pale Beauty-heads	12
Calotis hispidula	Hairy Burr-daisy	42
Carpobrotus modestus	Inland Pigface	2
Casuarina obesa	Swamp Sheoak	12
Casuarina pauper	Belah	1
Centipeda cunninghamii	Common Sneezeweed	8
Centipeda minima s.l.	Spreading Sneezeweed	1
Chamaesyce drummondii	Flat Spurge	10
Chenopodium cristatum	Crested Goosefoot	3
Chenopodium curvispicatum	Cottony Saltbush	2
Chenopodium desertorum subsp. desertorum	Frosted Goosefoot	1
Chenopodium nitrariaceum	Nitre Goosefoot	16
Chrysocephalum apiculatum s.l.	Common Everlasting	1
Chrysocephalum semipapposum	Clustered Everlasting	1
Convolvulus clementii	Desert Bindweed	1
Crassula colorata	Dense Crassula	95

Scientific Name	Common Name	Records
Crassula decumbens var. decumbens	Spreading Crassula	1
Crassula sieberiana s.l.	Sieber Crassula	63
Crassula spp.	Crassula	2
Cressa australis	Rosinweed	14
Cullen pallidum	Woolly Scurf-pea	3
Cynodon dactylon	Couch	12
Cynoglossum australe	Australian Hound's-tongue	3
Daucus glochidiatus	Australian Carrot	1
Dianella revoluta s.l.	Black-anther Flax-lily	1
Disphyma crassifolium subsp. clavellatum	Rounded Noon-flower	35
Dissocarpus paradoxus	Hard-head Saltbush	5
Dodonaea bursariifolia	Small Hop-bush	1
Dodonaea spp.	Hop Bush	6
Dodonaea viscosa	Sticky Hop-bush	4
Dodonaea viscosa subsp. angustissima	Slender Hop-bush	12
Eclipta platyglossa	Yellow Twin-heads	1
Einadia nutans subsp. nutans	Nodding Saltbush	76
Eleocharis plana	Flat Spike-sedge	1
Enchylaena tomentosa var. tomentosa	Ruby Saltbush	81
Enneapogon avenaceus	Common Bottle-washers	1
Enteropogon acicularis	Spider Grass	9
Epaltes cunninghamii	Tall Nut-heads	1
Eragrostis australasica	Cane Grass	7

Scientific Name	Common Name	Records
Eragrostis dielsii	Mallee Love-grass	32
Eragrostis infecunda	Southern Cane-grass	4
Eragrostis lacunaria	Purple Love-grass	3
Eragrostis setifolia	Bristly Love-grass	14
Eragrostis spp.	Love Grass	2
Eremophila deserti	Turkey Bush	1
Eremophila divaricata subsp. divaricata	Spreading Emu-bush	4
Eremophila glabra	Common Emu-bush	1
Eriochiton sclerolaenoides	Woolly-fruit Bluebush	1
Erodium crinitum	Blue Heron's-bill	1
Eucalyptus camaldulensis	River Red-gum	13
Eucalyptus costata subsp. murrayana	Yellow Mallee	1
Eucalyptus dumosa	Dumosa Mallee	3
Eucalyptus gracilis	Yorrell	1
Eucalyptus largiflorens	Black Box	26
Eucalyptus leptophylla	Slender-leaf Mallee	4
Eucalyptus oleosa subsp. oleosa	Oil Mallee	3
Eucalyptus socialis subsp. socialis	Grey Mallee	4
Eucalyptus spp.	Eucalypt	1
Euchiton sphaericus	Annual Cudweed	4
Euphorbia spp.	Spurge	2
Eutaxia microphylla	Common Eutaxia	1
Exocarpos aphyllus	Leafless Ballart	1

Scientific Name	Common Name	Records
Fimbristylis aestivalis	Summer Fringe-sedge	1
Frankenia foliosa	Leafy Sea-heath	2
Frankenia serpyllifolia	Bristly Sea-heath	2
Gahnia lanigera	Desert Saw-sedge	1
Geococcus pusillus	Earth Cress	2
Glinus oppositifolius	Slender Carpet-weed	1
Gnaphalium polycaulon	Indian Cudweed	1
Goodenia glauca	Pale Goodenia	18
Goodenia pinnatifida	Cut-leaf Goodenia	2
Goodenia spp.	Goodenia	3
Gratiola pumilo	Dwarf Brooklime	2
Grevillea huegelii	Comb Grevillea	1
Hakea leucoptera subsp. leucoptera	Silver Needlewood	5
Halgania cyanea	Rough Halgania	2
Haloragis aspera	Rough Raspwort	2
Helichrysum leucopsideum	Satin Everlasting	1
Hymenolobus procumbens	Oval Purse	3
Isoetopsis graminifolia	Grass Cushion	3
Juncus aridicola	Tussock Rush	1
Lachnagrostis filiformis s.l.	Common Blown-grass	18
Lawrencia glomerata	Clustered Lawrencia	1
Leiocarpa websteri	Stalked Plover-daisy	3
Lepidium papillosum	Warty Peppercress	1

Scientific Name	Common Name	Records
Lepidium pseudohyssopifolium	Native Peppercress	2
Lepidium spp.	Peppercress	2
Lomandra effusa	Scented Mat-rush	4
Lomandra spp.	Mat-rush	1
Lycium australe	Australian Box-thorn	2
Lysiana exocarpi	Harlequin Mistletoe	1
Maireana appressa	Grey Bluebush	17
Maireana brevifolia	Short-leaf Bluebush	28
Maireana decalvans	Black Cotton-bush	11
Maireana georgei	Slit-wing Bluebush	1
Maireana pentagona	Hairy Bluebush	8
Maireana pentatropis	Erect Bluebush	5
Maireana pyramidata	Sago Bush	3
Maireana radiata	Radiant Bluebush	3
Maireana spp.	Bluebush	2
Maireana triptera	Three-wing Bluebush	1
Maireana turbinata	Satiny Bluebush	2
Malacocera tricornis	Goat Head	3
Marsilea drummondii	Common Nardoo	7
Marsilea spp.	Nardoo	2
Melilotus indicus	Sweet Melilot	3
Menkea spp.	Spectacles	2
Millotia perpusilla	Tiny Bow-flower	1

Scientific Name	Common Name	Records
Mimulus repens	Creeping Monkey-flower	1
Minuria cunninghamii	Bush Minuria	1
Minuria denticulata	Woolly Minuria	2
Minuria integerrima	Smooth Minuria	1
Muehlenbeckia diclina	Twiggy Lignum	1
Muehlenbeckia florulenta	Tangled Lignum	57
Muehlenbeckia horrida subsp. horrida	Spiny Lignum	1
Myoporum platycarpum subsp. perbellum	Sugarwood	1
Myoporum platycarpum subsp. platycarpum	Sugarwood	1
Nicotiana velutina	Velvet Tobacco	1
Nitraria billardierei	Nitre-bush	16
Olearia muelleri	Mueller Daisy-bush	2
Olearia pimeleoides	Pimelea Daisy-bush	9
Osteocarpum acropterum var. deminutum	Babbagia	13
Parietaria cardiostegia	Mallee Pellitory	2
Parietaria debilis s.s.	Shade Pellitory	3
Paspalidium jubiflorum	Warrego Summer-grass	64
Paspalidium spp.	Panic Grass	3
Phyllanthus lacunellus	Sandhill Spurge	1
Picris squarrosa	Squat Picris	3
Pimelea microcephala subsp. microcephala	Mallee Rice-flower	1
Pimelea trichostachya	Annual Rice-flower	2
Pittosporum angustifolium	Weeping Pittosporum	6

Scientific Name	Common Name	Records
Plantago drummondii	Dark Plantain	6
Plantago turrifera	Crowned Plantain	16
Podolepis capillaris	Wiry Podolepis	4
Pogonolepis muelleriana	Stiff Cup-flower	11
Polycalymma stuartii	Poached-eggs Daisy	14
Pseudognaphalium luteoalbum	Jersey Cudweed	6
Ptilotus exaltatus	Mulla Mulla	1
Ptilotus exaltatus var. exaltatus	Pink Mulla-mulla	4
Ptilotus nobilis var. nobilis	Yellow Tails	1
Ptilotus seminudus	Rabbit Tails	2
Ranunculus pentandrus var. platycarpus	Inland Buttercup	6
Rhagodia spinescens	Hedge Saltbush	58
Rhodanthe pygmaea	Pygmy Sunray	1
Rytidosperma caespitosum	Common Wallaby-grass	16
Rytidosperma setaceum	Bristly Wallaby-grass	5
Rytidosperma spp.	Wallaby Grass	1
Salsola tragus	Prickly Saltwort	35
Salvia spp.	Sage	2
Sarcozona praecox	Sarcozona	48
Scleroblitum atriplicinum	Starry Goosefoot	1
Sclerochlamys brachyptera	Short-wing Saltbush	25
Sclerolaena diacantha	Grey Copperburr	75
Sclerolaena muricata var. villosa	Grey Roly-poly	5

Scientific Name	Common Name	Records
Sclerolaena obliquicuspis	Limestone Copperburr	35
Sclerolaena spp.	Copperburr	2
Sclerolaena tricuspis	Streaked Copperburr	31
Senecio glossanthus s.l.	Slender GrounDEPIl	19
Senecio quadridentatus	Cotton Fireweed	3
Senecio runcinifolius	Tall Fireweed	2
Senecio spanomerus	Mallee GrounDEPIl	1
Senna form taxon 'petiolaris'	Woody Cassia	2
Sida ammophila	Sand Sida	4
Sida intricata	Twiggy Sida	5
Sida trichopoda	Narrow-leaf Sida	2
Solanum esuriale	Quena	25
Solanum simile	Oondoroo	1
Sonchus hydrophilus	Native Sow-thistle	4
Sonchus spp.	Sow Thistle	2
Spergularia sp. 3	Salt Sea-spurrey	2
Sphaeromorphaea australis	Spreading Nut-heads	4
Sporobolus caroli	Yakka Grass	2
Sporobolus mitchellii	Rat-tail Couch	53
Stelligera endecaspinis	Star Bluebush	10
Stemodia florulenta	Blue Rod	9
Suaeda spp.	Seablite	2
Swainsona microphylla	Small-leaf Swainson-pea	3

Scientific Name	Common Name	Records
Swainsona procumbens	Broughton Pea	2
Swainsona reticulata	Kneed Swainson-pea	4
Swainsona spp.	Swainson Pea	4
Tecticornia halocnemoides subsp. halocnemoides	Grey Glasswort	1
Tecticornia pergranulata	Blackseed Glasswort	85
Tecticornia pruinosa	Bluish Glasswort	10
Tecticornia spp.	Glasswort	5
Templetonia egena	Round Templetonia	1
Tetragonia eremaea s.s.	Desert Spinach	2
Tetragonia moorei	Annual Spinach	5
Thysanotus baueri	Mallee Fringe-lily	2
Tragus australianus	Small Burr-grass	1
Tribulus terrestris	Caltrop	1
Tricoryne tenella	Mallee Rush-lily	1
Triglochin calcitrapa s.l.	Spurred Arrowgrass	3
Triglochin dubia	Slender Water-ribbons	1
Triglochin nana	Dwarf Arrowgrass	4
Triodia scariosa	Porcupine Grass	2
Triptilodiscus pygmaeus	Common Sunray	1
Vittadinia cervicularis	Annual New Holland Daisy	4
Vittadinia cervicularis var. subcervicularis	Annual New Holland Daisy	2
Vittadinia cuneata	Fuzzy New Holland Daisy	1
Vittadinia dissecta s.l.	Dissected New Holland Daisy	10

Scientific Name	Common Name	Records
Vittadinia dissecta var. hirta	Dissected New Holland Daisy	2
Vittadinia gracilis	Woolly New Holland Daisy	5
Vittadinia spp.	New Holland Daisy	16
Wahlenbergia fluminalis	River Bluebell	6
Wahlenbergia gracilenta s.s.	Hairy Annual-bluebell	2
Wahlenbergia spp.	Bluebell	1
Wahlenbergia tumidifructa	Mallee Annual-bluebell	1
Walwhalleya proluta	Rigid Panic	1
Westringia rigida	Stiff Westringia	1
Zygophyllum ammophilum	Sand Twin-leaf	7
Zygophyllum angustifolium	Scrambling Twin-leaf	1
Zygophyllum apiculatum	Pointed Twin-leaf	7
Zygophyllum aurantiacum subsp. aurantiacum	Shrubby Twin-leaf	3
Zygophyllum eremaeum	Climbing Twin-leaf	4
Zygophyllum glaucum	Pale Twin-leaf	4
Zygophyllum spp.	Twin-leaf	2

Flora – Introduced

Common Name	Scientific Name	Records
Orange Fox-tail	*Alopecurus aequalis*	1
Cape Weed	*Arctotheca calendula*	8
Bridal Creeper	*Asparagus asparagoides*	1
Asparagus	*Asparagus officinalis*	2

Common Name	Scientific Name	Records
Onion Weed	*Asphodelus fistulosus*	19
Aster-weed	*Aster subulatus*	8
Bearded Oat	*Avena barbata*	2
Oat	*Avena spp.*	7
Twiggy Turnip	*Brassica fruticulosa*	2
Turnip	*Brassica spp.*	2
Mediterranean Turnip	*Brassica tournefortii*	59
Great Brome	*Bromus diandrus*	8
Madrid Brome	*Bromus madritensis*	1
Red Brome	*Bromus rubens*	56
Saffron Thistle	*Carthamus lanatus*	5
Spiny Burr-grass	*Cenchrus longispinus*	1
Malta Thistle	*Centaurea melitensis*	9
Fat Hen	*Chenopodium album*	2
Rhodes Grass	*Chloris gayana*	2
Skeleton Weed	*Chondrilla juncea*	2
Spear Thistle	*Cirsium vulgare*	5
Flaxleaf Fleabane	*Conyza bonariensis*	6
Fleabane	*Conyza spp.*	1
Tall Fleabane	*Conyza sumatrensis*	4
Ferny Cotula	*Cotula bipinnata*	3
Water Buttons	*Cotula coronopifolia*	3
Paddy Melon	*Cucumis myriocarpus subsp. leptodermis*	1

Common Name	Scientific Name	Records
Drain Flat-sedge	*Cyperus eragrostis*	1
Stinkwort	*Dittrichia graveolens*	7
Barnyard Grass	*Echinochloa crus-galli*	2
Spiny Emex	*Emex australis*	1
Common Heron's-bill	*Erodium cicutarium*	2
Terracina Spurge	*Euphorbia terracina*	2
Fumitory	*Fumaria spp.*	1
Cleavers	*Galium aparine*	2
Gazania	*Gazania linearis*	1
Creeping Heliotrope	*Heliotropium supinum*	3
Hairy Rupture-wort	*Herniaria cinerea*	1
Barley-grass	*Hordeum leporinum*	1
Barley-grass	*Hordeum murinum s.l.*	34
Smooth Cat's-ear	*Hypochaeris glabra*	43
Flatweed	*Hypochaeris radicata*	1
Spiny Rush	*Juncus acutus subsp. acutus*	2
Prickly Lettuce	*Lactuca serriola*	10
Common Peppercress	*Lepidium africanum*	12
Winged Sea-lavender	*Limonium lobatum*	11
Wimmera Rye-grass	*Lolium rigidum*	1
African Box-thorn	*Lycium ferocissimum*	4
Horehound	*Marrubium vulgare*	2
Little Medic	*Medicago minima*	32

Common Name	Scientific Name	Records
Burr Medic	*Medicago polymorpha*	10
Barrel Medic	*Medicago truncatula*	1
Sweet Melilot	*Melilotus indicus*	3
Common Ice-plant	*Mesembryanthemum crystallinum*	4
Small Ice-plant	*Mesembryanthemum nodiflorum*	44
Tree Tobacco	*Nicotiana glauca*	1
Stemless Thistle	*Onopordum acaulon*	1
Lesser Broomrape	*Orobanche minor*	1
Tripteris	*Osteospermum clandestinum*	20
Coolah Grass	*Panicum coloratum*	1
Coast Barb-grass	*Parapholis incurva*	19
Slender Barb-grass	*Parapholis strigosa*	1
False Hair-grass	*Pentameris airoides subsp. airoides*	10
Annual Beard-grass	*Polypogon monspeliensis*	1
Wiry Noon-flower	*Psilocaulon granulicaule*	3
Wild Radish	*Raphanus raphanistrum*	2
False Sow-thistle	*Reichardia tingitana*	29
Tiny Bristle-grass	*Rostraria pumila*	7
Fiddle Dock	*Rumex pulcher subsp. pulcher*	3
Wild Sage	*Salvia verbenaca*	14
Wild Sage	*Salvia verbenaca var. vernalis*	1
Pepper Tree	*Schinus molle*	1
Arabian Grass	*Schismus barbatus*	40

Common Name	Scientific Name	Records
Mallee Catchfly	*Silene apetala var. apetala*	14
Mediterranean Catchfly	*Silene nocturna*	2
Smooth Mustard	*Sisymbrium erysimoides*	22
London Rocket	*Sisymbrium irio*	10
Mustard	*Sisymbrium spp.*	2
Silver-leaf Nightshade	*Solanum elaeagnifolium*	13
Black Nightshade	*Solanum nigrum sensu Willis (1972)*	4
Rough Sow-thistle	*Sonchus asper s.l.*	1
Common Sow-thistle	*Sonchus oleraceus*	67
Corn Spurrey	*Spergula spp.*	1
Lesser Sand-spurrey	*Spergularia diandra*	13
Red Sand-spurrey	*Spergularia rubra s.l.*	9
Red Sand-spurrey	*Spergularia rubra s.s.*	18
Berry Seablite	*Suaeda baccifera*	1
Stinking Roger	*Tagetes minuta*	8
Woolly Clover	*Trifolium tomentosum var. tomentosum*	1
Rat's-tail Fescue	*Vulpia myuros*	45
Rat's-tail Fescue	*Vulpia myuros f. myuros*	1
Noogoora Burr	*Xanthium occidentale*	2
Noogoora Burr species aggregate	*Xanthium strumarium spp. agg.*	1

Fauna – Native

Common Name	Scientific Name	Type	Record

Common Name	Scientific Name	Type	Record
Peaceful Dove	*Geopelia striata*	B	4
Common Bronzewing	*Phaps chalcoptera*	B	5
Crested Pigeon	*Ocyphaps lophotes*	B	2
Australasian Grebe	*Tachybaptus novaehollandiae*	B	2
Hoary-headed Grebe	*Poliocephalus poliocephalus*	B	2
Great Cormorant	*Phalacrocorax carbo*	B	3
Little Black Cormorant	*Phalacrocorax sulcirostris*	B	4
Pied Cormorant	*Phalacrocorax varius*	B	2
Little Pied Cormorant	*Microcarbo melanoleucos*	B	5
Darter	*Anhinga novaehollandiae*	B	1
Australian Pelican	*Pelecanus conspicillatus*	B	1
Caspian Tern	*Hydroprogne caspia*	B	2
Silver Gull	*Chroicocephalus novaehollandiae*	B	1
Masked Lapwing	*Vanellus miles*	B	4
Red-capped Plover	*Charadrius ruficapillus*	B	1
Black-fronted Dotterel	*Elseyornis melanops*	B	2
Black-winged Stilt	*Himantopus himantopus*	B	1
Red-necked Avocet	*Recurvirostra novaehollandiae*	B	1
Brolga	*Grus rubicunda*	B	1
Australian White Ibis	*Threskiornis molucca*	B	2
Straw-necked Ibis	*Threskiornis spinicollis*	B	1
Yellow-billed Spoonbill	*Platalea flavipes*	B	2
Intermediate Egret	*Ardea intermedia*	B	2
Eastern Great Egret	*Ardea modesta*	B	4

Common Name	Scientific Name	Type	Record
White-faced Heron	*Egretta novaehollandiae*	B	8
White-necked Heron	*Ardea pacifica*	B	3
Nankeen Night Heron	*Nycticorax caledonicus*	B	2
Australian Wood Duck	*Chenonetta jubata*	B	7
Black Swan	*Cygnus atratus*	B	1
Australian Shelduck	*Tadorna tadornoides*	B	4
Pacific Black Duck	*Anas superciliosa*	B	8
Chestnut Teal	*Anas castanea*	B	1
Grey Teal	*Anas gracilis*	B	6
Pink-eared Duck	*Malacorhynchus membranaceus*	B	1
Hardhead	*Aythya australis*	B	2
Brown Goshawk	*Accipiter fasciatus*	B	1
Collared Sparrowhawk	*Accipiter cirrhocephalus*	B	1
Wedge-tailed Eagle	*Aquila audax*	B	3
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	B	5
Whistling Kite	*Haliastur sphenurus*	B	6
Black Kite	*Milvus migrans*	B	4
Square-tailed Kite	*Lophoictinia isura*	B	1
Peregrine Falcon	*Falco peregrinus*	B	1
Brown Falcon	*Falco berigora*	B	1
Southern Boobook	*Ninox novaeseelandiae*	B	1
Sulphur-crested Cockatoo	*Cacatua galerita*	B	8
Little Corella	*Cacatua sanguinea*	B	6
Galah	*Eolophus roseicapilla*	B	10

Common Name	Scientific Name	Type	Record
Regent Parrot	*Polytelis anthopeplus*	B	38
Crimson Rosella	*Platycercus elegans elegans*	B	2
Yellow Rosella	*Platycercus elegans flaveolus*	B	16
Mallee Ringneck	*Barnardius zonarius barnardi*	B	2
Western Ringneck	*Barnardius zonarius zonarius*	B	2
Red-rumped Parrot	*Psephotus haematonotus*	B	6
Mulga Parrot	*Psephotus varius*	B	1
Blue Bonnet	*Northiella haematogaster*	B	1
Australian Owlet-nightjar	*Aegotheles cristatus*	B	1
Laughing Kookaburra	*Dacelo novaeguineae*	B	6
Sacred Kingfisher	*Todiramphus sanctus*	B	5
Rainbow Bee-eater	*Merops ornatus*	B	5
Welcome Swallow	*Hirundo neoxena*	B	4
White-backed Swallow	*Cheramoeca leucosternus*	B	1
Tree Martin	*Hirundo nigricans*	B	6
Grey Fantail	*Rhipidura albiscarpa*	B	2
Willie Wagtail	*Rhipidura leucophrys*	B	11
Restless Flycatcher	*Myiagra inquieta*	B	3
Jacky Winter	*Microeca fascinans*	B	1
Red-capped Robin	*Petroica goodenovii*	B	4
Rufous Whistler	*Pachycephala rufiventris*	B	6
Grey Shrike-thrush	*Colluricincla harmonica*	B	9
Magpie-lark	*Grallina cyanoleuca*	B	7
Crested Shrike-tit	*Falcunculus frontatus*	B	2

Common Name	Scientific Name	Type	Record
Crested Bellbird	*Oreoica gutturalis*	B	1
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	B	4
White-browed Babbler	*Pomatostomus superciliosus*	B	1
Chestnut-crowned Babbler	*Pomatostomus ruficeps*	B	1
White-fronted Chat	*Epthianura albifrons*	B	1
Orange Chat	*Epthianura aurifrons*	B	1
Western Gerygone	*Gerygone fusca*	B	1
Weebill	*Smicrornis brevirostris*	B	6
Southern Whiteface	*Aphelocephala leucopsis*	B	1
Yellow Thornbill	*Acanthiza nana*	B	3
Chestnut-rumped Thornbill	*Acanthiza uropygialis*	B	4
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	B	5
Clamorous Reed Warbler	*Acrocephalus stentoreus*	B	1
Mallee Emu-wren	*Stipiturus mallee*	B	1
Splendid Fairy-wren	*Malurus splendens*	B	5
White-winged Fairy-wren	*Malurus leucopterus*	B	2
Variegated Fairy-wren	*Malurus lamberti*	B	3
Varied Sittella	*Daphoenositta chrysoptera*	B	1
Brown Treecreeper (south-eastern ssp.)	*Climacteris picumnus victoriae*	B	9
Mistletoebird	*Dicaeum hirundinaceum*	B	3
Silvereye	*Zosterops lateralis*	B	1
Brown-headed Honeyeater	*Melithreptus brevirostris*	B	1
Striped Honeyeater	*Plectorhyncha lanceolata*	B	6
White-eared Honeyeater	*Lichenostomus leucotis*	B	2

Common Name	Scientific Name	Type	Record
White-plumed Honeyeater	*Lichenostomus penicillatus*	B	10
Noisy Miner	*Manorina melanocephala*	B	7
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*	B	3
Blue-faced Honeyeater	*Entomyzon cyanotis*	B	4
Little Friarbird	*Philemon citreogularis*	B	4
Zebra Finch	*Taeniopygia guttata*	B	2
White-winged Chough	*Corcorax melanorhamphos*	B	4
Grey Currawong	*Strepera versicolor*	B	1
Pied Butcherbird	*Cracticus nigrogularis*	B	4
Grey Butcherbird	*Cracticus torquatus*	B	3
Australian Magpie	*Gymnorhina tibicen*	B	8
Unknown Raven	*Corvus sp.*	B	3
Australian Raven	*Corvus coronoides*	B	5
Striated Pardalote	*Pardalotus striatus*	B	5
Common Blackbird	*Turdus merula*	B	1
House Sparrow	*Passer domesticus*	B	1
Common Starling	*Sturnus vulgaris*	B	2
Feathertail Glider	*Acrobates pygmaeus*	M	1
Western Grey Kangaroo	*Macropus fuliginosus*	M	2
Marbled Gecko	*Christinus marmoratus*	R	2
Tree Skink	*Egernia striolata*	R	1
Southern Bullfrog	*Limnodynastes dumerilii*	A	2
Barking Marsh Frog	*Limnodynastes fletcheri*	A	2
Spotted Marsh Frog	*Limnodynastes tasmaniensis*	A	5

Common Name	Scientific Name	Type	Record
Plains Froglet	*Crinia parinsignifera*	A	10
Peron's Tree Frog	*Litoria peronii*	A	8
Growling Grass Frog	*Litoria raniformis*	A	4
Eastern Banjo Frog	*Limnodynastes dumerilii dumerilii*	A	4
Golden Perch	*Macquaria ambigua*	F	4
Common Yabbie	*Cherax destructor*	I	1
River Snail	*Notopala sublineata*	I	1

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

Fauna – Introduced

Common Name	*Scientific Name*	Type	Records
Red Fox	*Vulpes vulpes*	M	1

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

Appendix 2 - Ecological Vegetation Classes (EVCs)

Appendix 2 provides a description of each EVC at Spence's Bend.

EVC no.	EVC name	Bioregional Conservation Status	Description
		Robinvale Plains Fans	
810	Floodway Pond Herbland	Depleted	Low herbland to <0.3m 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.
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 20m tall with a groundlayer dominated by graminoids and sometimes lightly shrubby or with chenopod shrubs.
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 25m tall with a groundlayer dominated by tussock-forming graminoids. Occasional tall shrubs present.
811	Grassy Riverine Forest / Floodway Pond Herbland Complex	Depleted	Eucalypt forest or woodland of flood-prone areas, where herbaceous species characteristic of drying mud within wetlands (Floodway Pond Herbland or in part Lake Bed Herbland) are conspicuous in association or fine-scale mosaic with *Paspalidium jubiflorum* and other species characteristic of Grassy Riverine Forest. Restricted extent, Murray River system mainly in far north-west, but upstream at least as far as Barmah Forest.

EVC no.	EVC name	Bioregional Conservation Status	Description
104	Lignum Swamp	Vulnerable	Typically treeless shrubland to 4m tall, with robust (but sometimes patchy) growth of lignum. Widespread wetland vegetation type in low rainfall area on heavy soils, subject to infrequent inundation resulting from overbank flows from rivers or local runoff.
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.
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.
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 herbaceousperennial, several with a growth-form approaching that of small shrub) are often conspicuous.

EVC no.	EVC name	Bioregional Conservation Status	Description
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 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.
107	Lake Bed Herbland	Depleted	Herbland or shrubland to 0.5m tall dominated by species adapted to drying mud within lake beds. Some evade periods of prolonged inundation as seed, others as dormant tuber-like rootstock. Occupies drying deep-cracking mud of lakes on floodplains, Floods are intermittent but water may be retained for several seasons leading to active growth at the 'drying mud stage'.
200	Shallow Freshwater Marsh	Vulnerable	Generally, shallow freshwater marshes are no more than half a metre deep and usually dry out in summer. They are usually formed in volcanic flow beds. Large stands of River Red Gum or Lignum are often found around shallow freshwater marshes, with reeds, rushes and Cane Grass, or low-growing herbs and sedges, dominating the vegetation.
103	Riverine Chenopod Woodland	Depleted	Eucalypt woodland to 15m 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.

Appendix 3 – 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.

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 Mallee CMA Indigenous Facilitator
- Within a period not exceeding one working day a decision/recommendation will be made by the the Mallee CMA Indigenous Facilitator and the Aboriginal stakeholder, as to the process to be followed to manage the Aboriginal cultural heritage in a culturally appropriate manner, and how to proceed with the works;
- A separate contingency plan has been developed in the event that suspected human remains are discovered during the conduct of the activity.

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

1. Discovery:

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

2. Notification:

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

3. Impact Mitigation or Salvage:

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

4. Curation and Further Analysis:

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

5. Reburial:

    - Any reburial site(s) must be fully documented by an experienced and qualified archaeologist, clearly marked and all details provide to AAV;
    - Appropriate management measures must be implemented to ensure that the remains are not disturbed in the future.