Abbotsford Bend and Darling Junction Environmental Water Management Plan

SUNRAYSIA environmental
Land, Water & Environment

mallee
catchment management authority

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Contact

For queries regarding this document, please contact :

Louise Chapman

Louise.Chapman@delwp.vic.gov.au

Waterways Coordinator

Mallee Catchment Management Authority

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Executive Summary

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

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

Abbotsford Bend and Darling Junction are located in the Murray Scroll Belt bioregion within the Mallee Catchment Management Authority (Mallee CMA) region downstream of Mildura and cover 4,160 ha.

Abbotsford Bend and Darling Junction have a complex mix of private and public land, eleven wetlands and a creek system. This plan focuses on a target area predominantly within the eastern section of Abbotsford Bend, covering 98 ha that is able to be inundated through environmental watering.

Two major features within the Abbotsford Bend and Darling Junction target area are the Wentworth Weir (Lock 10) and the junction of the Murray and Darling Rivers. The floodplain in this reach of the river consists of River Red Gum forests and Black Box on higher elevations. Cowra Rocks is a 66 ha permanent wetland connected to the Lock 10 weir pool and provides habitat for a large range of fauna, including at least 17 species of waterbirds. Twenty-seven listed species of native fauna, including the State listed Pied Cormorant (*Phalacrocorax varius*), Hardhead (*Aythya australis*), Musk Duck (*Biziura lobata*) and Blue-billed Duck (*Oxyura australis*) have been recorded in the area. In particular, these species of diving duck may utilise the deep open water and dense fringing vegetation at Cowra Rocks. The vulnerable Murray-Darling Rainbowfish (*Melanotaenia fluviatilis*) and Murray River Turtle (*Emydura macquarii*) have both been recorded at Cowra Rocks, indicating suitable habitat exists within the wetland.

Additionally, the static water level at Cowra Rocks has facilitated dense Cumbungi (Typha spp.) colonisation around most of the wetland and offers important habitat and forage areas for waterbirds and aquatic fauna such as frogs, fish and turtle species. Other significant flora in the target area includes the iconic River Red Gum, and also Black Box and Lignum communities, which provide habitat to a variety of native fauna.

The long term management goal of the Abbotsford Bend and Darling Junction EWMP is to provide a flow regime that more closely reflects natural events, thus improving the capacity of the target area to provide a productive ecosystem for native flora and fauna.

To achieve this, ecological and hydrological objectives, were designed for Cowra Rocks. These have been developed to sustain the various ecological components of the wetland, and have been incorporated in an optimal long-term water management regime.

The ecological objectives for the Abbotsford Bend and Darling Junction target area are outlined below:

- Improve aquatic productivity at Cowra Rocks;
- Promote diversity of aquatic macrophytes at Cowra Rocks;
- Improve recruitment, diversity and productivity to meet EVC benchmarks for Lignum Swampy Woodland (823) at Cowra Rocks;
- Improve floristic diversity to the Floodway Pond Herbland EVC and EVC Complex at Darling Junction; and
- Improve fish passage at Cowra Rocks, and fish passage and flow through at Darling Junction Creeks.

The proposed water management regimes in this document have been designed to better reflect natural (pre-regulation) inundation frequency, seasonality and duration in order to improve the quality of vegetation in and surrounding these wetlands and to provide better habitat to support both rare and common species found at Cowra Rocks and further afield in Abbotsford Bend and Darling Junction. Regimes are constrained by the use of the wetland for water skiing across most of the year.

The following optimal water management regimes have been developed to sustain and improve the ecological components of Cowra Rocks.

Option 1: Drying Phase

Reduce the water level at Cowra Rocks commencing in late Autumn by pumping to improve the health of Lignum communities and allow natural floodplain recession. Reduce the water level in Cowra Rocks to approximately 29.8 m AHD twice in ten years with an interval of five years between events. Maintain the water level at 29.8 m AHD for up to three months, then allow to recharge slowly in late winter via the regulator to 30.8 m AHD to increase the diversity and extent of aquatic macrophytes fringing the wetland.

Option 2: Inundation Phase

Inundate the area surrounding Cowra Rocks to a height of 31.5 m AHD three years in ten with a maximum interval of seven years between events. Maintain water on the floodplain for at least four months to promote Lignum growth and recruitment and improve aquatic macrophyte diversity and extent before allowing natural recession through the Cowra Rocks regulator.

Option 3: Wetting and Drying Phases

Reduce the water level at Cowra Rocks commencing in late Autumn to improve the health of Lignum communities and allow natural floodplain recession. Reduce the water level in Cowra Rocks to approximately 29.8 m AHD. Maintain the water level at 29.8 m AHD for up to three months, then allow to recharge slowly in late winter to normal river operations level. Inundate the littoral zone to 31.5 m AHD. Maintain water on the floodplain for at least four months before allowing a natural recession, to increase the diversity and extent of aquatic macrophytes and refresh Lignum communities fringing the wetland. Implement this combined regime once in ten years.

The delivery of environmental water necessary for these water management regimes will require the installation of infrastructure and consultation with stakeholders, outlined in this plan. A water delivery regime is not recommended for Darling Junction, however this plan suggests infrastructure to achieve the ecological objectives at that site. The infrastructure proposed in this plan requires further investigation and design.

1.0 Introduction

This Environmental Water Management Plan (EWMP) has been prepared to establish the long-term management goals at Abbotsford Bend and Darling Junction. The key purposes of the EWMP are to:

- identify the long-term objectives and water requirements for Cowra Rocks Wetland, Darling Junction Wetland and Darling Junction Creeks, identified as medium priorities in the *Mallee Waterway Strategy* (MWS);
- provide a vehicle for community consultation, including for the long-term objectives and water requirements of the wetland and creeks;
- 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.

2.0 Site overview

2.1 Site Location

The Mallee CMA region is located in the north-west of Victoria and is the largest catchment in the state. Its area of responsibility covers approximately 39,000 km² with an estimated regional population of 65,000. The catchment runs along the Murray River from Nyah to the South Australian border, and as far south as Birchip and Rainbow (MCMA 2014). Major towns include Mildura, Birchip, Sea Lake, Ouyen, Robinvale, Red Cliffs and Merbein. The region has a semi-arid climate, with an annual mean rainfall of around 250 mm and average daily temperatures (at Mildura) ranging from 32°C in summer to 15°C in winter (MCMA 2006b).

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

In 2007, 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 for 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 incorporates the Abbotsford Bend and Darling Junction FMUs (or sub-units), hereafter referred to as Abbotsford Bend and Darling Junction in this document, on the Murray River floodplain. The eastern extremity of the area is situated approximately 4 km west of the township of Merbein (Figure 1, over page). Abbotsford Bend is located between 837 and 850 river km; Darling Junction is located immediately downstream, between 829 and 837 river km. Both sub-units fall within the western section of the Merbein Water Management Unit (WMU) identified in the *Mallee Waterway Strategy 2014-22.*

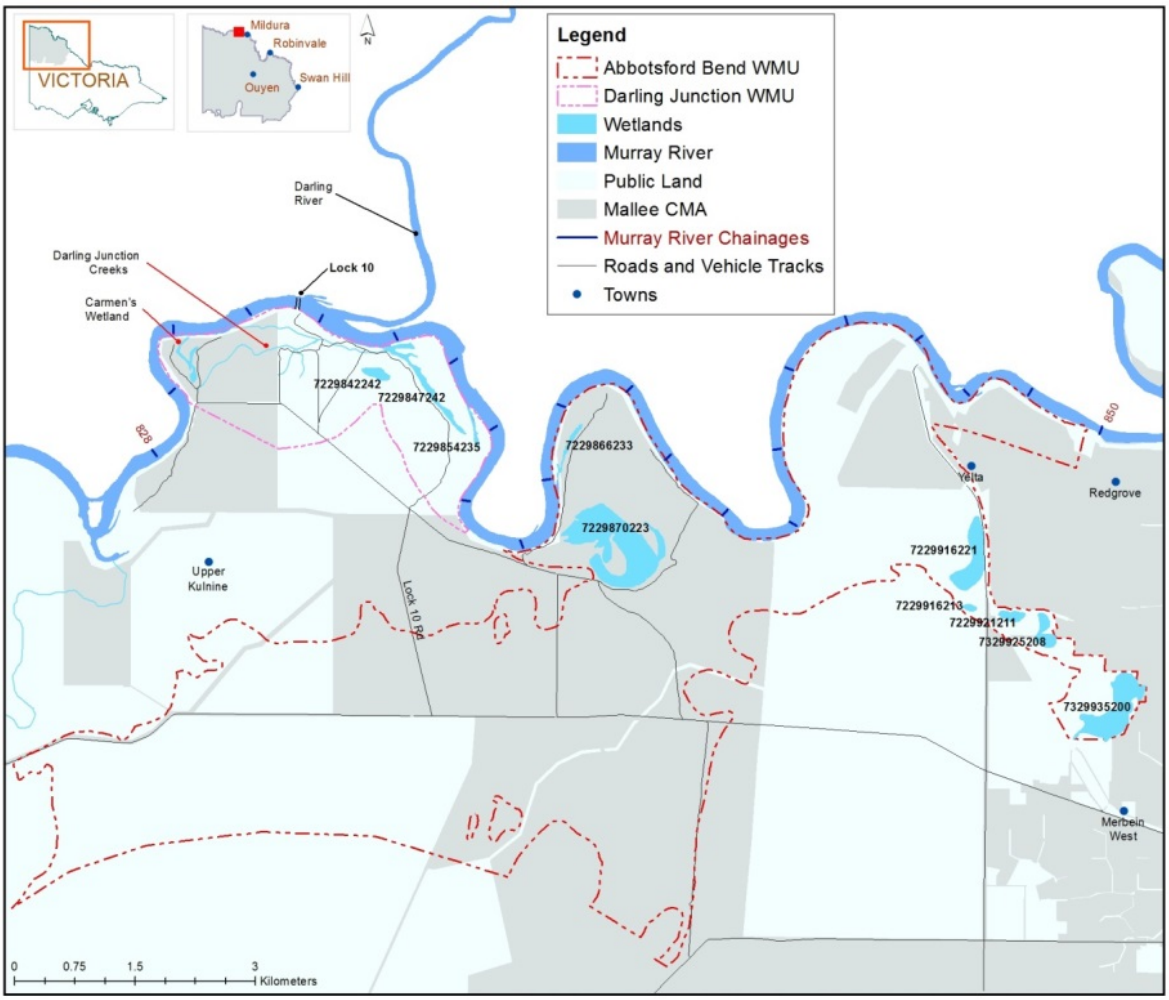

Figure 1. Map of Abbotsford Bend and Darling Junction

2.2 Conceptualisation of Cowra Rocks

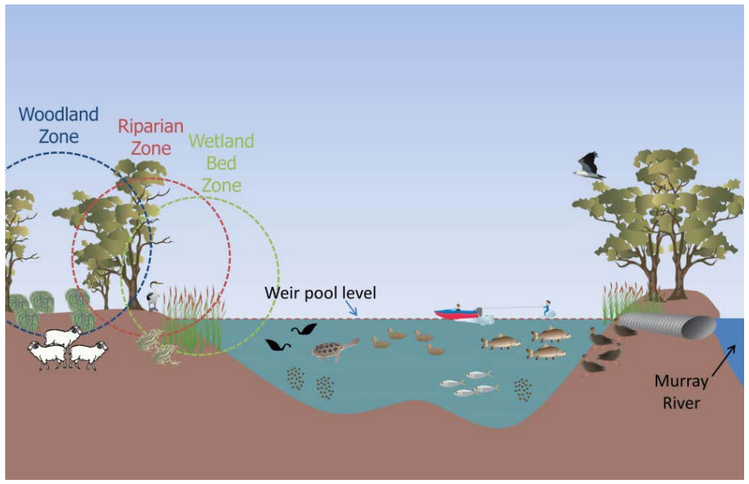

Figure 2. Conceptualisation of Cowra Rocks

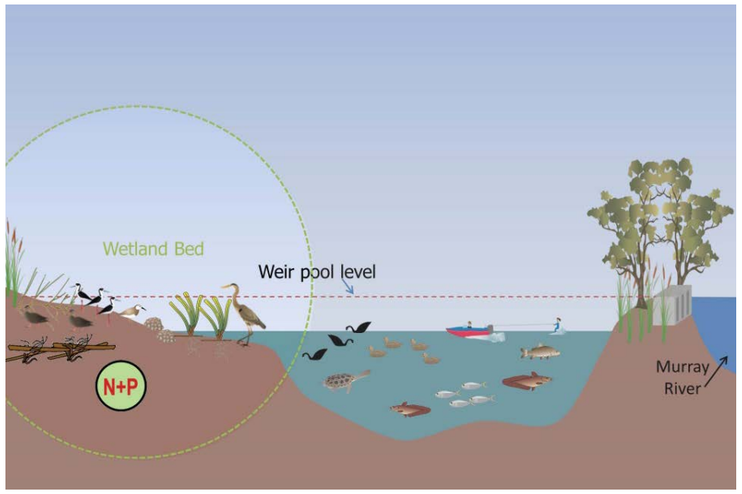

Figure 3. Cowra Rocks Drying Phase, exposing Wetland Bed

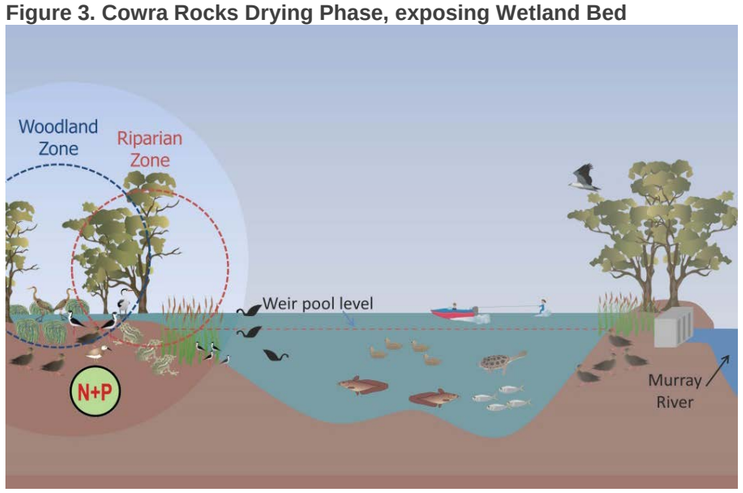

Figure 4. Cowra Rocks Inundation Phase, Riparian Zone & Lignum Swampy Woodland

Listed Water Dependent Fauna

- Murray-Darling Rainbowfish
- Pied Cormorant
- Murray River Turtle

Wetland Fauna

- Native Fish
- White-bellied Sea-eagle
- Frogs
- Grazing Waterfowl
- Dabbling & Diving Ducks
- Small Waders
- Large Waders

Proposed Infrastructure

- Regulator

Water Dependent Flora

- River Red Gum
- Cumbungi
- Lignum

Threats

- Sediment
- Grazing
- Common Carp
- Piped Track Crossing

Activities

- Ski Tournaments & Practice

Processes

- Egg Banks Produced
- Exposure of Tubers and Roots
- Nutrient Cycling
- Plant material & detritus

Cowra Rocks is a large wetland with deep open water. Water within the wetland has greater salinity and lower dissolved oxygen. It also has greater turbidity than in the river channel, indicating higher sediment levels may occur. It is fringed in many places by dense **Cumbungi** which offers nesting and foraging habitat for **waterbirds** and feeding areas for **native aquatic fauna**. Cowra Rocks offers deep water habitat for dabbling and diving waterbirds.

River Red Gum lines the wetland riparian zone; **Lignum** woodland is in poor condition on the northern floodplain.

The floodplain is used to graze **sheep** for a limited time each year, and the **Mildura Ski Club** hosts events and tournaments in the summer and use the site for practice year-round.

Water levels are relatively static, under the influence of the Lock 10 weir pool and the wetland is connected via an inlet channel that has a track crossing with several **pipes** allowing water flow but restricting fish passage.

The wetland hosts pest fish including **Common Carp**, and Eastern Gambusia, however **native fish** including the vulnerable **Murray-Darling Rainbowfish** and turtles are also recorded. Catfish may also occur.

With the installation of a regulator, a partial drying phase (Figure 3) will expose mud banks, tubers and aquatic vegetation for foraging waterbirds, and help restart nutrient cycling (Lloyd 2012). It may also reduce Cumbungi dominance to facilitate a greater diversity of aquatic macrophytes and allow egg banks to be produced (Lloyd 2012).

An inundation phase (Figure 4) may lead to the rapid release of nutrients from the soils, and the seed and egg banks of plants and aquatic invertebrates may emerge. This pulse in aquatic macrophytes and invertebrates may provide food for aquatic fauna such as **turtles** and **frogs**, and **waterbirds.** The wetlands become more productive and may offer greater diversity of native flora and fauna species.

Inundation of the northern floodplain may help improve the condition of the Lignum Swampy Woodland community and may promote aquatic macrophyte diversity. The expanded littoral zone may offer foraging habitat for waders and improve nesting habitat quality and diversity for waterbirds.

Varying the water level at Cowra Rocks is likely improve wetland condition to benefit waterbirds such as the listed Musk Duck, Blue-billed Duck and Hardhead that utilise deep open water, dense stands of Cumbungi, diverse aquatic vegetation and Lignum as feeding, foraging, breeding and nesting habitat.

2.3 Catchment Setting

Abbotsford Bend and Darling Junction is located in the Murray Scroll Belt bioregion, which is characterised by an entrenched river valley and associated floodplain and lake complexes of numerous oxbow lakes, billabongs, ephemeral lakes, swamps and active meander belts. Alluvial deposits from the Cainozoic period gave rise to the red brown earths, cracking clays and texture contrast soils (Dermosols, Vertosols, Chromosols and Sodosols) that supports Alluvial-Plain Shrubland, Riverine Grassy Chenopod Woodland and Riverine Grassy Forest ecosystems (DELWP 2015).

The sites are located near the junction of the Murray and Darling Rivers. The Abbotsford Bend sub-unit consists of two floodplain meander scroll systems (Ecological Associates 2007) and a series of drainage basins higher in the landscape. The Darling Junction sub-unit consists of one Murray River backwater and a former short anabranch that passes from this backwater upstream of Lock 10 across the floodplain to the Murray River less than one kilometre downstream of Lock 10. Both sub-units comprise extensive floodplain areas supporting River Red Gum communities on the lower terraces and Black Box woodlands on higher elevations.

Lock 10 is situated at 831 river km, adjacent to the floodplain of the Darling Junction sub-unit. The confluence of the Darling River and Murray River at Wentworth (NSW) occurs immediately upstream of Lock 10. Thus the Abbotsford Bend and Darling Junction area includes floodplain both within the Lock 10 weir pool influence, and below Lock 10. Below the weir, the width of the river has increased due to erosion; some in-channel benches have been eroded in some reaches (Thoms et al 2000). Some benches above the weir are now permanently inundated (Thoms et al 2000).

To the south and east of Abbotsford Bend, and to the south of Darling Junction, the landscape follows a pattern typical of the Mallee CMA region, with floodplain giving way to elevated terraces of mallee dunes and mallee vegetation. Areas of privately owned land within Abbotsford Bend are used for grazing, this includes Cowra Station which is the largest area of private land within the sub-unit. The western portion of Darling Junction is privately owned, with some areas used for irrigated pasture in the past. Irrigation occurs in parts of Abbotsford Bend, this includes in the north-eastern section near Abbotsford Bridge, south of the Old Mail Road near the intersection with Cowra Station Road, and areas of irrigated pasture around Cowra Homestead.

2.3.1 Groundwater

Large areas in the eastern part of Abbotsford Bend are affected by saline groundwater discharge. This includes Lamberts Swamp (7329 935200) and unnamed wetlands 7329 925208 and 7229 916221.During a site inspection on 04 September 2015, groundwater intrusion was apparent along the southern bank of the Murray River west of wetland 7229 916221 and across parts of the floodplain at this location.

Some wetlands within the eastern part of Abbotsford Bend are also impacted by irrigation drainage disposal from the irrigation area directly to the east. Lamberts Swamp was originally established as a drainage disposal basin to receive local irrigation drainage and storm water runoff (Aquaterra 2010). Groundwater discharge into the swamp also became an issue due to rising regional groundwater, with salinity levels within Lamberts Swamp rising to greater than 100,000 EC (SKM 2001 cited in Aquaterra 2010). Highly saline water was then periodically pumped from Lamberts Swamp into an open drain to the Murray River to manage water levels within the swamp. It is estimated that this resulted in an average of 6,752 tonnes of salt per year being discharged directly into the Murray River (Aquaterra 2010). Since the late 1990s works have been undertaken to reduce salinity impacts on the Murray River. These works have become part of a registered salinity credit claim of 2.9 EC (Aquaterra 2010) under the Basin Salinity Management Strategy (BSMS) Salinity Registers, and

have included diverting irrigation drainage water away from Lamberts Swamp, ceasing pumping from Lamberts Swamp to the Murray River and the piping of open drains to the west of Lamberts Swamp.

The current irrigation drainage storage and disposal system, managed by Lower Murray Water, diverts local drainage water into the North West Drain, an open drain that starts immediately north of wetland 7329 925208. The drain then runs west past wetland 7229 921211, under Meridian Road, past wetland 7229 916213, and then north-west until it connects to the Murray River. Wetlands 7229 921211 and 7229 916213 are inundated with drainage water from the North West Drain for significant periods of time, in particular wetland 7229 921211 east of the Meridian Road which, based on historic aerial imagery, appears to be almost permanently inundated.

Any future management actions targeted at wetlands within this part of Abbotsford Bend will need to consider that the primary purpose of the North West Drain is drainage water disposal (pers. comm. F. Murdoch, 26 October 2015). Any management actions that impact on the effectiveness of the current drainage management system are also likely to impact the salinity credit claim under the BSMS Salinity Registers. Another consideration is that several landholders have current agreements in place with Lower Murray Water for the re-use of drainage water from the North West drain, pumping water from the section of drain to the east of the Meridian Road (pers. comm. F. Murdoch, 26 October 2015).

Due to the constraints outlined above, it is not proposed to deliver environmental water to Lamberts Swamp and the Merbein North West drain. However wetland 7229 921211 may have some potential as a nursery site for the threatened fish species Murray Hardyhead (*Craterocephalus fluviatilis)*. The suitability of this site is to be investigated by DELWP during 2016.

2.4 Features of the sub-units

Abbotsford Bend covers an area of 3,630 ha, and Darling Junction an area of 530 ha. The main features of Abbotsford Bend are shown in Figure 5 (over page) and include:

- Lamberts Swamp (7329 935200), a hypersaline wetland set above the floodplain amid irrigated horticulture;
- Drainage basins used to receive, store and transfer irrigation drainage water (7229, 916213 and 7229 921211) and a former drainage basin (7329 925208);
- A floodplain wetland that is now dry but for a time received drainage water (7229 916221)
- Unnamed floodrunner/permanently inundated backwater (7229 866233); and
- Cowra Rocks (7229 870223), a permanently inundated wetland within influence of the Lock 10 weir pool.

The main features of Darling Junction are also shown in Figure 5 and include:

- Two permanently inundated Murray River backwaters in the Lock 10 weir pool:
    - Weltand 7229 9854235; and
    - Wetland 7229 847242;
- The Darling Junction Creeks, comprising:
    - a short floodplain anabranch; and
    - an elevated watercourse
- Carmens Wetland (not currently listed in the State wetland database).

The constraints of Lamberts Swamp and the current and former drainage basins have been discussed in the previous section. Unnamed wetland 7229 916221 was dried down to control Cumbungi invasion (pers. comm. P. Kelly, 04 Sept 2015). The three backwaters in the area are permanently inundated. Carmens Wetland is connected to the Murray River directly to the north and is an important ecological asset that should benefit from the greater frequency in moderate flow peaks that Basin Plan flows are expected to provide. Thus these sites are not proposed for the specific delivery of environmental water.

Due to its high elevation on the floodplain, the south-westerly flowing elevated watercourse at Darling Junction has been excluded from this plan. The elevated watercourse branches from the main short floodplain anabranch, just downstream of the Lock 10 Rd crossing. The bed of this elevated watercourse lies 2.4 m above the main anabranch channel and 0.9 m above the normal Lock 10 weir pool height (Ecological Associates 2007b). Water management in this elevated channel is not considered feasible due to the cost of works and limited ecological benefit. However, infrastructure is proposed on a road crossing to enhance natural flow through of the main anabranch channel. Water management is not proposed for the Darling Junction sub-unit.

2.5 Target Areas

This plan proposes a water management regime for Cowra Rocks. Infrastructure is proposed to enhance flow through of natural flood events in the main anabranch channel at Darling Junction Creeks.

The Cowra Rocks target area within Abbotsford Bend is the extent to which environmental water can be managed with proposed infrastructure in place. The section on Environmental Water Management Infrastructure discusses constraints and proposed infrastructure in more detail, including recommendations for Darling Junction.

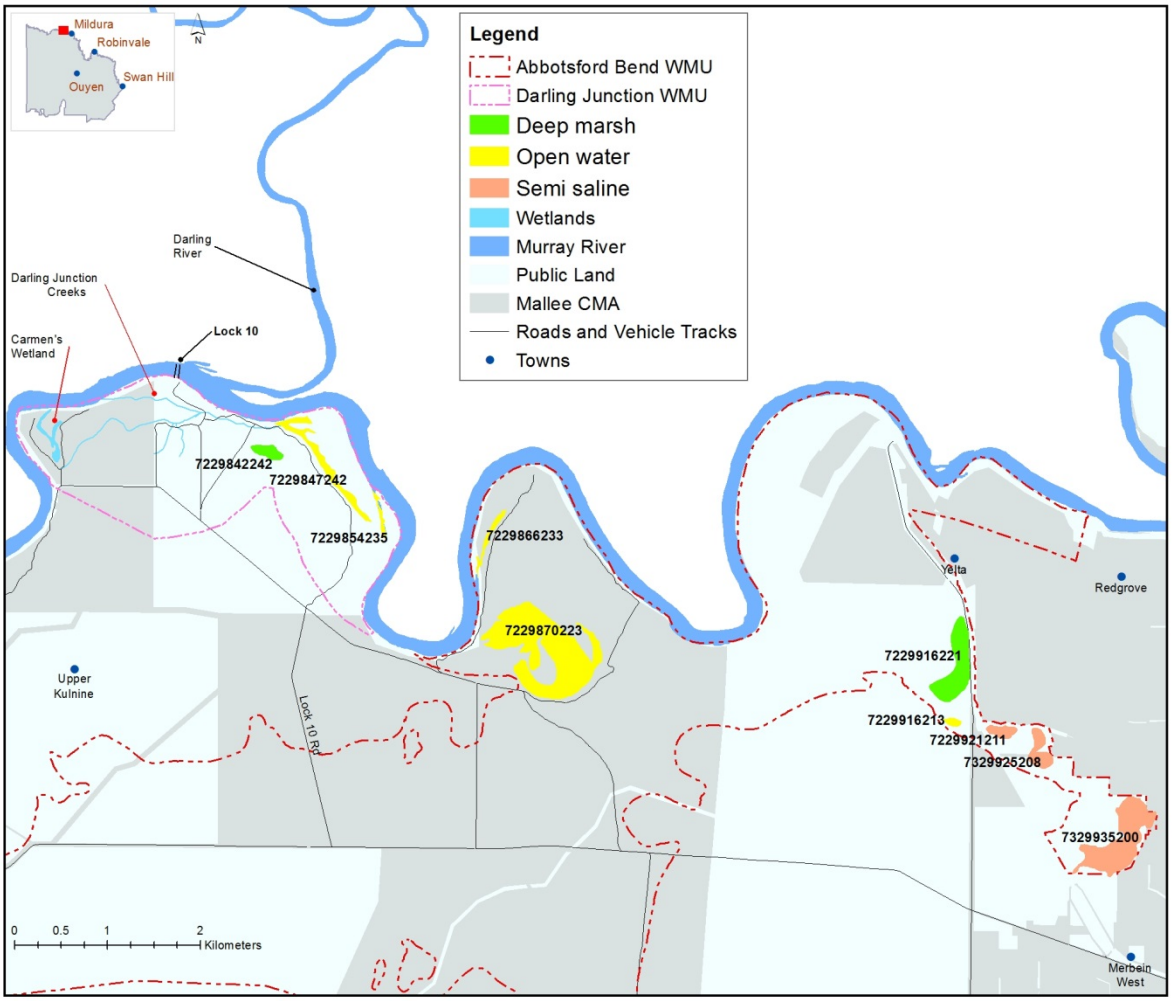

Figure 5. Map of the wetland categories at Abbotsford Bend and Darling Junction

2.6 Land Status and Management

The Abbotsford Bend and Darling Junction areas have complex land ownership and management arrangements (Figure 6). The area includes the Proposed Murray River Park, the River Murray Reserve and private land tenure, National Park, a Bushland Reserve and drainage basins.

Public land in the area is managed by Parks Victoria as per the River Red Gum Investigation (VEAC 2008). Two private land tenures are located on the floodplain within the Park at Abbotsford Bend, and a private tenure is located west of Lock 10 (Figure 6). There is a larger private tenure in the west of the Abbotsford Bend WMU, in which Cowra Rocks is located. The River Murray Reserve extends along the Murray River frontage and is managed by Parks Victoria. Two drainage basin areas in the east of Abbotsford Bend are managed by Lower Murray Water.

The Darling Junction Education Area is located in part of the Darling Junction WMU and is incorporated into the Proposed Murray River Park. The Education Area was established in 1990 following the final recommendations from the 1989 Land Conservation Council Mallee Area Review. The VEAC (2006) River Red Gum Review recommended 321 ha be retained as Education Area. Education areas are established as sites where students can study the nature and functioning of natural ecosystems, observe and practice environmental analysis and field techniques and conduct simple long-term experiments (VEAC 2006).

Relevant stakeholders are listed in Table 1 (over page).

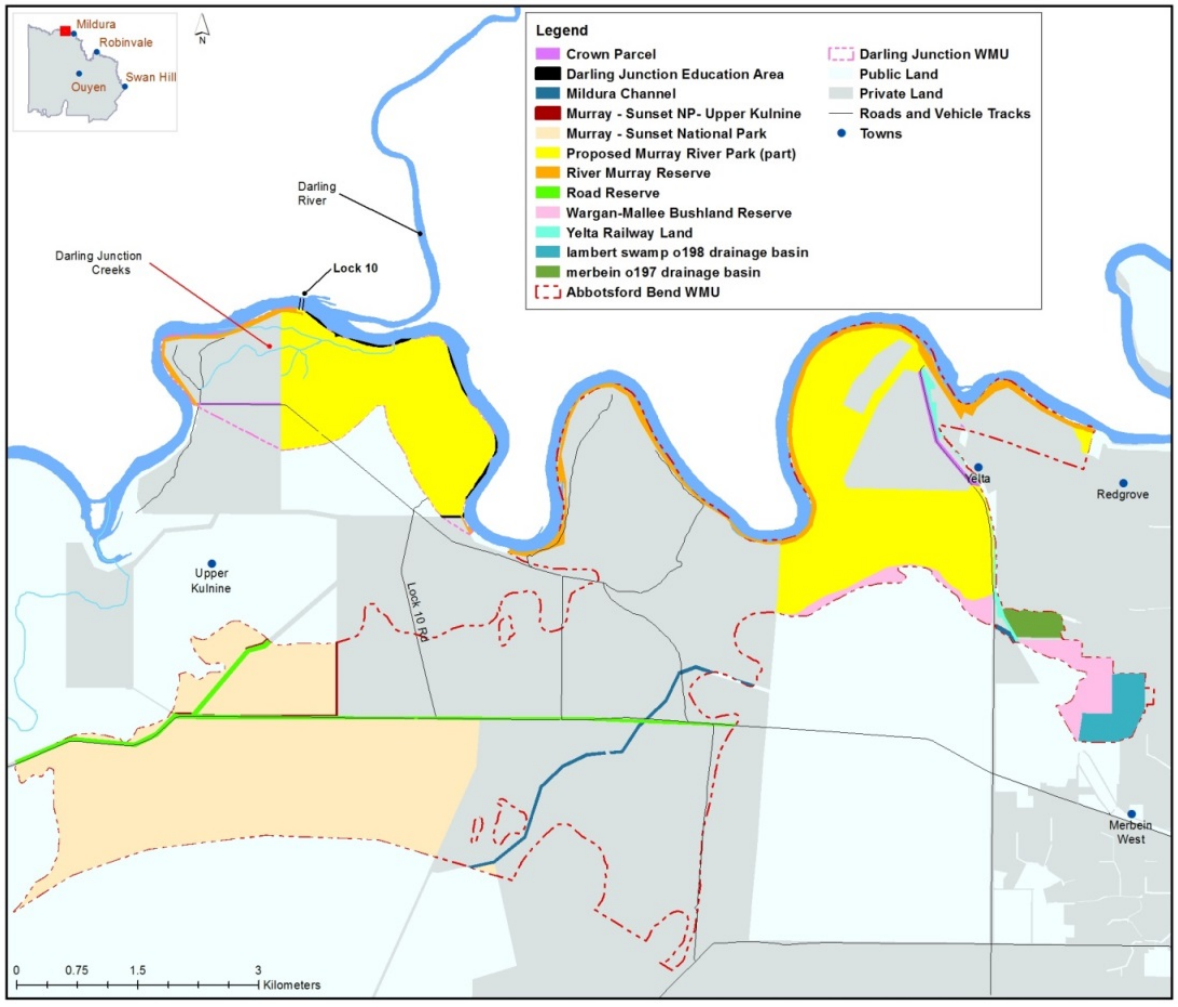

Figure 6. Land management boundaries at Abbotsford Bend and Darling Junction

Table 1. Stakeholders for Abbotsford Bend and Darling Junction

Group	Role
Parks Victoria	Land Manager (Proposed Murray River Park, Murray River Reserve, Wargan-Mallee Bushland Reserve)
Private Landholder(s)	Land Manager(s) (private land)
Irrigators	Access to drainage water for re-use
Mildura District Ski Club	Wetland user group (Cowra Rocks)
Mallee CMA	Regional environmental management
Department of Environment, Land, Water and Planning	State level environmental management
NSW Water	River Murray operations
Lower Murray Water	Management of irrigation drainage water and drainage basins
Mildura Rural City Council	Local Government
Aboriginal Stakeholders	Aboriginal Stakeholders. Provides assistance in planning and implementation of programs.
Yelta Landcare Group	(East of Meridian Road) Assistance in planning and implementation of programs
Millewa-Carwarp Landcare Group	(West of Meridian Road) Assistance in planning and implementation of programs
Victorian Environmental Water Holder	Determines locations and volumes for environmental water delivery

Figure 7. The inlet channel to Cowra Rocks (Murray River in the middle distance).

2.7 Creek and Wetland Characteristics

Eleven wetlands and one creek are mapped in Abbotsford Bend and Darling Junction. A brief overview of the main characteristics of each sub-unit is provided in Table 2 and Table 3 (over page).

Table 2. Summary of Abbotsford Bend Characteristics

Characteristics	Description						
Name	Cowra Rocks	Unnamed Floodrunner	Yelta Drains	Unnamed Wetland (West of Meridian Rd)	Unnamed Wetland (East of Meridian Rd)	Unnamed Wetland (Now dry (piped now, channel filled in))	Lamberts Swamp
Mapping ID within area	7229 870223	7229 866233	7229 916221	7229 916213	7229 921211	7329 925208	7329 935200
Area (ha)	66.4	3.2	18.9	1.3	3.6	6.8	30.8
Bioregion	Murray Scroll Belt						
Conservation status	Areas of EVCs listed as Endangered, Vulnerable, Depleted and Least Concern						
Conservation status	Depleted, Least Concern	Depleted, Least Concern	Depleted	Depleted	Depleted	Depleted	Depleted, Vulnerable
Land status	Private Land	Private Land	Proposed Murray River Park	Reserve	Drainage basin	Drainage basin	Drainage basin
Land manager	Private Landholder	Private Landholder	Parks Victoria	Lower Murray Water	Lower Murray Water	Lower Murray Water / Parks Victoria	Lower Murray Water
Surrounding land use	Grazing	Grazing	Reserve and Irrigated Horticulture	Reserve	Irrigated Horticulture / Reserve	Irrigated Horticulture / Reserve	Irrigated Horticulture / Reserve
Water supply	Permanently inundated by Lock 10 weir pool	Permanently inundated by Lock 10 weir pool	Connected to Murray River at flows > ~117,000 ML/day (RimFIM data)	Receives irrigation drainage water from 7229 921211 and delivers to Murray River via the North West Drain	Receives irrigation drainage water and delivers to Murray River via 7229 916213 and the North West Drain	Not connected. Historically an irrigation drainage basin fed by channel. Now remains dry, with water piped instead to 7229 921211*.	Saline groundwater, local stormwater / runoff
1788 wetland category	Permanent Open Freshwater	Permanent Open Freshwater	Deep Freshwater Marsh	Deep Freshwater Marsh	Semi-permanent Saline	Semi-permanent Saline	Semi-permanent Saline
1994 wetland category	Permanent Open Freshwater	Permanent Open Freshwater	Deep Freshwater Marsh	Permanent Open Freshwater	Semi-permanent Saline	Semi-permanent Saline	Semi-permanent Saline
IWC Wetland Mapping Tool	Permanent Freshwater Lake	Temporary Freshwater Lake	Temporary Freshwater Swamp	Temporary Freshwater Lake	Permanent Saline Lake	Unknown	Unknown
Wetland depth at capacity	Est. 5m*	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown

* (Pers. comm. P. Kelly 04 Sept 2015)

Table 3 Summary of Darling Junction Characteristics

Characteristics	Description				
Name	Carmens Wetland	Unnamed Wetland	Darling Junction	Unnamed Wetland	Darling Junction Creeks
Mapping ID within area	10651*	7229 842242	7229 847242	7229 854235	
Area (ha)	3.9	3.8	11	1.8	~2 km (length of main anabranch channel)
Bioregion	Murray Scroll Belt				
Conservation status	Areas of Depleted EVCs				
Land status	Private / Murray River Reserve	Public	Public	Public	Proposed Murray River Park / River Murray Reserve / Private
Land manager	Landholder	Parks Victoria	Parks Victoria	Parks Victoria	Landholder/ Parks Victoria
Surrounding land use	Grazing, conservation	Reserve, Education Area	Reserve, Education Area	Reserve, Education Area	Reserve, Education Area
Water supply	Connects at Murray river flows > 30,000 ML/day#	Likely to connect at Murray river flows > 66,000 ML/day#	Permanently inundated by Lock 10 weir pool	Permanently inundated by Lock 10 weir pool	Likely to connect at Murray river flows >13-17,000 ML/day# downstream. Flow-through would occur at flow volumes of >66,000 ML/day#
1788 wetland category	Not mapped	Deep Freshwater Marsh	Permanent Open Freshwater	Permanent Open Freshwater	
2013 wetland category	Not assessed	Unknown	Permanent Open Freshwater	Permanent Open Freshwater	
Wetland depth at capacity	Unknown	Unknown	Unknown	Unknown	Unknown

* Mapped in the State Wetland Database with reference number 10651, but no wetland number. # CTF values are estimates only and have been compared based on a limited data set. A more detailed analysis is required to determine accurate CTF values.

2.8 Management Scale

The whole of Abbotsford Bend and Darling Junction have water requirements as floodplain complexes, but the focus of this plan is to provide variation to water levels in Cowra Rocks and improve flow-through in the main anabranch channel at Darling Junction Creeks. Delivery of environmental water at Darling Junction is not currently feasible and thus no regime is proposed. However infrastructure could improve connectivity and movement of aquatic fauna through the anabranch during natural flood events.

At Cowra Rocks it is proposed the wetland be managed under the options outlined below. The area described in the three options is the target area for this EWMP and represents the area that is able to be managed with partial drying phases and delivery of environmental water following the construction of the infrastructure proposed in this EWMP. The section titled Environmental Water Management Infrastructure discusses constraints and proposed infrastructure at both sites in more detail. A key constraint to management at Cowra Rocks is the year-round use of the wetland as a water source for sheep, and a water skiing site, which limits the timing, frequency and duration of water management activities.

2.8.1 Overview of the Watering Proposal and Regime Options

Three water management options are proposed for Cowra Rocks. All options require installation of a regulator structure. Option 1 can be achieved in consultation with the Mildura Ski Club. Option 2 would require further liaison with the Ski Club and track raising. Option 3 combines both regimes. The complete drying of the wetland is discussed, including reasons why this is not proposed as part of this plan. Additionally, this would need further consultation with the Ski Club and land holder.

Option 1: Partial Drying Phase: expose part of Wetland Bed

Option 1 (Figure 8) involves drawing down the water level in Cowra Rocks by approximately one metre (29.8 m AHD) during the skiing off-season (winter) to expose part of the wetland bed. Bathymetry of the wetland bed is not known, however it is estimated that the wetland volume would be reduced by approximately 300-500 ML, and could expose approximately 30% (~20ha) of the total wetland area. It is unlikely that this volume could be removed during winter through evaporation and seepage losses alone.

It may be possible to deliver the pumped water to floodplain depressions north of Cowra Rocks. Whilst the timing is not ideal, it may benefit the floodplain and provide a use for the water, or the water could be returned to the Murray River.

Refilling of the wetland to normal Lock 10 operating level (30.8 m AHD) could be achieved by opening the regulator. This option may not require delivery of environmental water; it may be possible to utilise normal river operations to refill the wetland, but may be dependent on timing (early spring). This option is also dependent on consultation with Ski Club representatives.

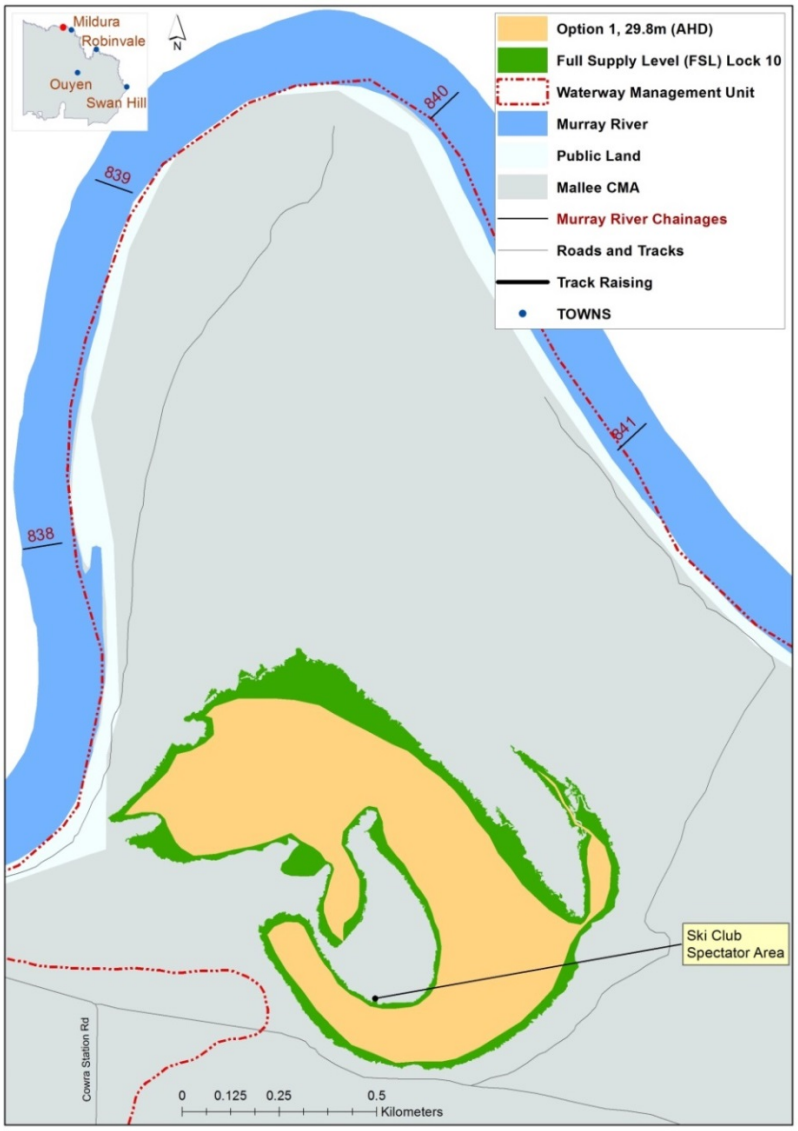

Figure 8. Target area at Cowra Rocks – Option 1

(Drawdown area shown is an example only, and not derived from data. A bathymetric study is required to determine extent and volume for draw down).

Option 2: Inundate Wetland Riparian Zone & Lignum Swampy Woodland

Option 2 (Figure 9) involves inundation of approximately 32 ha of fringing riparian zone and woodland vegetation requiring approximately 550 ML of environmental water, delivered using a temporary diesel pump that would pump from the Murray River, over the regulator, into the inlet channel, raising the level in Cowra Rocks to 31.5 m AHD. This option is also dependent on consultation with the Ski Club. Road raising is required at two sites to prevent break out to the Murray River, and potentially on a separate track if the Ski Club requires access to an existing spectator area (Figure 9).

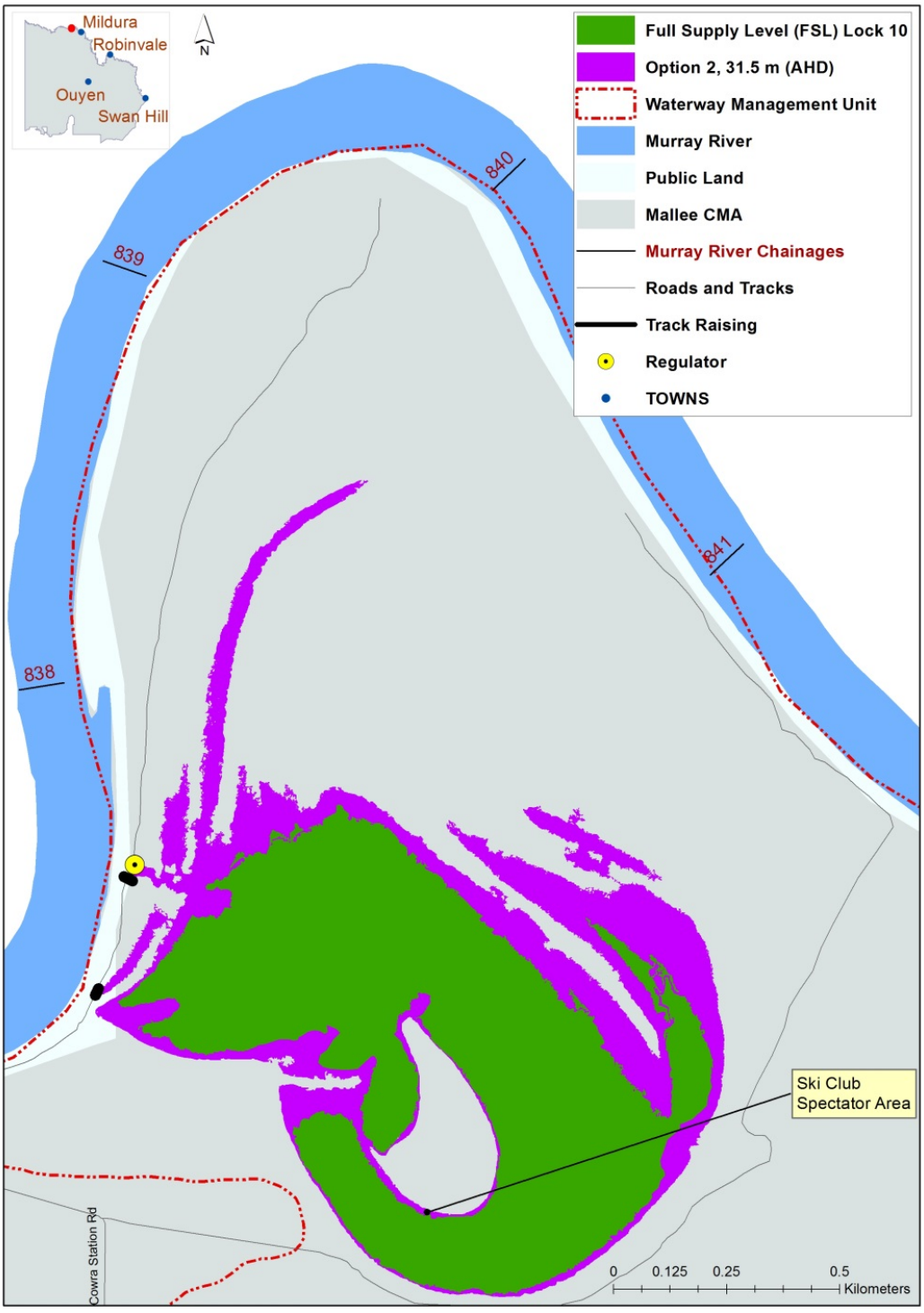

Figure 9. Target area at Cowra Rocks – Option 2

Option 3: Wetting & Drying Phases

Option 3 involves both a partial dry down phase (as per Option 1) and a wetting phase (Option 2). This option involves utilising a diesel pump to pump between approximately 300 ML and 500 ML of water from Cowra Rocks, lowering the water level by approximately 1 metre (to 29.8 m AHD). As with Option 1, the timing (winter) and duration constraints of this event necessitate pumping rather than allowing losses to evaporation and seepage. It may be an option to disperse the water pumped from Cowra Rocks to the northern floodplain, or return the water to the Murray River.

After a period of drying of part of the wetland bed, the regulator would be opened to return the wetland to weir pool height. By closing the regulator and pumping environmental water into the wetland it would be possible to raise the water level to 31.5 m AHD, thus achieving a net change in water level of approximately 1.7 metres. Refilling Cowra Rocks to FSL would require approximately 300-500 ML of water. It may be possible to utilise normal river operations to refill the wetland, but this may be dependent on timing (early spring). Inundating above FSL to 31.5 m AHD would require approximately 550 ML of environmental water.

This option would require a regulator and road raising as per Options 1 and 2, and could only be achieved if Ski Club use was suspended for several months, or the Ski Club accepted the access constraints. Due to the current use of this wetland by the Ski Club, summer drawdown and summer/autumn inundation are not feasible, although more ecologically beneficial.

Complete Dry Down

Whilst not consistent with the wetland's current use as a water skiing facility, a complete dry down may benefit the wetland by providing a regime that more closely reflects natural cycles.

Due to the large volume of water held within Cowra Rocks (estimated to be approx. 1.3 GL), pumping would be necessary to achieve complete drying of the wetland bed. It may be possible to pump water to the northern floodplain, however additional works would be needed to hold this volume of water on the floodplain, preventing return to both the wetland and the river. Alternatively, the water could be pumped over the regulator structure and straight into the inlet channel or river.

It would take considerable time to draw down (estimated to take approximately 50-65 days days), and refilling such a volume would need careful investigation as to timing and whether refilling would constitute a use of accountable environmental water. Consideration would also need to be given to the potential impact of complete drying on native aquatic species (see the section on Aquatic Fauna).

2.9 Related Agreements, Policy, Plans and Activities

Abbotsford Bend and Darling Junction are situated on the Victorian floodplain of the Murray River, which is the subject of investigation in many guises. These include salinity management plans, flow studies and Land Conservation Council Reviews. An investigation into River Red Gum Health by the Victorian Environmental Assessment Council (VEAC) in 2008 resulted in parts of it being changed from State Forest status to the Proposed Murray River Park.

The Mallee River Health Strategy (MCMA 2006a) refers to the stretch of the Murray River at Abbotsford Bend as Reach 11, and Darling Junction as Reach 12, within the M3-1 and M3-2 Murray River Management Zones respectively. Both reaches are classified as Priority River Classification 1 and 3 due to their high environmental and economic value.

The Mallee Waterway Strategy (MCMA 2014) identifies Cowra Rocks as a medium priority wetland and Darling Junction Creeks as a medium priority reach. Long term Resource Condition Targets include (MCMA 2014):

- To improve the condition of riparian habitat associated with high and medium priority waterways by 2022.
- To improve the condition of aquatic habitat associated with high and medium priority waterways by 2022.
- To improve hydrology within high and medium priority waterways by 2022.
- To improve water quality within high and medium priority waterways by 2022.
- To increase the number of Cultural Heritage sites associated with priority waterways which are formally recorded and captured within registered management plans/agreements by 2022.
- To increase community understanding of, and participation in the management of, priority waterways by 2022.

Further information on Management Activities can be found in the *Mallee Waterway Strategy.*

Lamberts Swamp (including Wetlands 7329 9925208, 7229 921211 and 7229 916213), is listed under the *Basin Salinity Management Strategy Register A,* with a salinity credit of 2.9 EC recorded under current management actions (Aquaterra 2010). This Register entry is reviewed five yearly and any works proposed for Lamberts Swamp or its associated wetlands must take this credit into account, considering any potential impact on the credit claim and subsequent potential to impact the Murray River.

Cowra Rocks is currently used by the Mildura Ski Club for practice and events. The Ski Club has a licence agreement with the current landholder, and maintains some basic infrastructure at the site.

Additional information on regional agreements, policies, plans and activities can be found in the *Context Document for Environmental Water Management Plans, Mallee CMA Region* (Sunraysia Environmental 2014).

3.0 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 (DEPI 2005). A wetland's hydrology is determined by morphology, surface and groundwater inflows and outflows in addition to precipitation and evapotranspiration (Mitsch and Gosselink, 2000 in DEPI 2005). Duration, frequency and seasonality (timing) are the main components of the hydrological regime for wetlands, creeks and rivers.

Abbotsford Bend and Darling Junction are located on the Victorian floodplain of the Murray River (chainage 829 km to 850 km) approximately 48 km downstream of river gauge (# 414216a) Mildura Weir Downstream. The westernmost section of Darling Junction lies 3 km downstream of the Wentworth weir and river gauge (# 425010) Wentworth Weir (Lock 10). The Darling River is a major tributary of the Murray River, joining the Murray at 832 river km, just upstream of Wentworth Weir.

Cowra Rocks is located 5 km upstream of Lock 10, and is permanently inundated to 30.8 m AHD under the influence of the Lock 10 weir pool (Full Supply Level). The western (downstream) connection of Darling Junction Creeks is 1 km downstream of the weir, and 2 km downstream of the junction with the Darling River.

It is not known to what extent high Darling River flows may influence Cowra Rocks and the surrounding floodplain, particularly when combined with high Murray River flows. Additionally, the validity of Euston Weir flow data is limited due to losses and irrigation demand downstream of Euston Weir.

The upstream extremity of Darling Junction lies within the Lock 10 Weir Pool, the downstream extremity is located below the weir and the junction of the Murray and Darling Rivers. The hydrology is broadly described in terms of flow passing Lock 9, although fluctuations in river height are possible downstream of Wentworth Weir due to changes in discharge (Ecological Associates 2007b). To provide an overview more closely related to the target areas, brief information is also provided on long term flow changes at Wentworth Weir, as well as approximations of flow volumes at relevant river heights.

3.1 Water Management and Delivery

3.1.1 Pre-regulation

Prior to river regulation, in the reach of the Murray River between Mildura and Wentworth weirs, the floodplain experienced inundation more frequently and these events had a greater duration (Ecological Associates 2007c). Natural flows were highest in spring and lowest in autumn.

Cowra Rocks would have experienced drying cycles in at least the shallower parts of the wetland. It also would have experienced inundation cycles. The fluctuating water levels would have allowed for a diversity of aquatic and terrestrial flora species in the littoral zone, and offered more regular access to a wider range of habitat and food sources for birds and aquatic fauna.

The Darling Junction Creeks would have experienced inundation regularly during high river flows, with smaller pools persisting as water receded. The inundation would have offered more regular access to a wider range of habitat and food sources for aquatic species, including small and large native fish species, frogs and turtles.

3.1.2 Post-regulation

Locks and weirs were completed at Mildura (upstream) in 1927 (G-MW 2015), and at Wentworth (downstream) in 1929 (MDBC [n.d.]), and along with others installed at similar times, have had a significant impact on the flow and flood regime in the river. In this part of the Murray River, the frequency, duration and magnitude of all but the largest floods have been reduced due to effects of regulation and major storages in the Murray and its tributaries (Thoms et al. 2000). River regulation and increased consumptive water use have reduced overbank flows that are important for water dependent flora and fauna species. Additionally, river regulation has caused some formerly ephemeral wetlands upstream of weirs, such as Cowra Rocks, to remain permanently inundated, reducing the capacity of these wetlands to sustain diverse populations of flora and fauna and contribute to ecosystem services.

A comparison of daily discharge by month for the pre-regulation and post-regulation (current) conditions for Euston Downstream is reproduced from Gippel (2014) (Figure 10) and Ecological Associates (2007c) (Figure 11) and indicates both the magnitude and frequency of large flood events has reduced. Additionally, almost constant inundation at Cowra Rocks has reduced the capacity for the wetland to contribute to valuable ecosystem services.

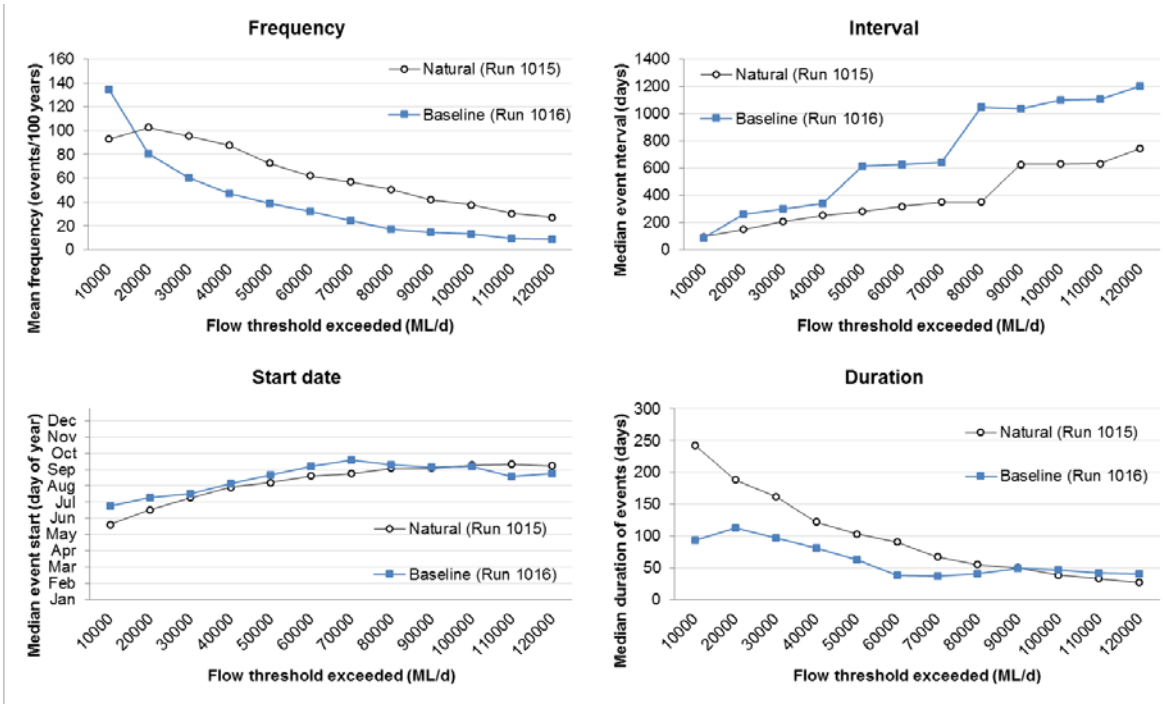

Figure 10. Comparison of Natural (pre-regulation) and Baseline Modelled Flow (post-regulation) scenarios for Euston Downstream (Gippel, 2014).

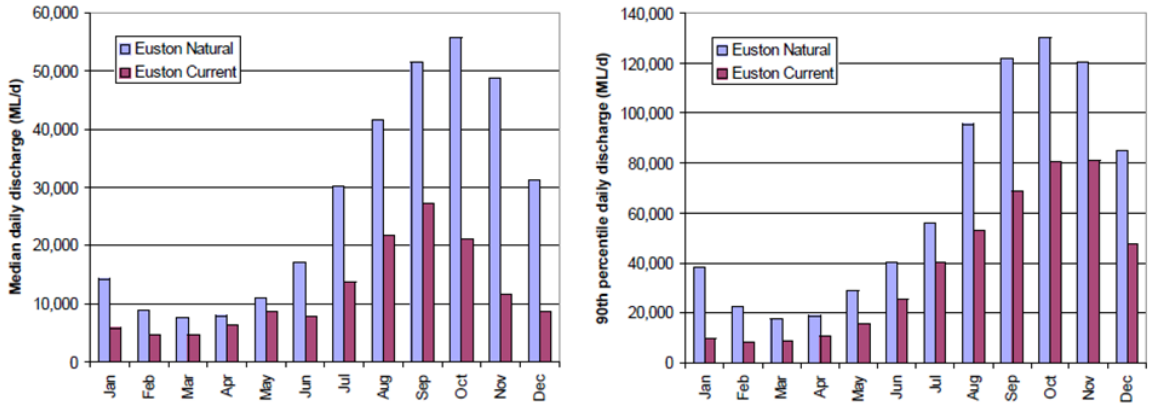

Figure 11. Distribution of median flows and 90th percentile flows for each month in the Murray River through Euston Weir for natural (pre-regulation) and current (post-regulation) conditions Source: derived from MDBC MSM-Bigmod 109-year data (Ecological Associates, 2007c).

Similarly, a comparison of daily discharge by month for the pre-regulation and post-regulation (current) conditions for Upstream Lock 9 is reproduced from Gippel (2014) in Figure 12 for Darling Junction, also indicating reduced magnitude and frequency of large flood events.

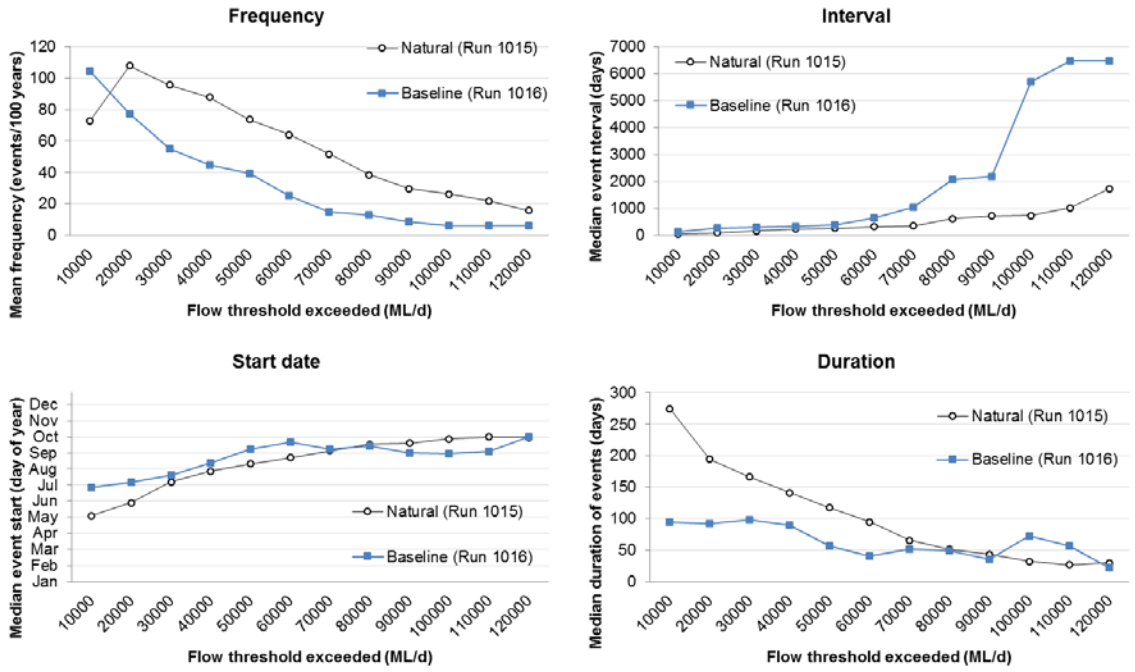

Figure 12. Comparison of Natural (pre-regulation) and Baseline Modelled Flow (post-regulation) scenarios for Lock 9 upstream (Gippel, 2014).

Closer to the target area, flow data at Wentworth may be more applicable. Thoms et al. (2000) suggested floods at Wentworth of 40,000 ML/day for a two month duration occurred in 84 years in 100 under natural conditions. By 1994 that frequency had been reduced to 31 years in 100. For flows of 60,000 ML/day for one month, frequency had been reduced from 61 to 21 years in 100 (Thoms et al. 2000).

A review of lidar for Cowra Rocks indicates the floodplain engages at around 31.5 m AHD. A check of flow data downstream of Wentworth Weir for 2011 indicated that a river height of 31.5 m translated to an approximate flow of 70,000 ML/day. This analysis is limited to the 2011 flood event, and a more detailed spells analysis over longer time period (and incorporating Downstream Mildura Weir) is recommended to help determine the CTF for the Cowra Rocks floodplain and Darling Junction Creeks.

The depth of the inlet at Cowra Rocks is estimated to be 30 cm, providing an approximate height of 30.5 m AHD. Again using the 2011 flow data for Wentworth Weir, this river height translates to approximately 50,000 ML/day.

3.1.3 Changes to frequency of inundation at Cowra Rocks

The commence to flow (CTF) rates measured in ML/day Downstream of Wentworth Weir for the floodplain around Cowra Rocks is broadly estimated at 70,000 ML/day. The CTF for the floodplain has been selected for reference in addition to the CTF for the wetland to provide an indication of the change in inundation cycles under regulated conditions.

Spells analysis undertaken by Gippel (2014) was consulted to better understand the frequency of inundation of the Cowra Rocks and the floodplain under post-regulation conditions. The analysis for Lock 9 was selected to better represent Darling River inflows and losses downstream of Euston. The percentage of years with the threshold event from pre-regulation to post-regulation have significantly reduced for all thresholds above 20,000 ML/day, and the durations of these events are also significantly reduced for all flow thresholds (Table 4). In a natural system it is likely that Cowra Rocks disconnected from the Murray River during dry spells and this may have occurred for extended periods of time. Furthermore, this is likely to have resulted in parts of the wetland experiencing regular drying phases.

Lock 10 flow data from 2011 indicates floods of approximately 70,000 ML/day are required to engage the floodplain at Cowra Rocks, and the spells analysis indicates these occur on average one third as often post-regulation, and are of shorter duration. Furthermore, flow volumes likely to inundate Cowra Rocks wetland (50,000 ML/day) occurred on average 7 out of 10 years pre-regulation, and would have been disconnected for a period of time in most years, whereas the wetland remains constantly inundated within the Lock 10 weir pool.

Table 4 - Modelled natural (pre-regulation) and baseline (post-regulation) flows for flow threshold of 50,000 & 70,000 ML/day upstream of Lock 9

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	50,000	7.37	269	117	15th Aug	78%
B	50,000	3.95	387	57	12th Sept	41%
N	70,000	5.18	350	66	9th Sept	51%
B	70,000	1.49	1034	52	13th Sept	31%

3.1.4 Current Wetland and Creeks Hydrology

Cowra Rocks has a shallow and narrow inlet channel at approximately 838 river km. The wetland is within the influence of the Lock 10 weir pool and is continually inundated to 30.8 m AHD. There is a track crossing the inlet channel that limits movement of aquatic fauna (Figure 17, page 40).

The Darling Junction Creeks connect upstream of Lock 10 via Darling Junction Wetland (7229 847242) and flow westerly for approximately 2 km, with an elevated branch flowing to the southwest. The main creek channel connects the Murray River at 830.5 river km. The downstream end connects first, where the bed level is 28.5 m AHD. There is a sill located at the upstream connection with Darling Junction Wetland that prevents flow through from the wetland under normal (regulated) river operations. Flow through is not achieved until the river height reaches 31.6 m AHD, which is 0.8 m above weir pool height; the weir is typically removed at these flow volumes. The southwest branch would flow when the river height was in excess of 31.7 m AHD (Ecological Associates 2007b).

The Lock 10 road crosses the main channel of the Darling Junction Creeks, providing a sill that restricts flow-through.

3.1.5 Environmental Watering

Environmental water has not been delivered to Abbotsford Bend or Darling Junction to date. It is expected that inundating Cowra Rocks to a height of 31.5 m AHD may utilise 550 ML of environmental water. A drying phase has not been initiated at Cowra Rocks to date.

The proposed extent of inundation achieved through the delivery of environmental water at Cowra Rocks could be achieved if infrastructure were to be put in place. Similarly, flow through of the main anabranch at Darling Junction Creeks could be achieved by lower natural flow events if infrastructure was constructed. Opportunities for future works are discussed in Section 8.0.

4.0 Water Dependent Values

4.1 Environmental Values

Wetlands and waterways on the floodplain support an array of flora and fauna. 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.

4.2 Listings and Significance

4.2.1 Fauna

Native species recorded at Abbotsford Bend and Darling Junction are listed in Appendix 1. Of special interest and responsibility are the species listed in legislation, agreements or conventions that would benefit from an altered inundation regime. These are summarised in Table 5. At the time of writing, total of 148 species of native fauna had been recorded in the Victorian Biodiversity Atlas (VBA) at Abbotsford Bend and Darling Junction including 10 reptile and 135 bird species. One additional species (Murray-Darling Rainbowfish) was recorded during a recent survey and is included in Table 5.

Table 5. Listed fauna recorded at the site

Scientific name	Common name	Type	International agreements	EPBC status	FFG status	DELWP status
Actitis hypoleucos	Common Sandpiper	B	J,Bo	Ma	NL	V
Alcedo azurea	Azure Kingfisher	B	J,C,R,Bo	NL	NL	NT
Anas rhynchotis	Australasian Shoveler	B	NL	NL	NL	V
Ardea modesta	Eastern Great Egret	B	J	Ma	L	V
Aythya australis	Hardhead	B	NL	NL	NL	V
Biziura lobata	Musk Duck	B	NL	NL	NL	V
Burhinus grallarius	Bush Stone-curlew	B	NL	NL	L	EN
Calidris canutus	Red Knot	B	J,C,R,Bo	Ma	NL	EN
Circus assimilis	Spotted Harrier	B	NL	NL	NL	NT
Climacteris picumnus	Brown Treecreeper	B	NL	NL	NL	NT
Dromaius novaehollandiae	Emu	B	NL	NL	NL	NT
Emydura macquarii	Murray River Turtle	A	NL	NL	NL	V
Egretta garzetta nigripes	Little Egret	B	NL	Ma	L	EN
Gallinago hardwickii	Latham's Snipe	B	J,R,Bo	Ma	NL	NT
Haliaeetus leucogaster	White-bellied Sea-Eagle	B	NL	Ma	L	V

Scientific name	Common name	Type	International agreements	EPBC status	FFG status	DELWP status
Hydroprogne caspia	Caspian Tern	B	J	Ma	NL	NT
Lichenostomus cratitius	Purple-gaped Honeyeater	B	NL	NL	NL	V
Lophocroa leadbeateri	Major Mitchell's Cockatoo	B	NL	NL	L	V
Melanotaenia fluviatilis	Murray-Darling Rainbowfish	F	NL	NL	L	V
Merops ornatus	Rainbow Bee-eater	B	J	NL	L	NL
Morelia spilota metcalfei	Carpet Python	R	NL	NL	L	EN
Oxyura australis	Blue-billed Duck	B	NL	NL	NL	EN
Phalacrocorax varius	Pied Cormorant	B	NL	NL	NL	NT
Platalea regia	Royal Spoonbill	B	NL	NL	NL	NT
Pluvialis squatarola	Grey Plover	B	J,C,R,Bo	Ma	NL	EN
Polytelis anthopeplus	Regent Parrot	B	NL	VU	L	V
Porzana pusilla palustris	Baillon's Crake	B	NL	Ma	L	V
Struthidea cinerea	Apostlebird	B	NL	NL	L	NL

Legend
Type: **R**eptile, **B**ird, **A**mphibian, **F**ish
EPBC status: **VU**lnerable, **Ma**rine, **Mi**gratory, **N**ot **L**isted
International Bird Agreements: **C**hina-Australia Migratory Bird Agreement, **J**apan-Australia Migratory Bird Agreement, **R**epublic of Korea-Australia Migratory Bird Agreement, **Bo**nn Convention, **N**ot **L**isted
FFG status: **L**isted as threatened, **N**ot **L**isted
DELWP status: **EN**dangered, **V**ulnerable, **N**ear **T**hreatened, **N**ot **L**isted

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

The species listed in Table 5 include species that forage or nest in or on water or require flooding to trigger breeding and fledging. The list also includes species that are indirectly dependent on water, i.e. they require riparian trees, vigorous ground cover and fallen timber. In order to provide breeding opportunities, habitat elements within Abbotsford Bend such as temporary wetlands and River Red Gum, Black Box and Lignum communities must be maintained in good condition.

Aquatic Fauna

A survey conducted at Cowra Rocks in December 2015 recorded five native fish species, two frog species and one turtle species (Table 6). Two exotic fish species were also recorded: Common Carp (*Cyprinus carpio*) and Eastern Gambusia (*Gambusia holbrooki*) (Biosis 2016).

Table 6. Aquatic fauna recorded at Cowra Rocks

Scientific name	Common name	Type	Number	EPBC status	FFG status	DELWP status
Emydura macquarii	Murray River Turtle	R	1	NL	NL	V
***Hypseleotris* spp.**	Carp Gudgeon	F	81	NL	NL	NL
Limnodynastes tasmaniensis	Spotted Marsh Frog	A	1	NL	NL	NL
Littoria peronii	Peron's Tree Frog	A	1	NL	NL	NL
Melanotaenia fluviatilis	Murray-Darling Rainbowfish	F	2	NL	L	V
Nematalosa erebi	Bony Bream	F	1	NL	NL	NL
Philypnodon grandiceps	Flat-headed Gudgeon	F	1	NL	NL	NL
Retropinna semoni	Australian Smelt	F	7	NL	NL	NL

Legend
Type: Reptile, Amphibian, Fish
EPBC status: Not Listed
FFG status: Listed as threatened, Not Listed
DELWP status: Vulnerable, Not Listed

The vulnerable Murray River Turtle (*Emydura macquarii*), may benefit from water management at Cowra Rocks. It is most often found in permanent water bodies including rivers and deep (>2m) lagoons close to the main river channel (Chessman, 1998), thus Cowra Rocks offers suitable habitat. This omnivorous turtle is known to feed on *Vallisneria* spp., carrion, beetle larvae and filamentous algae (Spencer, Thompson, & Hume, 1998). Cowra Rocks may offer suitable habitat for the Murray River Turtle and this species may benefit from improved diversity and condition of aquatic vegetation in the target area.

Also recently recorded at Cowra Rocks, the vulnerable Murray-Darling Rainbowfish (*Melanotaenia fluviatilis*) is a small bodied carnivorous species known to feed on aquatic and terrestrial invertebrates and filamentous algae (Lintermans 2007). This species may benefit from water management at Cowra Rocks through improved primary production within the wetland, and rejuvenated egg banks of invertebrates. Predation of larvae by Eastern Gambusia (*Gambusia holbrooki*) is considered a potential threat to this species (Lintermans 2007).

Water birds

Abbotsford Bend and Darling Junction have historically supported a diverse range of waterbirds, with a total of 47 listed and non-listed species recorded (Appendix 1), and 17 waterbird species recorded in a single survey in the target area at Cowra Rocks in 1999. A bird survey conducted in December 2015 and January 2016 recorded 40 species. This survey recorded a further 4 listed and non-listed species, comprising seven woodland species and five additional water bird species including the near threatened Pied Cormorant (*Phalacrocorax varius*) (GHD 2016).

Primary breeding stimuli for the Pied Cormorant include season and flooding; breeding is related to resource availability and water conditions, though the primary season is spring to autumn (Rogers & Ralph 2011). This species may benefit from delivery of environmental water at Cowra Rocks to provide extended forage habitat.

Waterbird diversity and abundance are influenced by wetland habitat diversity, with different species and feeding guilds using different habitats for breeding and foraging (Haig *et al.* 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 *et al.* 2002).

The wetland type and associated vegetation communities at Cowra Rocks provide habitat for a variety of waterbird guilds. In particular, Cowra Rocks provides deep, open water in combination with abundant fringing vegetation that is essential foraging and nesting habitat for the State listed Hardhead (*Aythya australis*), Musk Duck (*Biziura lobata*) and Blue-billed Duck (*Oxyura australis*) (Rogers & Ralph 2011). This habitat diversity and condition may be enhanced by the proposed environmental water management program. The habitat use and food and nesting requirements of the waterbird guilds recorded at the site are listed in Table 7.

Table 7 Waterbird functional groups, their resource use and nesting requirements

Waterbird Group	Example Species Recorded	Food Resource	Habitat Use	Nesting habitat*
Deep water foragers	Hardhead (V), Musk Duck (V), Blue-billed Duck (EN)	Generalists; plankton, small invertebrates, plant material	Deep water with abundant fringing vegetation	Cumbungi, rushes, sedges, Lignum
Dabbling Ducks	Australasian Shoveller (NL)	Generalists; plankton, small invertebrates, plant material	Shallow water, open water, soft mud, littoral zone	On ground, in reeds and rushes
Grazing Waterfowl	Black Swan (NL)	Plant material, seeds, invertebrates	Deep water, shallow water, littoral zone	Tall emergent vegetation
Piscivores	Pied Cormorant (NT)	Fish	Open and deep water	Tall trees, in or near water
Large Waders	Royal Spoonbill (NT) Little Egret (EN), Eastern Great Egret (V)	Macroinvertebrates, fish, amphibians	Littoral zone, emergent and aquatic vegetation, open water	Trees, shrubs, reeds, rushes
Small Waders	Plovers, Stilts	Small invertebrates, seeds	Littoral zone, mudflats, emergent vegetation	Rushes, Lignum, on ground
DELWP status: ENdangered, **V**ulnerable, **N**ear **T**hreatened, **N**ot **L**isted * Nesting habitat is described for the species listed in each functional group, not all species within the functional group (Rogers & Ralph 2011)				

The EPBC listed White-bellied Sea-eagle (*Haliaeetus leucogaster)* has been recorded at Abbotsford Bend. It nests near water in large live or dead trees, creating stick nests of up to 1.7m across, and breeds between April and August. Known to forage over large expanses of open water, the White-bellied Sea-eagle feeds on fish, birds, reptiles, mammals, crustaceans and carrion. The Victorian population is thought to be as low as 100 breeding pairs (DSE 2003). Deterioration of inland water resources and disturbance of nesting pairs by human activity are listed as threats for this species (Department of the Environment 2015). Improvement of wetland condition at Cowra Rocks may provide additional forage area and nesting sites.

The Inland Carpet Python (*Morelia spilota metcalfei)* has been recorded in the area. In a healthy wetland environment, the areas fringing the wetland would provide suitable habitat and cover in the form of thick litter and shrubs, tree hollows and fallen timber, and also a range of food sources.

Management of water levels under this plan will potentially encourage diversity and improve the quality of riparian vegetation, increasing the habitat value of the target area for this species.

4.2.2 Vegetation Communities

Five water dependent EVCs are identified within the target areas. These are outlined in Table 8. Four EVCs are listed as Depleted within the Murray Scroll Belt bioregion. The bioregional conservation status of all water dependant EVCs in the target areas is shown in Table 8.

For a full list of EVCs within the entire Abbotsford Bend and Darling Junction area and details on each see Appendix 2. The EVCs at Darling Junction are illustrated in Figure 13, and Cowra Rocks in Figure 14.

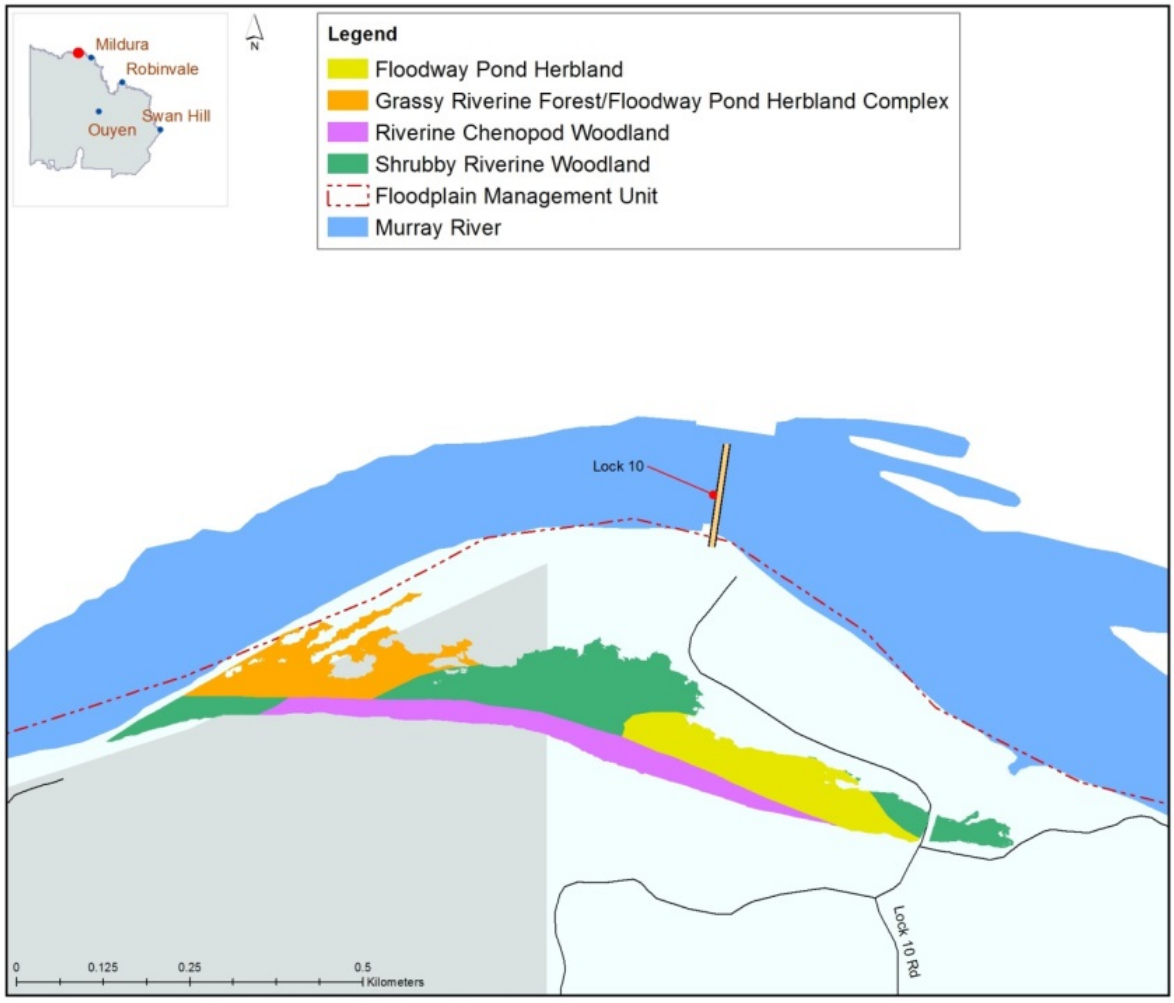

Figure 13. Ecological Vegetation Classes (EVCs) at Darling Junction

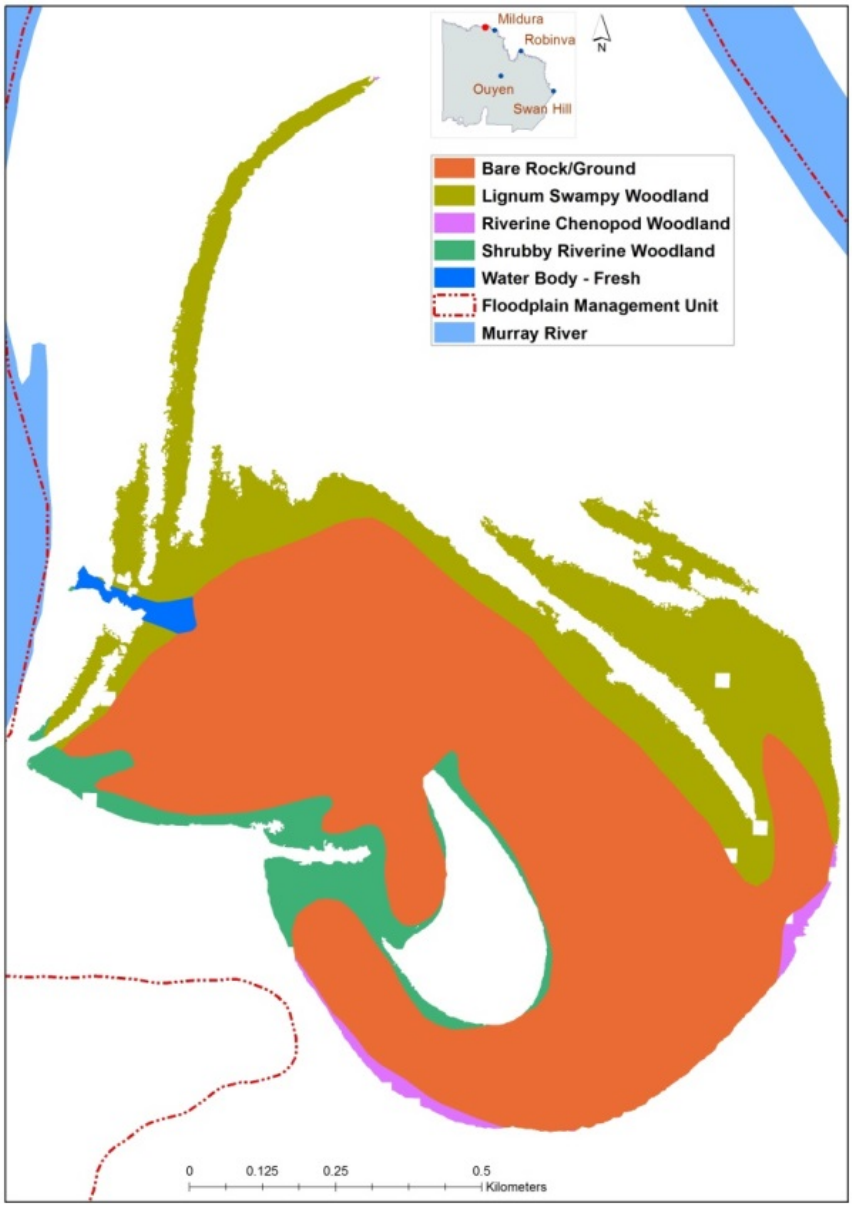

Figure 14. Ecological Vegetation Classes (EVCs) at Cowra Rocks

Table 8. Conservation status of water dependent EVCs in the target areas

EVC no.	EVC name	Bioregional Conservation Status*	Site
		Murray Scroll Belt Bioregion	
103	Riverine Chenopod Woodland	Depleted	Darling Junction; Cowra Rocks
810	Floodway Pond Herbland	Depleted	Darling Junction
811	Grassy Riverine Forest/Floodway Pond Herbland Complex	Depleted	Darling Junction
818	Shrubby Riverine Woodland	Least Concern (Terrestrial BCS)	Darling Junction; Cowra Rocks
823	Lignum Swampy Woodland	Depleted	Cowra Rocks

* The bioregional conservation status (BCS) of the wetland EVCs in this plan are based on expert advice but have not yet been formally approved by DEPI. In the case of Shrubby Riverine Woodland, no preliminary wetland BCS has been advised, consequently the terrestrial BCS has been applied.

Lignum Swampy Woodland is found along the northern edge of Cowra Rocks. Lignum dominates this EVC but it also supports Eucalypt or Acacia woodland with River Red Gum and Black Box being the dominant trees species. Healthy Lignum communities fringing a deep wetland like Cowra Rocks can offer additional nesting habitat for several waterbird species recorded in the area including deep water foragers like Hardhead, Musk Duck and Blue-billed Duck. When flooded, it also offers extended foraging habitat for grazing waterfowl such as the Grey Teal (*Anas gracilis*) and small waders (Rogers & Ralph 2011). This EVC 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 Swampy Woodland is 2-4 months (VEAC, 2008).

Shrubby Riverine Woodland fringes the 'island' at Cowra Rocks and the south and south west edges of the wetland. River Red Gum dominates this EVC and older trees may provide hollows, offering nesting opportunities for Regent Parrot (*Polytelis anthopeplus*), Major Mitchell's Cockatoo (*Lophocroa leadbeateri*) and Grey Teal. The shrub layer present in this EVC provides cover and forage habitat for reptiles and woodland birds. This EVC would have experienced frequent short inundation, with a flooding event 1-3 years in 5. The recommended ponding duration for Shrubby Riverine Woodland is less than one month (VEAC, 2008).

At Cowra Rocks, Riverine Chenopod Woodland occurs on the elevated terrace to the south; it is not proposed to deliver environmental water to this area, and although mapped in Figure 14, this EVC will not be inundated under this plan due to its elevation.

4.2.3 Flora

A full list of flora recorded at the site can be found in Appendix 3. Water dependent flora species listed in the various acts and agreements that have been recorded at Abbotsford Bend and Darling Junction are listed in Table 9.

Table 9. Listed water dependent flora species recorded at the site

Scientific Name	Common Name	EPBC Status	FFG Status	DELWP status
Calostemma luteum	Yellow Garland-lily	NL	NL	V
Duma horrida* subsp. *horrida	Spiny Lignum	NL	NL	R
Eragrostis australasica	Cane Grass	NL	NL	V
Hydrilla verticillata	Hydrilla	NL	NL	R
Minuria cunninghamii	Bush Minuria*	NL	NL	R
Sida ammophila	Sand Sida*	NL	NL	V
Swainsona reticulata	Kneed Swainson-pea*	NL	L	R
Tecticornia triandra	Desert Glasswort*	NL	NL	R
Legend **EPBC** status: **N**ot **L**isted **FFG** status: **L**isted as threatened, **N**ot **L**isted **DELWP** status: **EN**dangered, **V**ulnerable, **R**are, Poorly **K**nown				

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

Due most likely to the static water level at Cowra Rocks, the dominant emergent aquatic vegetation at Cowra Rocks is a dense zone of Cumbungi (*Typha* spp.) on the water line, with sedges growing close to the water's edge. Cumbungi provides nesting and foraging habitat for a wide range of waterbirds from the Black Swan to ducks and waders. It also offers habitat for fish, frogs and turtles.

Ecological values can be improved at Cowra Rocks by encouraging a diversity of macrophytes. Aquatic macrophytes are rooted to the wetland floor with their canopies submerged, emerging or floating near the water surface. They form highly productive wetland habitats providing shelter for macro-invertebrates, and frogs, turtles and small-bodied fish that graze on this vegetation and the macro-invertebrates within it (EA 2007c). They offer grazing habitat for a range of waterbirds including large waders and dabbling ducks and grazing waterfowl. Aquatic macrophytes are dependent on water for growth and reproduction. The ideal flood requirement is 9-12 months (Rogers & Ralph 2011). They may persist in wetlands that are frequently flooded but if summer drying occurs they will die off and be replaced by lake bed herbs (EA 2007c).

Emergent macrophytes are often found on the perimeter of ephemerally or seasonally wet locations and can provide essential habitat for frogs and nesting and foraging opportunities for waterbirds. Under flooding, native fish will also utilise reed beds and semi-emergent vegetation where they feed on macro-invertebrates and shelter from predators (EA 2007c). Emergent macrophytes require annual flooding of approximately 6-12 months depending on species. The return of an inundation cycle more closely mimicking natural conditions may encourage a diversity of species requiring differing water regimes.

The target area is generally surrounded by an overstorey comprised of River Red Gum (*Eucalyptus camaldulensis*), Eumong (*Acacia stenophylla*) and Black Box (*Eucalyptus largiflorens*) with a mid-storey of Tangled Lignum (*Muehlenbeckia florulenta*). Where wetlands and woodlands are combined in close proximity, such as at Cowra Rocks, conservation significance is high. When flooded, the woodland floor becomes an extension of the wetland habitat, thereby extending food and shelter opportunities for aquatic fauna (Ecological Associates 2006). Inundated woodlands provide habitat and grazing opportunities for fish through snags and debris deposited in the water. They also provide important refuges for birds, reptiles and mammals, in the form of perches and nesting hollows. Grey Teal is known to forage in spreading floodwaters (Rogers & Ralph 2011).

Black Box provides essential habitat and foraging opportunities for a range of species including the Inland Carpet Python as well as hollows for the Regent Parrot and Major Mitchell's Cockatoo. Black Box can tolerate a range of conditions from wet to dry (Roberts & Marston 2011), however, under extended periods of dry conditions trees will suffer a decline in health and eventually death (Ecological Associates 2007a).

River Red Gums are the most widespread eucalypt tree in Australia, occupying riparian habitats along water courses and wetlands (Roberts & Marston 2011). Trees in poor condition have little contribution to the function and productivity of the ecosystem and the quality of woodland habitat is greatly reduced (Roberts & Marston 2011). Healthy River Red Gums contribute to the wetland ecosystem by depositing organic material, and fallen trees and branches provide structural habitat features for native fauna such as the Inland Carpet Python. Older trees can provide perching sites for birdlife, nesting sites for the White-bellied Sea-eagle, and hollows for the Regent Parrot. Healthy River Red Gum stands also provide flight paths for the Regent Parrot. Both the River Red Gum and Black Box offer fallen timber for use by stick nest building birds including the White-bellied Sea-eagle.

Tangled Lignum is considered to be the most significant floodplain shrub in mainland Australia due to its extensive distribution, local dominance and value as habitat (Roberts & Marston 2011). Lignum occurs north of Cowra Rocks (Figure 19) and when healthy can offer shelter and nesting sites for many waterbirds, habitat for woodland birds, and cover for reptiles including the Inland Carpet Python.

4.2.4 Wetland Depletion and Rarity

The *Mallee CMA Regional Context Document* outlines wetland depletion and rarity within the Mallee CMA Region. The Abbotsford Bend and Darling Junction target area contains one wetland, classified using the Corrick-Norman wetland classification system, as permanent open freshwater (Table 10).

This category is more prevalent within the Mallee CMA Region (+5%), possibly as result of regulation, with six weir pools in the region. Permanent open freshwater is depleted in Victoria (-6%) and within the Murray Scroll Belt bioregion (-7%) (Mallee CMA 2006b). This makes Cowra Rocks significant in terms of representativeness at a state and bioregional scale, and management of water levels in this permanently inundated wetland may help improve its ecological value.

Table 10. Changes in area of the wetlands in the target area by Corrick classification

Category	No of Wetlands in target area	Total area (ha)	Decrease in wetland area from 1788 to 1994		
			% Change in area in Victoria	% Change in area in Mallee CMA	% Change in Murray Scroll Belt
Permanent open freshwater	1	66.4	-6	5	-7

Source: DEPI Biodiversity interactive maps, Mallee Wetland Strategy (Mallee CMA 2006b)

4.2.5 Ecosystem Functions

Healthy wetland ecosystems have the potential to support distinctive communities of plants and animals and provide numerous ecosystem services. These ecosystems can perform important functions necessary to maintain the hydrological, physical and ecological health of the river systems and floodplain. Wetting and drying cycles within wetlands facilitates both deposition and decomposition of organic matter, recycling dead matter back into the food web (Young 2001). Wetland ecosystem functions can include:

- enhancing wetland food chains;
- absorbing and releasing floodwaters;
- wetland primary production;
- providing organic material to rivers to maintain riverine food chains;
- providing extended foraging, breeding and basking opportunities for frogs and turtles;
- providing extended foraging and breeding habitat for waterbirds; and
- providing feeding, breeding and drought refuge sites for native flora and fauna.

Altered water regimes in the target area due to river regulation and extended dry conditions on the floodplain have seen a decrease in the frequency and extent of inundation on the floodplain at Abbotsford Bend, and a static water level within Cowra Rocks. This has reduced the ability for the wetland and fringing vegetation to perform these valuable ecosystem functions.

4.3 Social

4.3.1 Cultural Value

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

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

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

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

4.3.2 Cultural Heritage

Abbotsford Bend and Darling Junction is of significant cultural value and historically important to Indigenous and non-Indigenous people, with the area popular for fishing, camping, and as a meeting place.

In regard to Indigenous cultural values, sites are known to exist within Abbotsford Bend (GHD 2006), and there is a high likelihood of Aboriginal cultural heritage sites within the Abbotsford Bend and Darling Junction area because of its location on the Murray River floodplain and proximity to the confluence of the Murray and Darling Rivers.

Sites found near waterways can include middens, earth features, scarred trees, Aboriginal mounds and surface scatters. Surface scatters 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. However the true extent of the number and types of sites present in the target area is still unknown.

There is currently no Registered Aboriginal Party (RAP) that covers this area. It is likely however, that three Aboriginal groups have an interest in the area, as these groups are identified as having an interest in the area immediately downstream of Darling Junction. These groups are: Ngintait People, Latji Latji Mumthelang Aboriginal Corporation and Nyeri Nyeri People (Bell 2013). The Aboriginal Community continue to value this country through traditional laws and customs.

European heritage reflects the pioneering history of the area. Captain Charles Sturt discovered the Murray and Darling junction in 1830, and met with a large group of Aboriginals upon arrival. It was at the Junction that he named the river after Sir George Murray (Sturt 2009).

Pastoral activities reached the area in the following decade; Kulnine Station (Culnine), or Hawdon's Upper Run, was first gazetted in 1848 by John Hawdon Jnr (Bell 2013). Culnine Station (Figure 15) comprised three areas: Upper, Lower and Cowra. Cowra Station extended from Merbein to Darling Junction; Culnine Upper extended from there downstream. Culnine Lower is outside the target area.

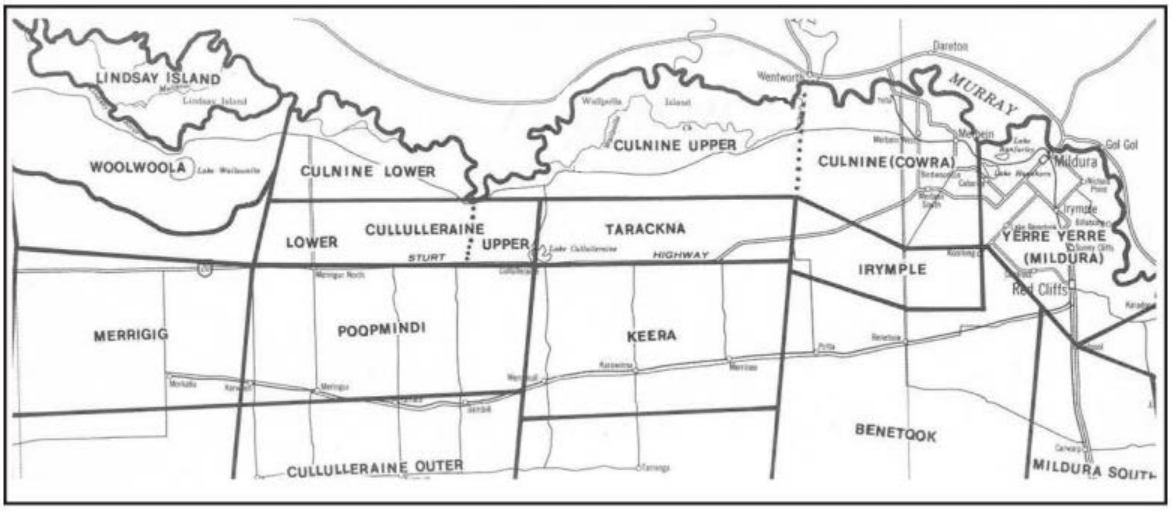

Figure 15. Pastoral Runs and Stations in the region (Spreadborough & Anderson, cited in Bell 2013, p.11)

The Victorian Heritage Database (VHD) holds four place records within Abbotsford Bend and Darling Junction. Three of these relate to individuals or stands of the vulnerable and FFG listed Nealie (*Acacia loderi*) delineating the southern limit for this species (Place IDs 67034, 71428 and 71429).

A fourth record in the database relates to the Abbotsford Bridge (Place ID 184811) (Heritage Council Victoria n.d). Built 1925-28, the bridge is a 14 span riveted steel bridge with a lattice frame lift span and is unique in the region (OEH n.d.). This bridge is also heritage listed in NSW due to its "historical significance as an important link in the evolving pattern of growth in the Sunraysia District", and aesthetic significance, having "outstanding setting and landmark qualities" (OEH n.d.).

4.3.3 Recreation

The region is popular for swimming, camping, fishing, boating, four wheel driving, picnicking, barbequing and walking and these uses will continue in the proposed Murray River Park.

An informal camping hut is located on the floodplain on Cowra Station indicating the area has been used for camping over a number of years.

Cowra Rocks and surrounds have been used since 2007 by the Mildura Ski Club, which currently has a license agreement with the landholder. The wetland is available to all club members throughout the year, and is used frequently for tournaments and practice through spring, summer and autumn. A junior Ski School is conducted at the site each year during the Victorian September school holidays, and other major events are scheduled in mid-summer. Club infrastructure held on site includes a ski jump ramp, judging tower, under cover area, catering van (Figure 16) and storage facilities. Spectators watch from a viewing area on the central 'island' of Cowra Rocks, accessible via a narrow and low lying (31 m AHD) track.

Figure 16. Mildura Ski Club has some basic infrastructure on site at Cowra Rocks. The edge of the wetland is discernible by the line of Cumbungi left of centre.

4.4 Economic

Part of Abbotsford Bend is private land, currently used for grazing, dryland farming and small areas of irrigated pasture and horticulture. The land surrounding Cowra Rocks is used for grazing livestock for part of the year. The floodplain at Abbotsford Bend and Darling Junction have been the subject of a range of land and water management investigations have been used for timber harvesting and livestock grazing in the past.

The North West Drain and the connected wetlands 7229 921211 and 7229 916213 at the eastern end of Abbotsford Bend are used for irrigation drainage disposal and storage by Lower Murray Water. Excess drainage water runs along the North West Drain and eventually the Murray River. There is a gauging station that continually monitors water level, volume, temperature and conductivity.

Darling Junction offers potential as a tourist site, as it is positioned on the junction of the Murray and Darling Rivers, and is a popular fishing site. Private land borders this area to the south, which is used for irrigated horticulture. Westward lies the Wallpolla Island: a popular tourist destination.

The river frontage has been gazetted as River Murray Reserve and the majority of the target area is proposed Murray River Park with small areas of private land and a Road Reserve in the south west.

4.5 Significance

Cowra Rocks and Darling Junction are able to support a rich diversity of flora and fauna. Darling Junction supports River Red Gum forest and woodland and Floodway Pond Herbland. Cowra Rocks supports Lignum, River Red Gum and Black Box communities and emergent and semi-emergent macrophytes. The iconic River Red Gum and Black Box, as the principal sources of hollows, provide essential habitat to a range of species, including the Regent Parrot, Major Mitchell's Cockatoo and the Inland Carpet Python; while Lignum provides shelter and nesting sites for a range of bird species.

The wetland type and associated vegetation communities within Abbotsford Bend and Darling Junction also provide habitat for a large variety of waterbird guilds. At least 47 different species of water dependent birds and waterbirds have been recorded, including the State listed Hardhead (*Aythya australis*), Musk Duck (*Biziura lobata*) and Blue-billed Duck (*Oxyura australis*). Cowra Rocks offers deep, open water, fringed by dense aquatic vegetation suitable as feeding, nesting and breeding habitat for these and many other waterbird species recorded in the area. The fringing Cumbungi also offers foraging and breeding habitat for fish, frogs and turtles.

Additionally, shallower water and timbered parts of the wetland increase the diversity of water habitat available, and surrounding terrestrial vegetation such as River Red Gum, Black Box and Lignum offer nesting and foraging habitat for waterbirds, reptiles and woodland birds. The array of small-bodied fish recorded in shallower areas of Cowra Rocks also suggest there is a diversity of suitable aquatic habitat present, with large-bodied fish likely to be found in deeper areas (Biosis 2016).

There is potential to improve ecological diversity at Cowra Rocks through management of water levels and delivery of environmental water. Implementing a regime of inundation and partial drying may increase wetland primary production, which in turn can increase biomass and decomposition of organic matter providing a food source for detritus feeders (Brinson, Lugo & Brown 1981) and macroinvertebrates. Varying water levels in the wetland zone may increase diversity of aquatic vegetation, enhancing insect and macroinvertebrate diversity (Diehl 1992), with potential benefits throughout the food chain, offering a wider variety of food sources for waterbirds, bats, fish, frogs, turtles, terrestrial reptiles and predatory birds.

Waterbirds in particular may benefit from management of water levels at Cowra Rocks. The condition of Lignum communities may be improved by delivery of water to the floodplain, offering additional nesting habitat and a temporary expansion of shallow forage areas. Improving diversity of aquatic macrophytes may offer additional food sources and more diverse forage habitat for waterbirds.

Cowra Rocks is of high social significance as a recreation site for the Ski Club and offers potential for bird observers, campers and bush walkers. Positioned on private land the site is unique in its wetland size. As a large (66 ha) open waterbody on the Murray River floodplain, this site has potential to offer many habitat types to many native fauna species. There is potential for this site to become a demonstration site exhibiting ecological benefits gained through management of water levels.

Positioned at the junction of the Murray and Darling Rivers, Darling Junction holds many significant features. It is popular for fishing and boating and has a Red Gum forest in good condition. Improving flow through during a natural inundation event may improve diversity and condition of the Floodway Pond Herbland EVC in this area as well as encourage regeneration of fringing River Red Gum that support listed species such as the Regent Parrot, White-bellied Sea-eagle and Inland Carpet Python.

The values contained within Abbotsford Bend and Darling Junction make this area a priority for protection and enhancement through environmental water management. Of particular significance is the potential to encourage habitat for a range of waterbird species through improving diversity of aquatic macrophytes at Cowra Rocks. Equally significant are the River Red Gum, Black Box and Lignum communities and the Floodway Pond Herbland EVC at Darling Junction. These vegetation groups form the basis for the functioning ecological system and are the primary focus of this plan.

5.0 Ecological Condition and Threats

The Mallee River Health Strategy (MCMA 2006a) lists threats in this area including groundwater inflows, changed flow regime, pest plants and animals, loss of wetland connectivity, and degraded riparian vegetation. The *Mallee Waterway Strategy 2014-22* (MCMA 2014) includes changed water regime, altered wetland form, degraded water quality and invasive species as threats within the Merbein Waterway Management Unit.

5.1 Current Condition

The waterbodies in the target area have not been assessed using the Index of Wetland Condition (IWC) developed by DELWP. This is noted as a knowledge gap to be addressed. The general condition of each of three sites is described based on a brief site visit by the authors on 4 September 2015, which provides an overview of the key issues at each location.

5.1.1 Cowra Rocks

Cowra Rocks is permanently connected to the Murray River and the water level remains static under the influence of the Lock 10 weir pool. Movement of aquatic fauna is restricted; the narrow inlet channel is partially blocked by a track crossing of basic design (Figure 17). Restricting movement of fish populations may impede genetic diversity within Cowra Rocks (Faulks, Gilligan & Beheregaray 2011).

Figure 17. Track crossing at inlet to Cowra Rocks.

In places, there is a dominance of Cumbungi around the edge of the Cowra Rocks wetland (Figure 18). Areas of surrounding Lignum have suffered from past dry periods (Figure 19).

Figure 18. Cumbungi dominates the shoreline in places

Figure 19. The floodplain on the north west edge of Cowra Rocks comprises Lignum Swampy Woodland with an overstorey of *Acacia stenophylla.* Several stressed Lignum are visible in the foreground.

Water Quality

Water quality measurements were obtained during an aquatic census conducted in 2015. These are provided in Table 11 and compared to the ANZECC (2000) guidelines for lowland streams in south-eastern Australia (Biosis 2016).

Table 11. Water quality measurements obtained at Cowra Rocks, Dec 2015 (Biosis 2016)

Parameter	Measurement Recorded
Temperature	23.15 °C
pH	7.44
Electrical Conductivity	347 µS/cm
Dissolved Oxygen	64.6 %
Turbidity	240 NTU

Groundwater Interaction

Cowra Rocks is located within close proximity to an area of Abbotsford Bend that is impacted by groundwater discharge. The extent to which groundwater may impact Cowra Rocks is currently unknown. Further studies are required to determine whether draw down may increase water salinity, produce groundwater inflows, increase the risk of acid sulfate soils, or reduce water quality.

5.1.2 Darling Junction

The Red Gum communities at Darling Junction appear to be in good condition with many age classes present (Figure 20), though there has been some invasion of terrestrial species across the water course (Figure 21).

Figure 20. The Darling Junction Creek, looking west from the Lock 10 track crossing.

Figure 21. Photopoint CD01 image captured during rabbit monitoring (2015) on private land at the western end of Darling Junction.

5.2 Condition Trajectory

The condition of Cowra Rocks wetland is likely to remain static or decline without management of water levels and occasional inundation. Drying cycles at Cowra Rocks and flow events that inundate the entire Abbotsford Bend and Darling Junction target area occur less frequently under regulated flow conditions than they did under natural conditions. This has reduced the volume and frequency of flooding at the site. Proximity to Lock 10 and the influence of the weir pool has provided a static water level allowing Cumbungi to dominate the edges of the wetland.

Conversely, Lignum communities are severely degraded, particularly to the north of Cowra Rocks. Extensive dieback has occurred in some areas with little evidence of recruitment. It is possible terrestrial species such as shrubby chenopods may invade if natural inundation cycles are not resumed.

Movement of aquatic fauna at Cowra Rocks is restricted, reducing the wetland's potential to contribute to diversity within the Murray River and limiting genetic diversity within species. Movement of aquatic fauna through the Darling Junction Creeks during a natural inundation event is impeded by the Lock 10 Road crossing. This poses a risk of stranding native species as waters recede. Additionally, the crossing increases the flow required in a natural event to connect the creek east and west of the road and achieve flow through. Invasion of terrestrial species into the creek bed may impede future flows, increase deposition of silt and alter the course and/or pace of flow within the creek.

The static water level at Cowra Rocks and reduced flooding duration and frequency at both sites will continue to impact the ecology of the wetland and creeks through:

- reduced organic matter recruitment;
- reduced connectivity for movement of organic matter and fish;
- reduced suitable nesting and roosting sites for waterbird species who rely on flooded shrub land and forest;
- lower capacity to provide nesting sites for hollow-dependent birds and reptiles;
- reduced understorey quality as habitat and shelter for birds and reptiles; 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

Without alterations to flow frequency and extent, the health of the ecosystem of Abbotsford Bend is likely to suffer.

5.3 Water Related Threats

Threats to the water dependent values identified in this plan are the result of such factors as human intervention and climate variability. Some of the threats which may have an impact on Abbotsford Bend and Darling Junction include:

- Changed water regime and reduced flow capacity;
- Loss or reduction of wetland and creek connectivity;
- Loss of instream habitat;
- Water quality; and
- Introduction/increase of exotic aquatic and terrestrial flora and fauna (Mallee CMA 2014).

5.3.1 River Regulation

The regulation of the Murray River and man-made impediments to flow has seen the water regime at Abbotsford Bend and Darling Junction altered. Flow events of the magnitude required allowing flows into the creek and wetlands are less frequent and of shorter duration (see the section on Hydrology and System Operations). This combined with relatively dry conditions over the last decade affects the vigour of the vegetation and places trees and other vegetation under stress, affecting the productivity and functioning of the floodplain ecosystem, and limits the capacity of water rich in organic matter to be returned to the river.

Furthermore the near-static water level at Cowra Rocks is likely to have reduced diversity of aquatic macrophytes, limiting habitat, food, forage and breeding potential for native fish, frogs, turtles and waterbirds. This is also likely to limit primary production within the wetland, impacting on many species within the foodweb including bats, reptiles and predatory birds.

5.3.2 Introduced Species

Common Carp (*Cyprinus carpio)* was recorded at Cowra Rocks during a recent survey (Biosis 2016), and may be prevalent throughout Abbotsford Bend during flood events. 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).

Eastern Gambusia (*Gambusia holbrooki*) was recorded at Cowra Rocks (Biosis 2016) and is known to predate on the larvae of native frogs and native fish, including the vulnerable Murray-Darling Rainbowfish (*Melanotaenia fluviatilis*) (Lintermans 2007), which has also been recorded at this site (Biosis 2016).

The Red Fox (*Vulpes vulpes)*, is a significant threat as a predator to many species of ground-nesting bird, opportunistically taking eggs from nests and preying on broods. Reptiles including the Inland Carpet Python are preyed upon, and freshwater turtles (Thompson 1983) are threatened by nest predation. Although the fox is not a water related threat, it may have a substantial impact on water dependent ecological values 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 Abbotsford Bend is provided in Appendix 1.

5.3.3 Land Use and Land Management

From time to time at Cowra Rocks the surrounding area is used for sheep grazing, reducing potential for recruitment of some species of native vegetation by both trampling and grazing. Introduction of sheep also increases the likelihood and spread of invasive weed species.

The current agreement with the Mildura Ski Club limits the timing and extent of draw down and inundation phases; this is described in more detail in the section titled Constraints. It is not known how the presence of powered boats may impact waterbird and fish populations and breeding areas, however it may be contributing to the lower water quality than that of the neighbouring river channel through erosion and disturbance of the substrate (Biosis 2016).

6.0 Management Objective

6.1 Management Goal

To provide a flow regime to the target site that improves biodiversity and thus increases the capacity of the target area to support key flora and fauna values.

6.2 Ecological Objectives

Ecological objectives represent the desired ecological outcomes of the site based on the management goal above, as well as the key values outlined in the Water Dependent Values section. The ecological objectives are expressed as the target condition or functionality for each key value.

As with any healthy wetland ecosystem, ecological outcomes are interrelated. The objectives outlined in Table 12, if achieved, contribute to wetland productivity and improve the overall health of the system. Improving aquatic and terrestrial vegetation condition and diversity may provide access to additional feeding sites, breeding sites and habitat for key fauna species including deep diving ducks such as the listed Musk Duck, Blue-billed Duck and Hardhead that also utilise Cumbungi, sedges and Lignum for nesting. The listed Murray-Darling Rainbowfish, Murray River Turtle, White-bellied Sea-eagle, Inland Carpet Python, as well as other native fish, frogs and turtles are all likely to benefit from a more diverse habitat and an improved foodweb in the target area.

Table 12. Ecological objectives for the Abbotsford Bend target area

Ecological objective	Justification (value based)	Management Zone
Improve aquatic productivity	Regular exposure of part of the wetland bed will promote mineralisation of organic material which will support higher levels of the microbial and invertebrate productivity on which vertebrate fauna depend.	Cowra Rocks, Wetland Bed Zone
Promote diversity of aquatic macrophytes	The aquatic vegetation at Cowra Rocks is in good health, although of limited diversity. A healthy wetland supporting a diverse range of emergent flora species including sedges, rushes, herbs and forbs provides feeding, breeding, spawning, nursery and habitat sites for native frogs, fish, turtles and aquatic invertebrates. A diverse community can also provide feeding, foraging and nesting habitat for native birds, particularly, many waterbird guilds. Wetland productivity may be improved through deposition of organic matter from all vegetation life forms present, enhancing foodweb provision.	Cowra Rocks, Riparian Zone
Improve recruitment, diversity and productivity to meet EVC benchmarks for Lignum Swampy Woodland (823)	Lignum condition is severely degraded to the north of Cowra Rocks; recruitment is poor to non-existent. In a healthy state Lignum and associated understorey can provide valuable habitat and breeding opportunities for waterbirds that nest, feed or forage in Lignum. Healthy Lignum also provides cover and forage habitat for reptiles such as the Inland Carpet Python.	Cowra Rocks, Woodland Zone
Improve fish passage between Murray River and wetland	Improving connectivity offers additional breeding, spawning and feeding sites for aquatic fauna. Cowra Rocks offers a range of aquatic habitats including reed beds, wooded areas and deep water suitable for many native aquatic species.	Cowra Rocks, Inlet Channel
Improve fish passage and flow-through during flood events	Enhancing flow-through during a natural flood event may provide waterbirds and native aquatic fauna, particularly turtles and frogs with additional forage area, and offers free movement for aquatic fauna through the Creek.	Darling Junction

Attainment of the ecological objectives is anticipated to have wider benefits for the target area and is expected to result in:

- Improving understorey productivity;
- Improving wetland productivity;
- Improving nesting opportunities in flooded trees lining the wetland and creek;
- Enhancing flow through at Darling Junction during a natural flood event; and
- Improving floodplain productivity.

As more is learnt about the area and the response to the water management 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.

Through management of water levels at Cowra Rocks, key habitat niches will potentially be maintained or improved. The recruitment of key flora species may assist over the longer term in the provision of suitable habitat for the many important waterbird species, particularly dabbling and diving ducks.

6.3 Hydrological Objectives

Hydrological objectives describe the components of the water regime required to achieve the ecological objectives at this site. The ecological objectives at this site are centred on improving the vegetation health and structure where possible (Table 12). The hydrological requirements to achieve these objectives are presented in Table 13 and are based on the assumption that maintenance of current health requires less frequent watering with longer intervals between events than for improving condition.

The following hydrological objectives address the underlying ecological objectives for each site:

- Wetting and drying cycles within wetlands facilitates both deposition and decomposition of organic matter, recycling dead matter back into the food web and supporting microbial and macroinvertebrate productivity. This in turn supports macroinvertebrate productivity and ultimately vertebrate fauna (Young 2001). Annual or biennial drying of part of the wetland bed following natural seasonality is encouraged.
- Several species of emergent macrophytes occur within Cowra Rocks. Submerged and semi-emergent species may also occur, or may germinate under the right conditions. Flood requirements vary depending on species, however annual inundation may encourage germination, vegetative growth and/or reproduction (Rogers & Ralph 2011). Durations of six to twelve months are required to sustain vigorous growth. Following natural seasonality is encouraged.
- Lignum is a dominant species in the Lignum Swampy Woodland EVC mapped to the north of Cowra Rocks. It can tolerate a wide range of wet and dry conditions. 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 these plants do not accommodate nesting by birds. Durations of three to seven months is required to sustain vigorous canopy, but continuous flooding is detrimental. Although timing of flooding is not crucial for Lignum, following natural seasonality is encouraged to provide for understorey and wetland plants (Roberts & Marston 2011).
- Floodway Pond Herbland and Grassy Riverine Forest/Floodway Pond Herbland EVCs are found along the Darling Junction Creeks. Flood requirements vary depending on species, however annual inundation may encourage germination, vegetative growth and/or reproduction (Rogers & Ralph 2011). It is suggested the natural duration may vary between one and eight months (DSE 2012) and a variance in ponding duration is encouraged.

These water requirements have been used as a guide to develop the hydrological objectives for the Abbotsford Bend and Darling Junction target areas. As little information exists as to the flood requirements of the various fauna species important to the target area, hydrological objectives have not been set for fauna species. Additionally, current site constraints (see section 8.1) limit the timing, duration and frequency able to be applied. Thus the following objectives present a ‘best case’ scenario and implementation would require consultation with the Ski Club as primary users. The regime indicated in brackets reflects what may be currently practicable to all parties.

Table 13 Hydrological objectives for Cowra Rocks

Ecological objective (Draw down)	Water management area	Hydrological Objectives								
		Mean frequency of events (Number per 10 years)			Tolerable interval between events (years)		Duration Drying Phase (months)			Preferred timing of draw down
		Min	Opt	Max	Min	Max	Min	Opt	Max	
Improve aquatic productivity (draw down phase)	Part of Wetland bed	8 (2)	10	10	0 (5)	1	2	4	12	Late summer (Winter)
Ecological objective (Water delivery)	**Water management area**	**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**	
Promote diversity of emergent macrophytes in the riparian zone	Riparian Zone (refill to FSL)	8 (2)	10	10	0	5 (0)	2	9 (2)	12 (2)	Winter/Spring
Improve recruitment, diversity and productivity of Lignum Swampy Woodland EVC (823)	Woodland, floodplain	1	5 (2)	6 (2)	1 (5)	10 (5)	2	4 (2)	12 (4)	Spring/early Summer (Winter/Spring)

Note: Figures in brackets represent the likely frequency, timing and duration that would not impact significantly on Ski Club operations.

6.3.1 Water Management Regime

The wetland water management regime has been derived from the ecological and hydrological objectives. Two separate phases have been provided:

- A partial drying phase; and
- An inundation phase

To allow for adaptive and integrated management, the water management regime is framed using the seasonally adaptive approach. This means that a regime is identified for optimal conditions, however flexibility is encouraged in accordance with the minimum, maximum and optimal hydrological objectives in Table 13. The minimum objectives are likely to be provided in drought or dry years, the optimum objectives in average conditions and the maximum objectives in wet or flood years.

The optimal watering regime for each stage is described in the following pages. The extent of the target area inundated is presented in Figure 23. 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.

Option 1: Partial Drying Phase: expose part of Wetland Bed

A Partial Drying Phase would see the water level in Cowra Rocks reduced by approximately 1 m by pumping. Additional track raising or a temporary levee at low break out points may allow for the water to be pumped onto the floodplain to inundate the Lignum Swampy Woodland.

Timing, frequency and duration of pumping of water from the wetland is limited by Ski Club use of the wetland. Delivery to the northern floodplain would be more ecologically beneficial for Lignum during spring and summer (Roberts & Marston 2011), however this provides an opportunity to take advantage of the water rather than return it to the river. Additionally, draw down in summer would more closely reflect a natural regime, and is likely to require less pumping.

To pump to the northern floodplain, an area would need to be identified using lidar, EVC mapping and a detailed ground survey of levels. Consultation with Ski Club representatives would be required prior to implementing a draw down within Cowra Rocks.

It is estimated that between 300 and 500 ML of water would need to be pumped from Cowra Rocks to implement a 1 metre draw down. Further studies are required to refine these figures and identify the approximate drying zone.

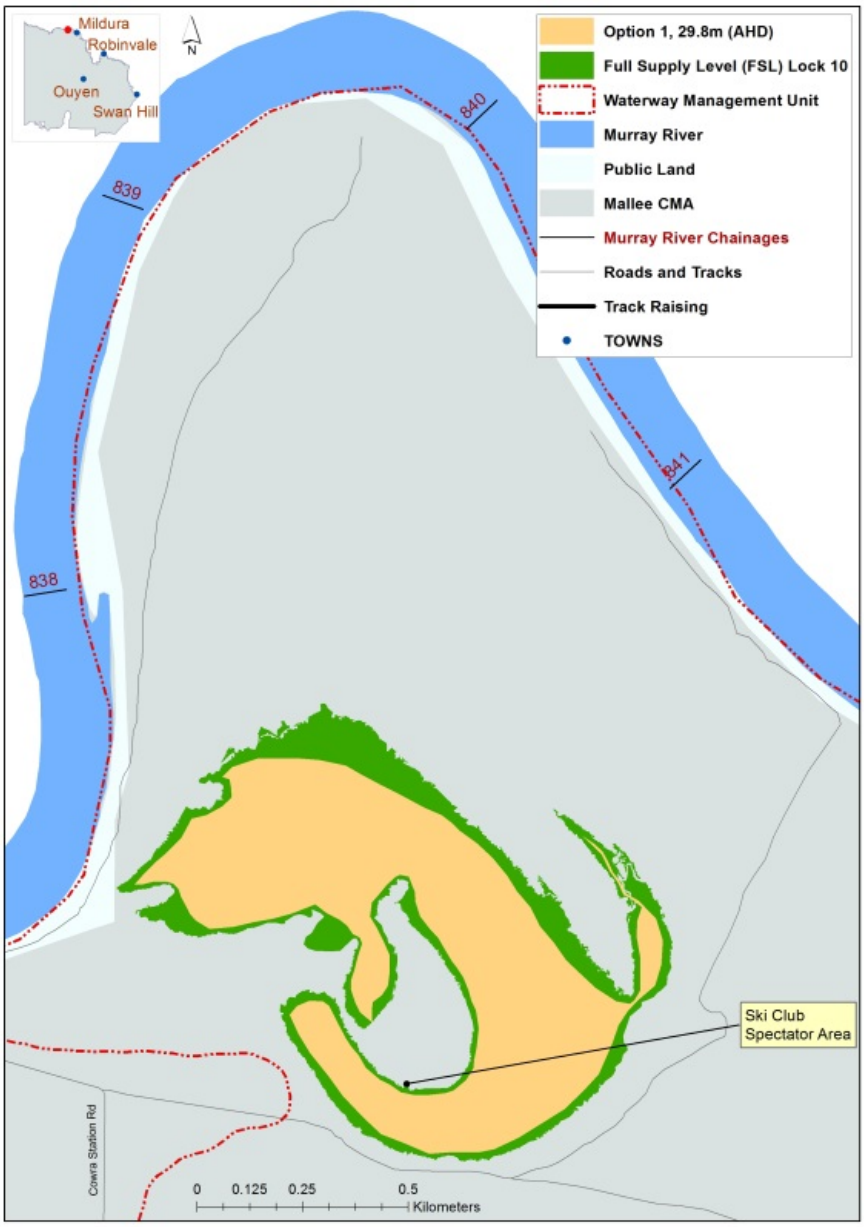

Figure 22. Target area at Cowra Rocks, Option 1: Drying Phase (estimated area)

Regime	Dry Down area, duration and frequency
Optimal	Reduce the water level at Cowra Rocks commencing in late Autumn by pumping. Reduce the water level in Cowra Rocks to approximately 29.8 m AHD twice in ten years with an interval of five years between events. Maintain the water level at 29.8 m AHD for up to three months, then allow to recharge slowly in late winter via the regulator to 30.8 m AHD to increase the diversity and extent of aquatic macrophytes fringing the wetland.

More frequent fluctuations in water level would promote greater macrophyte diversity, although Ski Club operations may be impacted if drawdown was to occur more often. Consideration should be given to setting a regime in consultation with the ski club that more closely reflects natural conditions, to achieve stronger ecological outcomes. Additionally, pumping to the northern floodplain could be implemented to improve the health of Lignum communities, allowing natural recession.

Option 2: Inundate Wetland Riparian Zone & Lignum Swampy Woodland

The Inundation Phase (Figure 23) involves the inundation of approximately 32 ha in addition to the existing wetland of 66 ha. This would require approximately 550 ML of environmental water. Water can be delivered to Cowra Rocks by pumping from the Murray River close to the proposed regulator site. In addition to the proposed regulator, track raising is required to retain water on the floodplain and efficiently inundate the target area (Figure 23). Infrastructure is described in more detail in section 8.0.

Water Regime	Inundation area, duration and frequency
Optimal	Inundate the area surrounding Cowra Rocks by pumping over the regulator structure to a height of 31.5 m AHD three years in ten with a maximum interval of seven years between events. Maintain water on the floodplain for at least four months to promote Lignum growth and recruitment and improve aquatic macrophyte diversity and extent before allowing natural recession through the Cowra Rocks regulator.

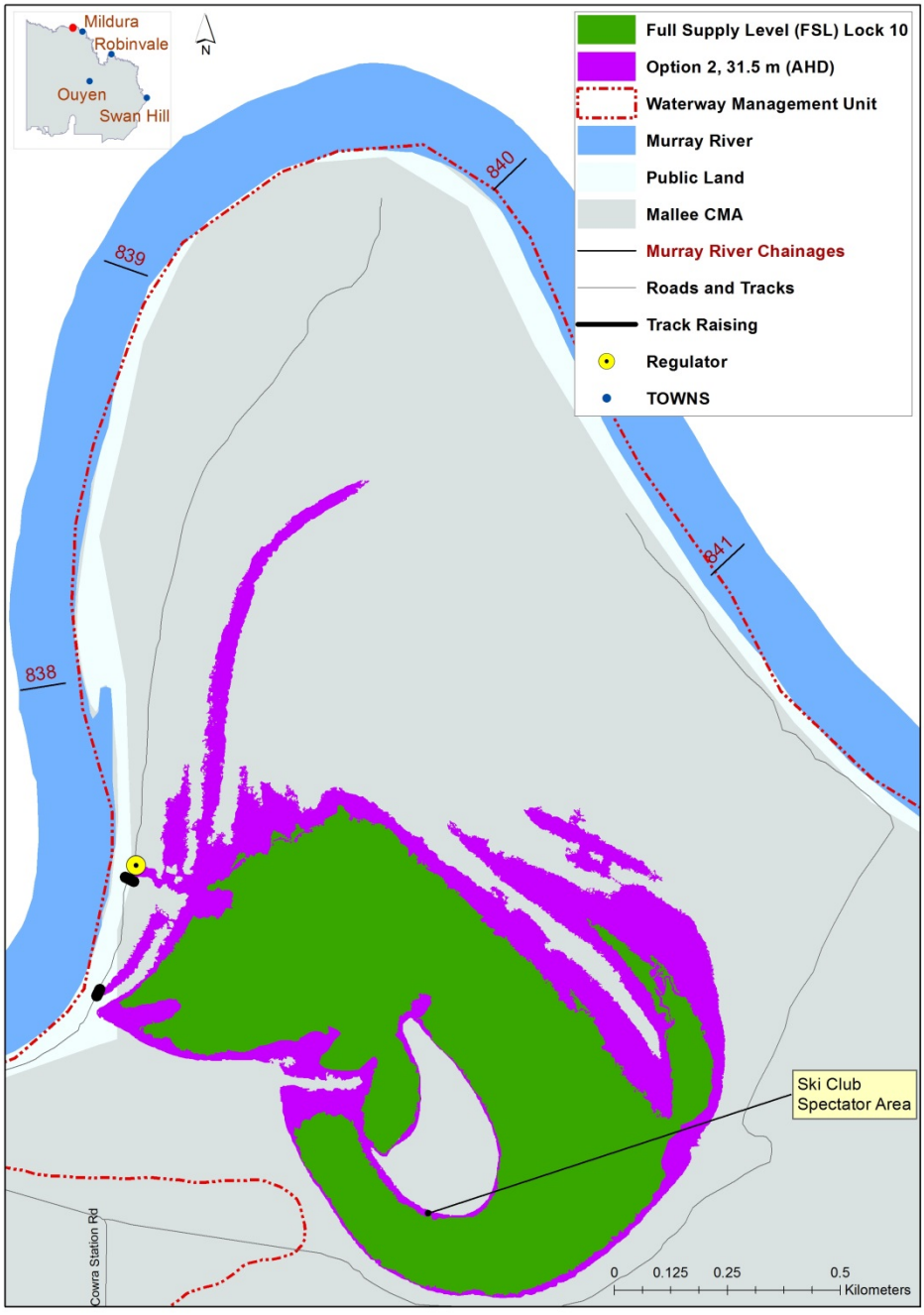

Figure 23. Target area at Cowra Rocks, Option 2: Inundation Phase

Option 3: Wetting & Drying Phases

A combination of Options 1 and 2 would see the water level drawn down by pumping from Cowra Rocks and, after a period of drying, recharging, and then delivering environmental water to Cowra Rocks to inundate the surrounding area. This option includes the inundation of the same area as Option 2: approximately 32 ha in addition to the existing wetland of 62 ha. This would require approximately 550 ML of environmental water. This would see the water level within Cowra Rocks varied by up to 1.7 metres.

As stated in Option 1, site use constraints limit the timing and duration of water management actions, consideration should be given to setting a regime in consultation with the ski club that more closely reflects natural conditions, to achieve stronger ecological outcomes.

Regime	Dry Down area, duration and frequency
Optimal: Drying	Reduce the water level at Cowra Rocks commencing in late Autumn by pumping. Reduce the water level in Cowra Rocks to approximately 29.8 m AHD. Maintain the water level at 29.8 m AHD for up to three months, then allow to recharge slowly in late winter via the regulator to 30.8 m AHD to increase the diversity and extent of aquatic macrophytes fringing the wetland.
Optimal: Inundation	Inundate the area surrounding Cowra Rocks by pumping over the regulator structure to a height of 31.5 m AHD. Maintain water on the floodplain for at least four months to promote Lignum growth and recruitment and improve aquatic macrophyte diversity and extent before allowing natural recession through the Cowra Rocks regulator.
	Implement this combined regime once in ten years.

More frequent fluctuations in water level would promote greater macrophyte diversity, although Ski Club operations may be impacted if drawdown was to occur more often. Consideration should be given to setting a regime in consultation with the ski club that more closely reflects natural conditions, to achieve stronger ecological outcomes. Additionally, pumping to the northern floodplain could be implemented to improve the health of Lignum communities, allowing natural recession.

7.0 Managing Risks to Achieve Objectives

Delivery Plans will be developed for all wetland sites allocated environmental water. A broad risk assessment has been undertaken for the system to identify any major risks which would require mitigation measures; these are outlined in Table 15. The Risk Rating matrix in Table 14 has been used to rate the risks in Table 15. Prior to delivering environmental water in any given season, these risks will be further refined as part of the Seasonal Watering Proposal and Environmental Water Delivery Plan process. These documents will provide a greater level of risk analysis and mitigation measures according to conditions observed closer to the proposed delivery (i.e. operational risks). The documents will also include detailed consideration of the impact of proposed mitigation measures on the likelihood and consequence of the risk occurring (residual risk) as this may change according to catchment conditions closer to the proposed delivery. They will clearly outline roles and responsibilities regarding risk management.

Table 14. Risk Rating

		Consequence				
Likelihood		Negligible 1	Minor 2	Moderate 3	Major 4	Extreme 5
	Almost Certain 5	Medium 5	Medium 10	High 15	High 20	High 25
	Likely 4	Low 4	Medium 8	Medium 12	High 16	High 20
	Possible 3	Low 3	Medium 6	Medium 9	Medium 12	High 15
	Unlikely 2	Low 2	Low 4	Medium 6	Medium 8	Medium 10
	Rare 1	Low 1	Low 2	Low 3	Low 4	Medium 5

Table 15: Environmental Water Delivery Risk Assessment

Risk Category	Risk #	Risk Type	Without Mitigation			Mitigation	Residual Risk		
			Likelihood	Consequence	Rating		Likelihood	Consequence	Rating
Volume	1.0	Current recommendations on environmental flow inaccurate	Possible	Moderate	Medium	• Base decisions on existing records and best available knowledge	Rare	Moderate	Low
Time	2.0	Draw down takes longer than estimated due to larger volume of water	Possible	Minor	Medium	• Bathymetry to inform pumping volumes • Consider reduced draw down volume, or timing	Rare	Moderate	
Cost	3.0	Cost of management exceeds available funding, particularly, due to poor estimate of volumes to be pumped	Unlikely	Moderate	Low	• CMA to manage pumping and regularly monitor volumes and costs	Rare	Moderate	Low
Human	4.0	Environmental water management causes personal injury to river user	Unlikely	Major	High	• Ensure land manager/land holder and site users are informed of delivery actions, particularly the Ski Club • Erect signage where suitable • Consider cordoning off shallower section(s) of the wetland (e.g. to the north)	Rare	Moderate	Low
Environment	5.0	Pumping water to floodplain causes blackwater, low DO, mobilisation of saline water	Possible	Minor	Medium	• Observe the quality of the water before pumping is implemented • Monitor floodplain vegetation response & soil conditions			

Risk Category	Risk #	Risk Type	Without Mitigation			Mitigation	Residual Risk		
			Likelihood	Consequence	Rating		Likelihood	Consequence	Rating
Environmental	5.1	Releases cause soil quality issues (e.g. acid-sulphate soils, increased soil salinity, etc.)	Possible	Minor	Medium	• Undertake soil monitoring • Observe the quality of the water throughout the watering season and manage accordingly	Rare	Moderate	Low
	5.2	Increase in *Typha* spp. dominance due to delivery of environmental water to the floodplain	Possible	Moderate	Medium	• Monitor change in extent of *Typha* spp. and consider alteration to timing, duration or frequency of delivery	Rare	Moderate	Low
	5.2	Improved conditions for non-native fish (e.g. Common Carp, Eastern Gambusia)	Possible	Moderate	Medium	• Consider eradication or control activities to reduce pest fish population levels • Regular aquatic surveys	Rare	Moderate	Low
	5.3	Water fluctation causes erosion/bank instability	Possible	Moderate	Medium	• Monitor bank status at high risk locations • Consider limiting boating activities during events	Rare	Moderate	Low
	5.4	Water management promotes weed spread	Possible	Moderate	Medium	• Liaise with land managers to control invasive weeds in vicinity of creek • Monitor weed emergence after event	Rare	Moderate	Low
	5.5	Delivery promotes pest animal activity (pigs, foxes, rabbits)	Possible	Moderate	Medium	• Monitor pest animal activity • Liaise with landholders/land manager to control pest animal infestations	Rare	Moderate	Low

Risk Category	Risk #	Risk Type	Without Mitigation			Mitigation	Residual Risk		
			Likelihood	Consequence	Rating		Likelihood	Consequence	Rating
	5.6	Red Gum saplings populate Darling Junction Creeks, choking watercourse and creating blockages to flow & aquatic fauna	Possible	Moderate	Medium	• Monitor germination after natural flood event • Consider and research delivery and retention of environmental water to inhibit Red Gum growth	Unlikely	Low	Low
Compliance	6.0	Environmental water account is overdrawn	Possible	Major	Medium	• Ensure timing of refill is consistent with normal river operations and allowable surcharge. • Ensure volume pumped from Cowra Rocks will not exceed any environmental water allocated for refill/inundation cycles • Ensure delivery contractor is aware of deliver volumes and adheres to delivery plan	Rare	Major	Medium
	6.1	Environmental releases causes flooding of access tracks	Possible	Minor	Medium	• Construct track crossings above proposed maximum level of environmental watering • Provide temporary signage where applicable • Consult with Ski Club to minimise impacts	Rare	Moderate	Low
Reputation	7.0	Unable to provide evidence in meeting ecological objective	Possible	Major	Medium	• Need to communicate ecological objectives • Ensure monitoring activities are undertaken • Establish monitoring framework	Rare	Moderate	Low
	7.1	Key stakeholders not supportive of environmental water release	Possible	Minor	Medium	• Continue to engage with stakeholders and undertake communications	Rare	Moderate	Low

8.0 Environmental Water Management Infrastructure

8.1 Constraints

8.1.1 Cowra Rocks

The existing use of the wetland by the Mildura Ski Club relies on a relatively consistent water level within the wetland which is achieved through permanent connection to the Lock 10 weir pool. This limits the extent to which water levels can be varied above or below the pool level of 30.8 m AHD and prevents the option of introducing a complete drying phase into the proposed watering regime without significantly impacting on the use of the wetland by the Ski Club.

Raising water levels is limited by the height of the access track to spectator facilities on the area referred to in this plan as the 'island' in the centre of the wetland. Inundation of the wetland beyond approximately 31 m AHD is likely to overtop the track and prevent spectators from accessing facilities on the 'island'. It may be possible to consult with the Ski Club in regard to restricting access to the spectator area. If restricting access, consideration should be given to the timing of inundation so as to avoid the tournament season (December-March).

A partial dry down of the wetland is limited by safety concerns for skiers. A partial dry down event is likely to be restricted to the off-season (winter), however this would require the cooperation of the Ski Club as the wetland is still used by club members for training purposes during the local off-season.

The height of the existing access track which runs along the western side of the wetland and crosses over the wetland inlet limits the extent of the area that can be inundated by environmental watering. Inundating areas of Lignum Swampy Woodland to the north of the wetland to the targeted level of 31.5 m AHD will require lower sections of this track and the inlet crossing to be raised. This will prevent water from breaking out at low points and flowing back to the Murray River, while also allowing the landholder to maintain property access. The current design of structure at the inlet crossing also limits the ability to manage the wetland's connection to the river and enable the wetland to be isolated form the river during environmental watering events.

8.1.2 Darling Junction

Wetlands within the upstream section of Darling Junction (wetlands 7229 847242 and 7229 854235) are directly connected to the Lock 10 weir pool. A watercourse, known as Darling Junction Creeks, which extends from Darling Junction Wetland (7229 847242) and runs in a westerly direction until it connects with the Murray River less than 1 km downstream of Lock 10, is isolated from the influence of the Lock 10 weir pool by block banks. Opportunities to undertake works to introduce environmental water to the main anabranch channel were identified in previous reports (Ecological Associates 2007 and Alluvium 2007). This proposed work involves removing a block bank and installing a regulating structure to enable flow from Darling Junction Wetland into the watercourse. The head difference from upstream to downstream of Lock 10 would result in the creation of approximately 2 km of relatively shallow flowing habitat along the waterway that would bypass Lock 10. This option has a number of constraints:

- the risk of scouring and incision along the watercourse and at the outlet to the Murray River due to the velocity flowing water;
- the road crossing to Lock 10 which crosses the watercourse approximately 840 m along its path and blocks flow; and
- a number of other smaller blockages along the path of the watercourse.

Works identified in Alluvium (2007) to manage these constraints included:

- installation of box culverts on the road crossing to Lock 10;
- construction of erosion protection works at the confluence of the watercourse and the Murray River; and
- potential works to modify other blockages that may be present along the waterway.

Further investigations and hydraulic analysis would be required to confirm the full extent of works required for erosion protection and blockage removal. Uncertainty regarding constraints at the site may limit options for the introduction of environmental water at this stage.

The constraints outlined above do not affect the proposal to install box culverts on the road crossing to Lock 10 to allow flow through of the main anabranch channel during a natural flood event. Proceeding with these works without the introduction of environmental water would still provide benefits by removing a major impediment to flow along the waterway during natural high flow events.

8.2 Infrastructure and Complementary Works Recommendations

8.2.1 Cowra Rocks

Recommended works for Cowra Rocks involve the construction of a regulator structure and road crossing at the inlet to the wetland, and track raising at low points on the existing track leading up to the inlet crossing from the south (Figure 24). Additional track raising for a distance of approximately 300 m may be required to provide Ski Club access to the 'island' during inundation events.

Installing a regulator at the inlet will enable the connection to the Murray River to be closed while environmental water is pumped past the regulator and into the wetland. This, along with the proposed track raising, will enable environmental water to be retained within the wetland so that the wetland can be inundated to the targeted level of 31.5 m AHD. Water levels can be maintained for the targeted duration, then the regulator opened to allow water to exit the wetland and the water level to return to 30.8 m AHD (normal Lock 10 weir pool height). The proposed works will also ensure that the landholder and authorised visitors maintain property access during environmental watering events. At other times the regulator can remain open to maintain connection with the Murray River and provide fish passage. The installation of the regulator will also allow for a partial drying of the wetland, subject to consultation with the landholder and the Mildura Ski Club.

A concept design for a regulator structure and track crossing at the wetland inlet has been prepared (Alluvium 2007), however the track crossing on this design is built to a height of at 31.0 m AHD, which is 0.5 m below the targeted inundation height. A new regulator structure and track crossing would need to allow for adequate freeboard above 31.5 m AHD.

Furthermore, if water was to be pumped from Cowra Rocks to the northern floodplain to inundate Lignum Swampy Woodland, minor earthworks are likely to be needed to prevent flow to the river and back into the wetland.

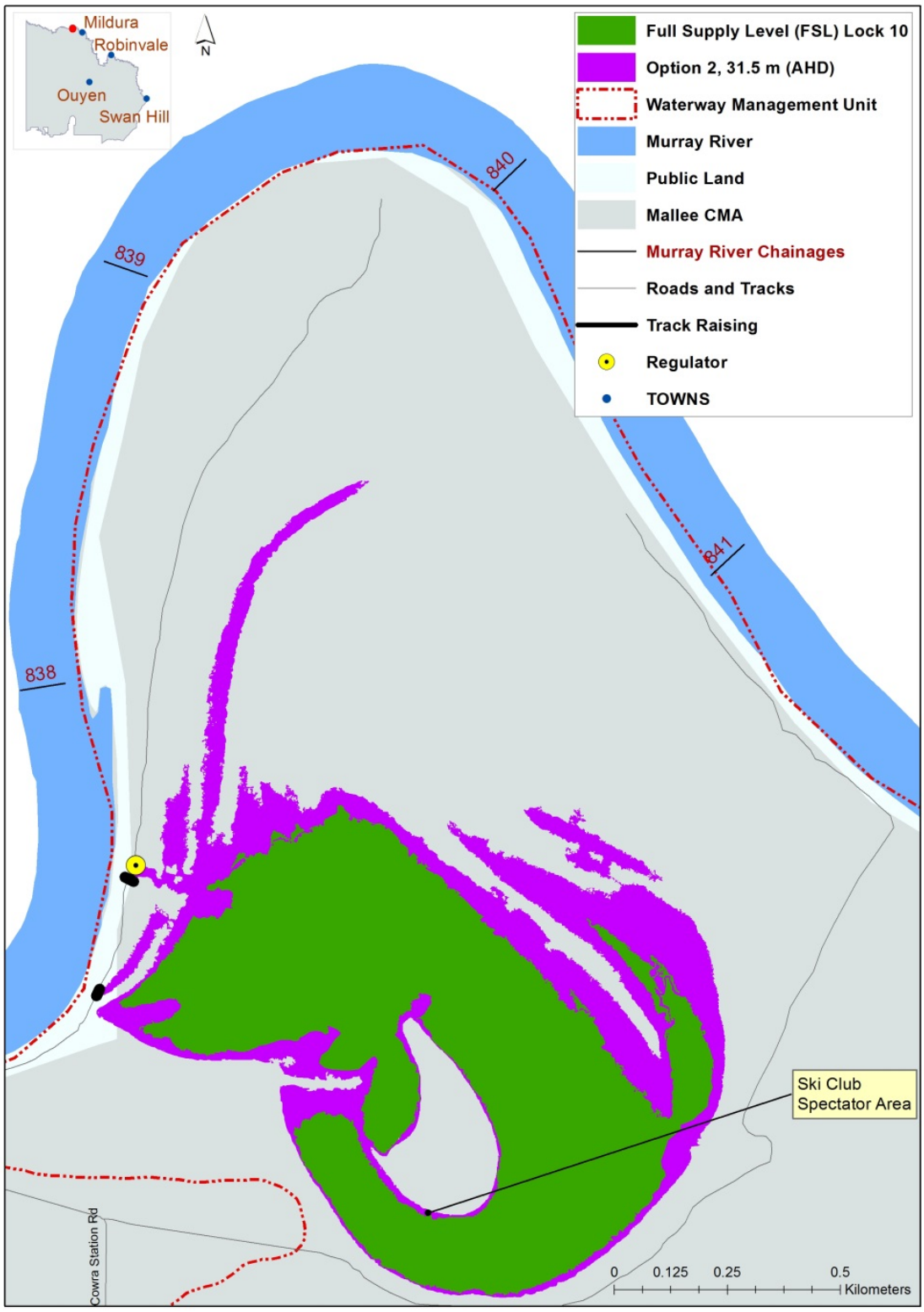

Figure 24. Anticipated inundation extent (98 ha total) at Cowra Rocks Wetland, Option 2, with proposed infrastructure in place.

8.2.2 Darling Junction

Recommended works for Darling Junction include the installation of box culverts on the main anabranch of Darling Junction Creeks (Figure 25), replacing the causeway on Lock 10 Road. These works would remove a major impediment to the flow of water along the waterway, allowing free flow past the Lock 10 Road during a natural flood event. A concept design for a three culvert structure at the road crossing has been prepared (Alluvium 2007). The proposed works also allow for future environmental watering at the site, which is not proposed at this time due to the constraints described in the preceding section, the high cost of works, and the relatively small environmental benefit. Consideration of delivery of environmental water would require further investigation and cost-benefit analysis into the full scope of works that will be required to facilitate environmental flows along the watercourse.

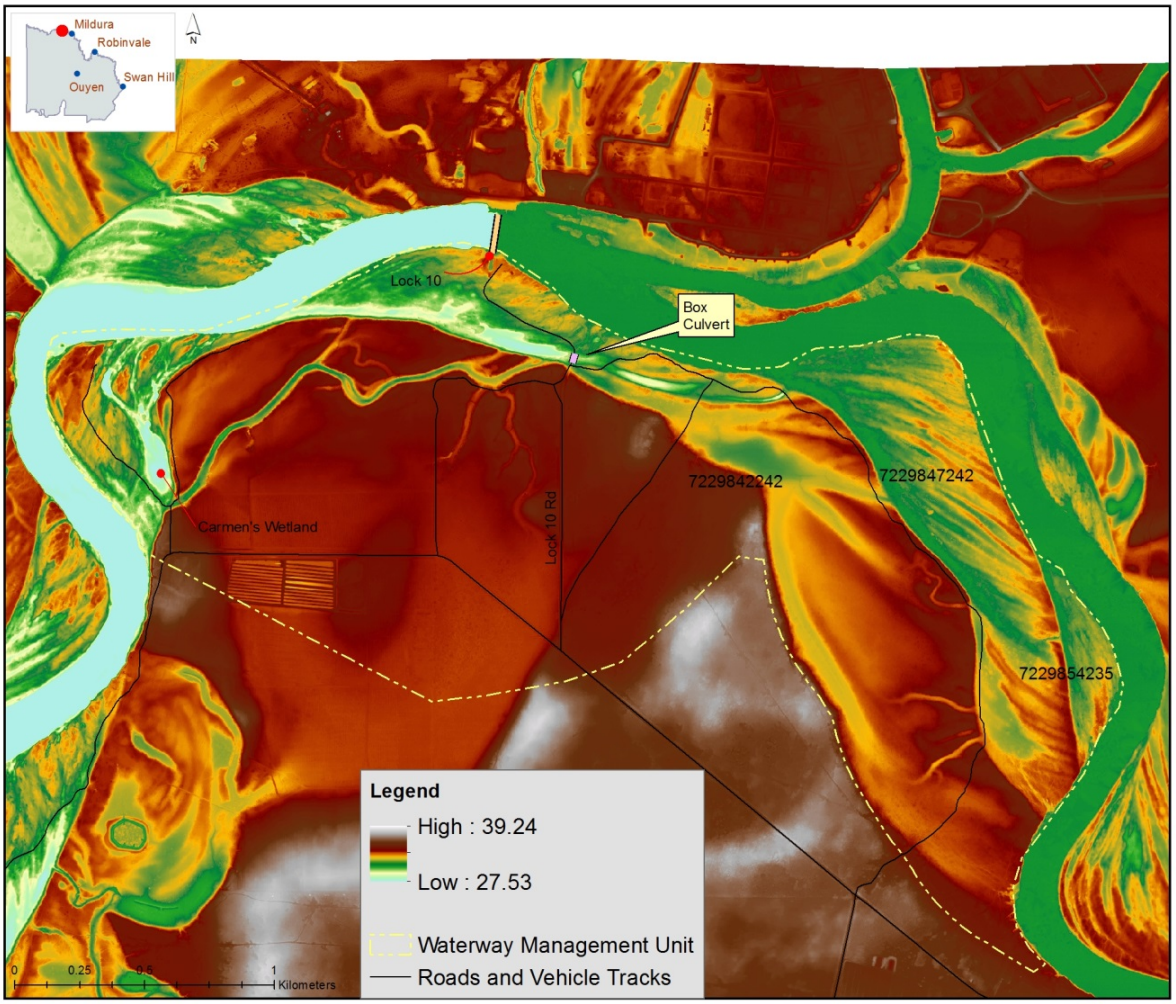

Figure 25. Location of proposed box culvert structure on Darling Junction Creeks.

9.0 Demonstrating Outcomes

9.1 Monitoring Priorities at the Site

Monitoring of the impact of water management events is proposed as outlined in Table 16. The monitoring events should include baseline and event-based monitoring.

Table 16. Proposed Monitoring for Cowra Rocks and Darling Junction Creeks

Target Area	Objective	Hypotheses	Indicator(s)	Frequency
Cowra Rocks	**Understand water quality over the long term**	The water in Cowra Rocks appears to have a high turbidity, higher salinity than that of the river channel, and lower dissolved oxygen. However it is assumed that water pumped from the wetland in a draw-down phase is of suitable quality to return to the river or be absorbed into the floodplain without impact	Water quality measurements Soil monitoring	Baseline & event-based Baseline & event-based
Cowra Rocks	**Improve recruitment, diversity & productivity for Lignum Swampy Woodland**	Delivery of environmental water as per plan will improve vegetation structure and condition	Photopoints IWC assessments	Every 2 years Every 5 years
Cowra Rocks	**Improve habitat value for waterbirds**	Delivery of environmental water as per plan will improve aquatic and terrestrial vegetation structure and condition offering improved habitat condition and diversity for waterbird guilds	Bird Survey	Every 5 years
Cowra Rocks	**Improve fish passage between Murray River and wetland**	Construction of a regulator on the inlet channel will allow fish passage during normal operations	Aquatic fauna surveys	Every 5 years
Cowra Rocks	**Promote diversity of submerged, semi-emergent and emergent macrophytes**	Variation in water level will improve diversity of aquatic flora	Macrophyte survey	Every 3 years
Darling Junction	**Maintain vegetation structure of the fringing River Red Gum communities**	Improving connectivity in moderate (natural) flood events will increase the inundation area delivering floodwater to fringing vegetation communities	Photopoints ISC assessments	Every 5 years Every 5 years

Photo point monitoring will be conducted before and after water management events at Cowra Rocks to measure the success of environmental watering and wetting and drying phases in improving wetland and riparian vegetation communities. Photopoints should also be established at Darling Junction to determine baseline condition.

Event based monitoring may be used to measure water quality, and to gauge the viability of discharging water to the Murray River from Cowra Rocks.

Other incidental observations that may occur in the course of the monitoring methods above, such as visitation by waterbirds and other species to the wetlands during and after watering events, may be utilised.

Detailed monitoring of water management at Cowra Rocks would be dependent on funding from the State or Commonwealth governments.

10.0 Consultation

This Plan was developed in collaboration with key stakeholders namely Parks Victoria, the landholder, the Department of Environment, Land, Water and Planning (DELWP), the Mildura Ski Club and local interest groups. Several meetings were held during the development phase to seek input and gather information from experts and stakeholders as well as meetings with DELWP and other CMAs involved in the development of the guidelines for the plans. Table 17 outlines consultation undertaken in the development of this plan.

Table 17. Consultation Process for development of the Abbotsford Bend and Darling Junction WMU sub-unit Environmental Water Management Plan

Meeting date	Stakeholders	Details
2015 & May 2016	Local landholder	Consultation and initial discussion to introduce concept of plan. Determine current usage, access requirements, views on delivery of environmental water, risk of private property inundation, current management of wetland on private land (7229 870223). Presentation of plan.
May 2016	Parks Victoria	Presentation of plan.
June 2016	First peoples of the Millewa-Mallee Aboriginal Corporation.	Presentation of plan.
June 2016	Friends of Merbein Common	Presentation of plan.
June 2016	Yelta Landcare	Presentation of plan
May 2016	Mallee CMA – Land and Water Advisory Committee	Presentation of plan.
June 2016	Department of Environment Land Water and Planning	Presentation of plan
Oct 2015 & June 2016	Mildura District Ski Club	Initial discussion to introduce concept of plan Consultation on capacity and timing of drawdown events Preparation for environmental watering/draw down event. Presentation of plan.

11.0 Knowledge Gaps and Recommendations

This plan is based on 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. Some areas where further knowledge would be beneficial are outlined in Table 18.

Table 18. Knowledge gaps and recommendations for the target area

Knowledge and data gaps	Action recommended	Priority level	Responsibility
Wetland bathymetry not known for Cowra Rocks, draw down volumes required, extent of wetland bed exposure	Conduct bathymetric survey, including the inlet channel	1	Implementation of any of these recommendations would be dependent on investment from Victorian and Australian Government funding sources as projects managed through the Mallee CMA
Break out points not identified for floodplain north of Cowra Rocks	Detailed land height survey to identify areas where water can be retained on the floodplain under Options 1 and 3.	2	
Accurate CTF values and understanding of floodplain hydrology in the target area	Incorporate local knowledge, and determine floodplain hydrology. Update records accordingly.	3	
Selection of best infrastructure to provide vehicle access across the Cowra Rocks inlet channel	Seek design options and costings for levee and regulator (Figure 23) to enable vehicle access as well as water management and fish passage	4	
Feasibility of Infrastructure and complementary works	Undertake feasibility assessment and costing of the additional works identified by Mallee CMA which would benefit environmental watering and/or connectivity in the target area.	5	
Index of Wetland Condition/ Index of Stream Condition Assessments	IWC/ISC assessments undertaken to establish baseline condition and as the basis for ongoing monitoring of improvement over time	6	
Carmens Wetland not mapped in State database	List Carmens Wetland in the State wetland database	7	
Stakeholder Agreements	Prior to the infrastructure upgrades proposed in this EWMP it is recommended that agreements with stakeholders and landholders be developed. These agreements should include details of the roles in management of the infrastructure, financial responsibilities for the infrastructure etc.	8	
Landholder Management Agreements	Landholder agreements should be signed outlining the proposed watering regimes and any inundation of private land.	9	
Operating rules for structures	Development of operating rules for structures and each wetland within the target area.	10	

Knowledge and data gaps	Action recommended	Priority level	Responsibility
Suitability of wetland 7229921211 as a Murray Hardyhead nursery site	Undertake feasibility assessment of wetland to determine whether water quality and other parameters are suitable for a breeding population of Murray Hardyhead.	11	Implementation of any of these recommendations would be dependent on investment from Victorian and Australian Government funding sources as projects managed through the Mallee CMA
Understanding of inundation cycles post regulation	Conduct Spells Analysis for Downstream of Mildura and Wentworth Weirs to understand Darling River flow impacts and system losses and irrigation demand below Euston Weir	12	

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APPENDIX 1: FLORA AND FAUNA SPECIES LIST

Flora – Native

Scientific Name	Common Name	Victorian Advisory List	Records
Abutilon otocarpum	Desert Lantern	Vulnerable	1
Acacia ligulata	Small Cooba		1
Acacia loderi	Nealie	Vulnerable	1
Acacia melvillei	Yarran	Vulnerable	1
Acacia oswaldii	Umbrella Wattle	Vulnerable	4
Acacia stenophylla	Eumong		2
Acacia victoriae subsp. *victoriae*	Bramble Wattle	Rare	2
Actinobole uliginosum	Flannel Cudweed		1
Amaranthus grandiflorus	Large-flower Amaranth	Vulnerable	1
Amyema linophylla subsp. *orientale*	Buloke Mistletoe	Vulnerable	1
Amyema miquelii	Box Mistletoe		1
Amyema miraculosa subsp. *boormanii*	Fleshy Mistletoe		1
Atriplex eardleyae	Small Saltbush		1
Atriplex leptocarpa	Slender-fruit Saltbush		3
Atriplex lindleyi	Flat-top Saltbush		4
Atriplex lindleyi subsp. *conduplicata*	Baldoo	Rare	1
Atriplex lindleyi subsp. *inflata*	Corky Saltbush		9
Atriplex nummularia	Old-man Saltbush		2
Atriplex nummularia subsp. *omissa*	Dwarf Old-man Saltbush	Rare	1
Atriplex pseudocampanulata	Mealy Saltbush	Rare	1
Atriplex pumilio	Mat Saltbush		2
Atriplex rhagodioides	Silver Saltbush	Vulnerable	3
Atriplex spp.	Saltbush		2
Atriplex vesicaria	Bladder Saltbush		7
Atriplex vesicaria subsp. *minor*	Bladder Saltbush	Poorly known	2
Atriplex vesicaria subsp. *variabilis*	Bladder Saltbush		1
Austrostipa elegantissima	Feather Spear-grass		3
Austrostipa nitida	Balcarra Spear-Grass		1
Austrostipa scabra subsp. *falcata*	Rough Spear-grass		2
Austrostipa scabra/nitida/nodosa spp. agg.	Variable Spear-grass		1
Bolboschoenus medianus	Marsh Club-sedge		1
Brachyscome ciliaris	Variable Daisy		1
Brachyscome lineariloba	Hard-head Daisy		5
Brachyscome spp.	Daisy		1
Bromus spp.	Brome		1
Bulbine semibarbata	Leek Lily		3

Scientific Name	Common Name	Victorian Advisory List	Records
Calandrinia eremaea	Small Purslane		1
Calandrinia volubilis	Twining Purslane	Rare	1
Callitris gracilis	Slender Cypress-pine		1
Calocephalus sonderi	Pale Beauty-heads		1
Calostemma luteum	Yellow Garland-lily	Vulnerable	1
Calotis cuneifolia	Blue Burr-daisy	Rare	1
Calotis hispidula	Hairy Burr-daisy		5
Calotis spp.	Burr Daisy		1
Casuarina pauper	Belah		2
Centipeda cunninghamii	Common Sneezeweed		1
Chenopodioideae spp.	Chenopod		1
Chenopodium curvispicatum	Cottony Saltbush		1
Chenopodium nitrariaceum	Nitre Goosefoot		3
Chenopodium spp.	Goosefoot		1
Crassula colorata	Dense Crassula		3
Crassula sieberiana s.l.	Sieber Crassula		1
Crassula spp.	Crassula		1
Cressa australis	Rosinweed		1
Cynoglossum australe	Australian Hound's-tongue		1
Daucus glochidiatus	Australian Carrot		1
Disphyma crassifolium subsp. *clavellatum*	Rounded Noon-flower		13
Dissocarpus biflorus var. *biflorus*	Twin-flower Saltbush	Rare	4
Dissocarpus paradoxus	Hard-head Saltbush		6
Dodonaea viscosa subsp. *angustifolia*	Giant Hop-bush	Rare	1
Dodonaea viscosa subsp. *angustissima*	Slender Hop-bush		4
Duma florulenta	Tangled Lignum		4
Duma horrida subsp. horrida	Spiny Lignum	Rare	1
Einadia nutans	Nodding Saltbush		5
Enchylaena tomentosa var. *tomentosa*	Ruby Saltbush		12
Enchylaena tomentosa var. *tomentosa* (shrubby form)	Ruby Saltbush (shrubby inland form)		1
Enneapogon avenaceus	Common Bottle-washers		1
Enteropogon acicularis	Spider Grass		2
Eragrostis australasica	Cane Grass	Vulnerable	1
Eragrostis dielsii	Mallee Love-grass		2
Eremophila polyclada	Twiggy Emu-bush	Vulnerable	5
Erodium crinitum	Blue Heron's-bill		1

Scientific Name	Common Name	Victorian Advisory List	Records
Eucalyptus camaldulensis	River Red-gum		1
Eucalyptus dumosa	Dumosa Mallee		1
Eucalyptus largiflorens	Black Box		8
Euphorbia drummondii spp. agg.	Flat Spurge		1
Exocarpos aphyllus	Leafless Ballart		3
Goodenia fascicularis	Silky Goodenia		1
Goodenia pinnatifida	Cut-leaf Goodenia		3
Goodenia pusilliflora	Small-flower Goodenia		1
Harmsiodoxa blennodioides	May Smocks		1
Hyalosperma semisterile	Orange Sunray		1
Hydrilla verticillata	Hydrilla	Rare	1
Isoetopsis graminifolia	Grass Cushion		3
Lawrencia squamata	Thorny Lawrencia		1
Leiocarpa panaetioides	Woolly Buttons		1
Leiocarpa websteri	Stalked Plover-daisy		1
Liliaceae spp. *(sensu lato)*	Lily		1
Lycium australe	Australian Box-thorn		2
Lysiana exocarpi	Harlequin Mistletoe		1
Maireana aphylla	Leafless Bluebush	Poorly known	1
Maireana appressa	Grey Bluebush		5
Maireana brevifolia	Short-leaf Bluebush		7
Maireana pentagona	Hairy Bluebush		1
Maireana pyramidata	Sago Bush		10
Maireana sedifolia	Pearl Bluebush	Rare	2
Maireana spp.	Bluebush		1
Maireana turbinata	Satiny Bluebush		2
Malacocera tricornis	Goat Head	Rare	2
Marsilea costulifera	Narrow-leaf Nardoo		1
Marsilea drummondii	Common Nardoo		2
Melaleuca lanceolata	Moonah		3
Minuria cunninghamii	Bush Minuria	Rare	4
Myoporum parvifolium	Creeping Myoporum		1
Myoporum platycarpum	Sugarwood		2
Myosurus australis	Mousetail		1
Myriocephalus rhizocephalus	Woolly-heads		2
Myriophyllum verrucosum	Red Water-milfoil		1
Nicotiana spp.	Tobacco		1
Nicotiana velutina	Velvet Tobacco		1
Nitraria billardierei	Nitre-bush		11

Scientific Name	Common Name	Victorian Advisory List	Records
Olearia pimeleoides	Pimelea Daisy-bush		1
Osteocarpum acropterum var. *deminutum*	Babbagia		7
Osteocarpum salsuginosum	Bonefruit		1
Phyllanthus lacunellus	Sandhill Spurge	Rare	1
Pimelea microcephala subsp. *microcephala*	Mallee Rice-flower		2
Pimelea spp.	Rice Flower		1
Pittosporum angustifolium	Weeping Pittosporum		1
Plagiobothrys elachanthus	Hairy Forget-me-not		2
Plantago cunninghamii	Clay Plantain		3
Pogonolepis muelleriana	Stiff Cup-flower		3
Polycalymma stuartii	Poached-eggs Daisy		2
Ptilotus nobilis subsp. *nobilis*	Pink Mulla-mulla		4
Ptilotus spathulatus	Pussy Tails		1
Ranunculus pentandrus var. *platycarpus*	Inland Buttercup		1
Ranunculus spp.	Buttercup		1
Rhagodia spinescens	Hedge Saltbush		12
Rhodanthe corymbiflora	Paper Sunray		3
Rhodanthe pygmaea	Pygmy Sunray		2
Rhodanthe stuartiana	Clay Sunray		1
Rumex brownii	Slender Dock		2
Rytidosperma caespitosum	Common Wallaby-grass		3
Rytidosperma spp.	Wallaby Grass		1
Salsola tragus	Prickly Saltwort		5
Salsola tragus subsp. *tragus*	Prickly Saltwort		1
Sarcozona praecox	Sarcozona	Rare	5
Sclerochlamys brachyptera	Short-wing Saltbush		6
Sclerolaena decurrens	Green Copperburr	Vulnerable	1
Sclerolaena diacantha	Grey Copperburr		4
Sclerolaena muricata	Black Roly-poly		1
Sclerolaena obliquicuspis	Limestone Copperburr		3
Sclerolaena tricuspis	Streaked Copperburr		7
Senecio glossanthus s.l.	Slender Groundsel		6
Senecio glossanthus s.s.	Slender Groundsel		2
Senna form taxon 'coriacea'	Broad-leaf Desert Cassia		1
Senna form taxon 'petiolaris'	Woody Cassia		1
Sida ammophila	Sand Sida	Vulnerable	1

Scientific Name	Common Name	Victorian Advisory List	Records
Sida intricata	Twiggy Sida	Vulnerable	1
Sida trichopoda	Narrow-leaf Sida		1
Solanum opacum	Green-berry Nightshade		2
Swainsona reticulata	Kneed Swainson-pea	Vulnerable	2
Tecticornia pergranulata	Blackseed Glasswort		7
Tecticornia pruinosa	Bluish Glasswort		5
Tecticornia tenuis	Slender Glasswort		2
Tecticornia triandra	Desert Glasswort	Rare	5
Tetragonia eremaea s.l.	Desert Spinach		3
Tetragonia tetragonioides	New Zealand Spinach		1
Triptilodiscus pygmaeus	Common Sunray		1
Vittadinia dissecta s.l.	Dissected New Holland Daisy		1
Vittadinia dissecta var. *hirta*	Dissected New Holland Daisy		1
Vittadinia pterochaeta	Winged New Holland Daisy	Vulnerable	1
Wahlenbergia gracilenta s.l.	Annual Bluebell		1
Zygophyllum apiculatum	Pointed Twin-leaf		1
Zygophyllum aurantiacum subsp. *aurantiacum*	Shrubby Twin-leaf		1
Zygophyllum glaucum	Pale Twin-leaf		1
Zygophyllum spp.	Twin-leaf		1

Flora – Exotic

Scientific Name	Common Name
Alhagi maurorum	Camel Thorn
Asphodelus fistulosus	Onion Weed
Avena spp.	Oat
Brassica tournefortii	Mediterranean Turnip
Bromus rubens	Red Brome
Carduus tenuiflorus	Winged Slender-thistle
Carrichtera annua	Ward's Weed
Carthamus lanatus	Saffron Thistle
Centaurea melitensis	Malta Thistle
Centaurea spp.	Knapweed
Cirsium vulgare	Spear Thistle
Citrullus lanatus	Camel Melon
Conyza bonariensis	Flaxleaf Fleabane
Cotula bipinnata	Ferny Cotula
Hordeum glaucum	Northern Barley-grass
Hypochaeris glabra	Smooth Cat's-ear

Scientific Name	Common Name
Juncus acutus subsp. *acutus*	Spiny Rush
Lactuca serriola	Prickly Lettuce
Lamarckia aurea	Golden-top
Lepidium didymum	Lesser Swine-cress
Lepidium draba	Hoary Cress
Limonium lobatum	Winged Sea-lavender
Lycium ferocissimum	African Box-thorn
Marrubium vulgare	Horehound
Medicago minima	Little Medic
Mesembryanthemum nodiflorum	Small Ice-plant
Nicotiana glauca	Tree Tobacco
Opuntia spp.	Prickly pear
Polycarpon tetraphyllum	Four-leaved Allseed
Psilocaulon granulicaule	Wiry Noon-flower
Reichardia tingitana	False Sow-thistle
Schismus barbatus	Arabian Grass
Sisymbrium erysimoides	Smooth Mustard
Solanum nigrum s.l.	Black Nightshade
Solanum nigrum s.s.	Black Nightshade
Sonchus oleraceus	Common Sow-thistle
Spergularia diandra	Lesser Sand-spurrey
Spergularia rubra s.l.	Red Sand-spurrey
Urtica urens	Small Nettle
Vulpia bromoides	Squirrel-tail Fescue

Fauna – Native

Scientific Name	Common Name	Victorian Advisory List
Acanthagenys rufogularis	Spiny-cheeked Honeyeater	
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	
Acanthiza nana	Yellow Thornbill	
Acanthiza uropygialis	Chestnut-rumped Thornbill	
Accipiter fasciatus	Brown Goshawk	
Acrocephalus australis	Australian Reed-Warbler	
Acrocephalus stentoreus	Clamorous Reed Warbler	
Actitis hypoleucos	Common Sandpiper	Vulnerable
Alcedo azurea	Azure Kingfisher	Near threatened
Anas gracilis	Grey Teal	
Anas rhynchotis	Australasian Shoveler	Vulnerable
Anas superciliosa	Pacific Black Duck	
Anhinga novaehollandiae	Darter	
Anthochaera carunculata	Red Wattlebird	
Anthus novaeseelandiae	Australasian Pipit	

Scientific Name	Common Name	Victorian Advisory List
Aphelocephala leucopsis	Southern Whiteface	
Aquila audax	Wedge-tailed Eagle	
Ardea ibis	Cattle Egret	
Ardea modesta	Eastern Great Egret	Vulnerable
Ardea pacifica	White-necked Heron	
Artamus cinereus	Black-faced Woodswallow	
Artamus cyanopterus	Dusky Woodswallow	
Artamus leucorynchus	White-breasted Woodswallow	
Artamus personatus	Masked Woodswallow	
Artamus superciliosus	White-browed Woodswallow	
Aythya australis	Hardhead	Vulnerable
Barnardius zonarius barnardi	Mallee Ringneck	
Barnardius zonarius zonarius	Australian Ringneck	
Biziura lobata	Musk Duck	Vulnerable
Burhinus grallarius	Bush Stone-curlew	Endangered
Cacatua sanguinea	Little Corella	
Calidris canutus	Red Knot	Endangered
Carduelis carduelis	European Goldfinch	
Certhionyx variegatus	Pied Honeyeater	
Charadrius ruficapillus	Red-capped Plover	
Chenonetta jubata	Australian Wood Duck	
Cheramoeca leucosternus	White-backed Swallow	
Chroicocephalus novaehollandiae	Silver Gull	
Cincloramphus mathewsi	Rufous Songlark	
Circus approximans	Swamp Harrier	
Circus assimilis	Spotted Harrier	Near threatened
Climacteris picumnus victoriae	Brown Treecreeper (south-eastern ssp.)	Near threatened
Colluricincla harmonica	Grey Shrike-thrush	
Coracina novaehollandiae	Black-faced Cuckoo-shrike	
Corcorax melanorhamphos	White-winged Chough	
Corvus coronoides	Australian Raven	
Corvus mellori	Little Raven	
Cracticus nigrogularis	Pied Butcherbird	
Cracticus torquatus	Grey Butcherbird	
Cryptoblepharus pannosus	Ragged Snake-eyed Skink	
Cygnus atratus	Black Swan	
Dacelo novaeguineae	Laughing Kookaburra	

Scientific Name	Common Name	Victorian Advisory List
Dicaeum hirundinaceum	Mistletoebird	
Diplodactylus damaeus	Beaded Gecko	
Diplodactylus tessellatus	Tessellated Gecko	
Dromaius novaehollandiae	Emu	Near threatened
Egretta garzetta nigripes	Little Egret	Endangered
Egretta novaehollandiae	White-faced Heron	
Elseyornis melanops	Black-fronted Dotterel	
Emydura macquarii	Murray River Turtle	Vulnerable
Entomyzon cyanotis	Blue-faced Honeyeater	
Eolophus roseicapilla	Galah	
Epthianura albifrons	White-fronted Chat	
Epthianura aurifrons	Orange Chat	
Epthianura tricolor	Crimson Chat	
Erythrogonys cinctus	Red-kneed Dotterel	
Falco cenchroides	Nankeen Kestrel	
Falco peregrinus	Peregrine Falcon	
Falcunculus frontatus	Crested Shrike-tit	
Fulica atra	Eurasian Coot	
Gallinago hardwickii	Latham's Snipe	Near threatened
Gallinula tenebrosa	Dusky Moorhen	
Gallinula ventralis	Black-tailed Native-hen	
Gehyra variegata	Tree Dtella	
Geopelia striata	Peaceful Dove	
Grallina cyanoleuca	Magpie-lark	
Gymnorhina tibicen	Australian Magpie	
Haliaeetus leucogaster	White-bellied Sea-Eagle	Vulnerable
Haliastur sphenurus	Whistling Kite	
Heteronotia binoei	Bynoe's Gecko	
Hieraaetus morphnoides	Little Eagle	
Himantopus himantopus	Black-winged Stilt	
Hirundo neoxena	Welcome Swallow	
Hydroprogne caspia	Caspian Tern	Near threatened
Hydromys chrysogaster	Water-rat	
***Hypseleotris* spp.**	Carp Gudgeon	
Lichenostomus cratitius	Purple-gaped Honeyeater	Vulnerable
Lichenostomus ornatus	Yellow-plumed Honeyeater	
Lichenostomus penicillatus	White-plumed Honeyeater	

Scientific Name	Common Name	Victorian Advisory List
Lichenostomus virescens	Singing Honeyeater	
Litoria peronii	Peron's Tree Frog	
Lophocroa leadbeateri	Major Mitchell's Cockatoo	Vulnerable
Malacorhynchus membranaceus	Pink-eared Duck	
Malurus cyaneus	Superb Fairy-wren	
Malurus lamberti	Variegated Fairy-wren	
Malurus leucopterus	White-winged Fairy-wren	
Malurus splendens	Splendid Fairy-wren	
Manorina flavigula	Yellow-throated Miner	
Manorina melanocephala	Noisy Miner	
Melanotaenia fluviatilis	Murray-Darling Rainbowfish	
Megalurus gramineus	Little Grassbird	
Merops ornatus	Rainbow Bee-eater	
Microcarbo melanoleucos	Little Pied Cormorant	
Milvus migrans	Black Kite	
Morelia spilota metcalfei	Carpet Python	Endangered
Myiagra inquieta	Restless Flycatcher	
Nematalosa erebi	Bony Bream	
Neophema chrysostoma	Blue-winged Parrot	
Ninox novaeseelandiae	Southern Boobook	
Northiella haematogaster	Blue Bonnet	
Nymphicus hollandicus	Cockatiel	
Ocyphaps lophotes	Crested Pigeon	
Oxyura australis	Blue-billed Duck	Endangered
Pachycephala rufiventris	Rufous Whistler	
Pardalotus striatus	Striated Pardalote	
Pelecanus conspicillatus	Australian Pelican	
Petrochelidon neoxena	Welcome Swallow	
Petrochelidon nigricans	Tree Martin	
Petroica goodenovii	Red-capped Robin	
Phalacrocorax carbo	Great Cormorant	
Phalacrocorax sulcirostris	Little Black Cormorant	
Phalacrocorax varius	Pied Cormorant	Near threatened
Phaps chalcoptera	Common Bronzewing	
Philemon citreogularis	Little Friarbird	
Philypnodon grandiceps	Flat-headed Gudgeon	
Platalea flavipes	Yellow-billed Spoonbill	
Platalea regia	Royal Spoonbill	Near threatened

Scientific Name	Common Name	Victorian Advisory List
Platycercus elegans	Crimson Rosella	
Platycercus elegans flaveolus	Yellow Rosella	
Plectorhyncha lanceolata	Striped Honeyeater	
Pluvialis squatarola	Grey Plover	Endangered
Podargus strigoides	Tawny Frogmouth	
Polytelis anthopeplus monarchoides	Regent Parrot	Vulnerable
Pomatostomus ruficeps	Chestnut-crowned Babbler	
Pomatostomus superciliosus	White-browed Babbler	
Porphyrio porphyrio	Purple Swamphen	
Porzana pusilla palustris	Baillon's Crake	Vulnerable
Porzana tabuensis	Spotless Crake	
Psephotus haematonotus	Red-rumped Parrot	
Psephotus varius	Mulga Parrot	
Pygopus schraderi	Hooded Scaly-foot	Critically endangered
Recurvirostra novaehollandiae	Red-necked Avocet	
Retropinna semoni	Australian Smelt	
Rhipidura albiscarpa	Grey Fantail	
Rhipidura leucophrys	Willie Wagtail	
Rhynchoedura ornata	Beaked Gecko	Critically endangered
Smicrornis brevirostris	Weebill	
Sminthopsis crassicaudata	Fat-tailed Dunnart	Near threatened
Struthidea cinerea	Apostlebird	
Suta suta	Curl Snake	
Tachybaptus novaehollandiae	Australasian Grebe	
Tadorna tadornoides	Australian Shelduck	
Taeniopygia guttata	Zebra Finch	
Threskiornis molucca	Australian White Ibis	
Threskiornis spinicollis	Straw-necked Ibis	
Tiliqua rugosa	Stumpy-tailed Lizard	
Todiramphus sanctus	Sacred Kingfisher	
Underwoodisaurus milii	Thick-tailed Barking Gecko	
Vanellus miles	Masked Lapwing	
Vanellus tricolor	Banded Lapwing	

Fauna – Exotic

Scientific Name	Common Name
Columba livia	Rock Dove
Cyprinus carpio	Common Carp
Gambusia holbrooki	Eastern Gambusia
Oryctolagus cuniculus	European Rabbit
Passer domesticus	House Sparrow
Sturnus vulgaris	Common Starling
Turdus merula	Common Blackbird
Vulpes vulpes	Red Fox

APPENDIX 2: ECOLOGICAL VEGETATION CLASSES

Description of each EVC in the Abbotsford Bend and Darling Junction WMU sub-units

EVC no.	EVC name	Bioregional Conservation Status	Description
		Murray Scroll Belt	
97	Semi-arid Woodland	Vulnerable	Non-eucalypt woodland or open forest to 12 m tall, of low rainfall areas. Occurs in a range of somewhat elevated positions not subject to flooding or inundation. The surface soils are typically light textured loamy sands or sandy loams.
98	Semi-arid Chenopod Woodland	Depleted (Terrestrial BCS)	Sparse, low non-eucalypt woodland to 12 m tall of the arid zone with a tall open chenopod shrub-dominated understorey to a treeless, tall chenopod shrubland to 3 m tall. This EVC may occur as either a woodland (typically with a very open structure but tree cover >10%) or a shrubland (tree cover <10%) with trees as an occasional emergent.
103	Riverine Chenopod Woodland	Depleted	Eucalypt woodland to 15 m tall with a diverse shrubby and grassy understorey occurring on most elevated riverine terraces. Confined to heavy clay soils on higher level terraces within or on the margins of riverine floodplains (or former floodplains), naturally subject to only extremely infrequent incidental shallow flooding from major events if at all flooded.
104	Lignum Swamp	Vulnerable	Typically treeless shrubland to 4 m tall, with robust (but sometimes patchy) growth of lignum. Widespread wetland vegetation type in low rainfall areas on heavy soils, subject to infrequent inundation resulting from overbank flows from rivers or local runoff.
106	Grassy Riverine Forest	Depleted	Occurs on the floodplain of major rivers, in a slightly elevated position where floods are infrequent, on deposited silts and sands, forming fertile alluvial soils. River Red Gum forest to 25 m tall with a groundlayer dominated by graminoids. Occasional tall shrubs present.
107	Lake Bed Herbland	Vulnerable	Herbland or shurbland to 0.5 m tall dominated by species adapted to drying mud within lake beds. Some evade periods of prolonged inundation as seed, others as dormant tuber-like rootstocks. 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'.
158	Chenopod Mallee	Vulnerable	Open to very open mallee woodland to 12 m tall (almost invariably dominated by Eucalyptus gracilis) supported by thin Woorinen deposits typically overlying gypsiferous and sodic clays. Characterised by the dominance of saltbushes and semi-succulent understorey shrubs.
200	Shallow Freshwater Marsh	Vulnerable	Shallow Freshwater Marsh occupies open sheets of water which are usually perennial although contract in size during the drier months. 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. Shallow Freshwater Marsh also occurs on deep brown anaerobic) silts where creeks and rivers broaden and flow slows as the water enters floodplains.

EVC no.	EVC name	Bioregional Conservation Status	Description
		Murray Scroll Belt	
295	Riverine Grassy Woodland	Depleted (Terrestrial BCS)	Occurs on the floodplain of major rivers, in a slightly elevated position where floods are rare, on deposited silts and sands, forming fertile alluvial soils. River Red Gum woodland to 20 m tall with a groundlayer dominated by graminoids and sometimes lightly shrubby or with chenopod shrubs.
808	Lignum Shrubland	Depleted	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.
809	Floodplain Grassy Wetland	Endangered	Wetland dominated by floating aquatic grasses (which persist to some extent as turf during drier periods), occurring in the most flood-prone riverine areas. Typically treeless, but sometimes with thickets of saplings or scattered more mature specimens of River Red Gum *Eucalyptus camaldulensis.* Restricted, Murray River floodplain, primarily within Barmah Forest
810	Floodway Pond Herbland	Depleted	Low herbland to < 0.3 m tall with occasional emergent life forms, usually with a high content of ephemeral species. Floors of ponds associated with floodway systems. Typically heavy deeply cracking clay soils. Characteristically smaller wetlands with a more regular flooding and drying cycle in comparison to sites supporting Lake Bed Herbland.
811	Grassy Riverine Forest/Floodway Pond Herbland Complex	Depleted	EVC complex
813	Intermittent Swampy Woodland	Depleted	Eucalypt (- Acacia) woodland with (variously shrubby) rhizomatous sedgy - turf grass understorey, at best development dominated by flood-stimulated species in association with flora tolerant of inundation. The floristics are variable and often appear modified as a consequence of disturbance. Riverine floodplains of north-west and lake verges of Wimmera and southern Mallee.
816	Sedgy Riverine Forest	Depleted	Eucalypt forest (to woodland) with understorey dominated by larger sedges (to sedgy-herbaceous or sedgy-grassy), floristics with some affinities to Red Gum Swamp. Floodplains of less arid Riverina and Wimmera (absent from further north-west).

EVC no.	EVC name	Bioregional Conservation Status	Description
		Murray Scroll Belt	
818	Shrubby Riverine Woodland	Least Concern (Terrestrial BCS)	Eucalypt woodland to open forest to 15 m tall of less flood-prone (riverine) watercourse fringes, principally on levees and higher sections of point-bar deposits. The understorey includes a range of species shared with drier floodplain habitats with a sparse shrub component, ground-layer patchily dominated by various life-forms. A range of large dicot herbs (mostly herbaceous perennial, several with a growth-form approaching that of small shrub) are often conspicuous. Dominant tree species; *Eucalyptus largiflorens Eucalyptus camaldulensis*
819	Spike-sedge Wetland	Vulnerable	Low sedgy vegetation of seasonal or intermittent wetlands, dominated by spike-sedges and usually species-poor. Typically treeless, but sparse eucalypts (mostly E. camaldulensis) can be present in marginal sites. Scattered in drier lowlands, including western volcanics, Riverina floodplains and Wimmera.
820	Sub-saline Depression Shrubland	Vulnerable	A low open shrubland/herbland dominated by chenopods and succulents and occurring on the highest terraces of the former (i.e. pre 1750) Murray River floodplain in far north-west Victoria. It occupies semi-saline treeless pans in low-lying areas within Riverine Chenopod Woodland on very heavy and mildly saline clay soils.
821	Tall Marsh	Depleted	Wetland dominated by tall emergent graminoids, typically in thick species-poor swards. Rushland, sedgeland or reedbed - locally closed or in association or fine-scale mosaic with Aquatic Herbland (e.g. along floodway lagoons). At optimum development, the vegetation is treeless, but sparse Eucalyptus camaldulensis (or in higher rainfall areas, E. ovata) are dispersed through some sites where sufficient dry periods occur to allow their survival. Scattered across lowland Victoria.
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.

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.

1 Management of Aboriginal Cultural Heritage found during the Activity

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

- The person who discovers Aboriginal cultural heritage during the activity will immediately notify the person in charge of the activity;
- The person in charge of the activity must then suspend any relevant works at the location of the discovery and within 5m of the relevant place extent;
- In order to prevent any further disturbance, the location will be isolated by safety webbing or an equivalent barrier and works may recommence outside the area of exclusion;
- The person in charge of the activity must contact the and the **Mallee CMA**

Indigenous Facilitator

- Within a period not exceeding 1 working days a decision/ recommendation will be made by the **Mallee CMA Indigenous Facilitator** and the

Aboriginal stakeholder ;

- as to the process to be followed to manage the Aboriginal cultural heritage in a culturally appropriate manner, and how to proceed with the works;

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

2 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**