Cardross and Koorlong Lakes
Waterway Management Unit
Environmental Water Management Plan

Mallee Catchment Management Authority

mallee
catchment management authority

State Government Victoria
Department of Environment and Primary Industries

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For further information on any of the information contained within this document contact:

Louise Searle

Coordinator Waterways

Mallee Catchment Management Authority

EXECUTIVE SUMMARY

Environmental water management plans have been developed for key sites in the Mallee region by the Mallee Catchment Management Authority in partnership with the Victorian Department of Environment and Primary Industries. These plans are based on Waterway Management Units (WMUs) and have been developed to guide future environmental water events at these sites.

The Cardross and Koorlong Lakes WMU's are situated 15 km's south-west of Mildura. This plan focuses on a target area within the WMU's for environmental watering events with an inundation extent of 93 ha.

Environmental values for the Cardross and Koorlong Lakes WMU's include a diverse range of water dependent flora and fauna species including some listed under state, national and international treaties, conventions, Acts and initiatives such as the Murray hardyhead. The area also contains a number of depleted and vulnerable water dependent ecological vegetation classes and wetlands. The target area has significant social values for the local community and the local indigenous community has connections to the area. The values which are central to the management of the site are the Murray hardyhead population and the Ruppia aquatic macrophyte community which provide essential habitat for Hardyhead.

Cardross and Koorlong Waterway Management Units management goals:

To provide a water regime to maintain and improve Murray hardyhead populations and the Ruppia aquatic habitat which supports them.

To achieve these objectives, a long-term watering regime has been developed. In order to achieve the management goals to maintain and improve Murray hardyhead populations and preserve Ruppia at these sites a rigid water regime is proposed which will potentially require annual watering.

Minimum watering regime

Provide environmental water to the target areas each year from August to October to above the minimum recommended level. Allow the water level to decrease slowly over summer, ensuring it does not fall below the identified minimum level.

Optimal watering regime

Provide environmental water to the target areas each year from August to October to the recommended optimal level to inundate fringing vegetation. Allow the water level to decrease slowly over summer to (but not below) the recommended minimum water level.

TABLE OF CONTENTS

FIGURES

TABLES

ACKNOWLEDGEMENTS

The Mallee Catchment Management Authority acknowledges the Victorian State Government for funding the development of the environmental watering plans. They also acknowledge the contribution to the development of the plans by Parks Victoria, Jane Roberts, Terry Hillman, other agencies and community members.

ABBREVIATIONS AND ACRONYMS

CAMBA	China-Australia Migratory Bird Agreement
CMAs	Catchment Management Authorities
DEH	Department of Environment and Heritage
DEPI	Department of Environment and Primary Industries
EVC	Ecological Vegetation Class
EWaMP	Environmental Water Management Plan
EWH	Environmental Water Holder
FSL	Full Supply Level
G-MW	Goulburn-Murray Water
JAMBA	Japan-Australia Migratory Bird Agreement
MDBA	Murray-Darling Basin Authority (formally Murray-Darling Basin Commission, MDBC)
MDFRC	Murray-Darling Freshwater Research Centre
Ramsar	Global treaty adopted in the Iranian city of Ramsar in 1971 that focuses on the conservation of internationally important wetlands
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement
RRG	River Red Gum
TLM	The Living Murray Initiative
TSL	Targeted Supply Level
VEWH	Victorian Environmental Water Holder
VWMS	Victorian Waterway Management Strategy

1. INTRODUCTION

1.1. Background

Environmental water management in Victoria is entering a new phase as ongoing water recovery sees significant volumes of water being returned to the environment. The increasing environmental water availability is providing new opportunities to protect, restore and reinstate high value ecosystems throughout northern Victoria. The spatial coverage of environmental watering has expanded considerably in recent years and this trend will continue into the future.

Environmental watering in Victoria has historically been supported by management plans which document key information such as the watering requirements of a site, predicted ecological responses and water delivery arrangements. State and Commonwealth environmental watering programs now have the potential to extend beyond those sites which have been watered in the past. Therefore, new plans are required to provide a transparent and informed approach to environmental water delivery across new environmental watering sites.

1.2. Purpose

The Victorian catchment management authorities (CMAs) and Department of Environment and Primary Industries (DEPI) are working together to develop new Environmental Water Management Plans for both current and future environmental watering sites throughout northern Victoria. The primary purpose of the plans is to provide a consistent set of documents that support the Seasonal Watering Proposals to be submitted by CMAs to the Victorian Environmental Water Holder (VEWH) each year. The supporting information includes:

- water dependent environmental, social and economic values;
- water dependent environmental condition, threats and objectives;
- long-term water regime requirements to meet environmental objectives, under a range of climatic conditions;
- environmental watering management responsibilities;
- recent records of water delivery;
- opportunities for improved efficiency or capacity through structural works or other measures; and
- scientific knowledge gaps and recommendations for future work.

1.3. Site location

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

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

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

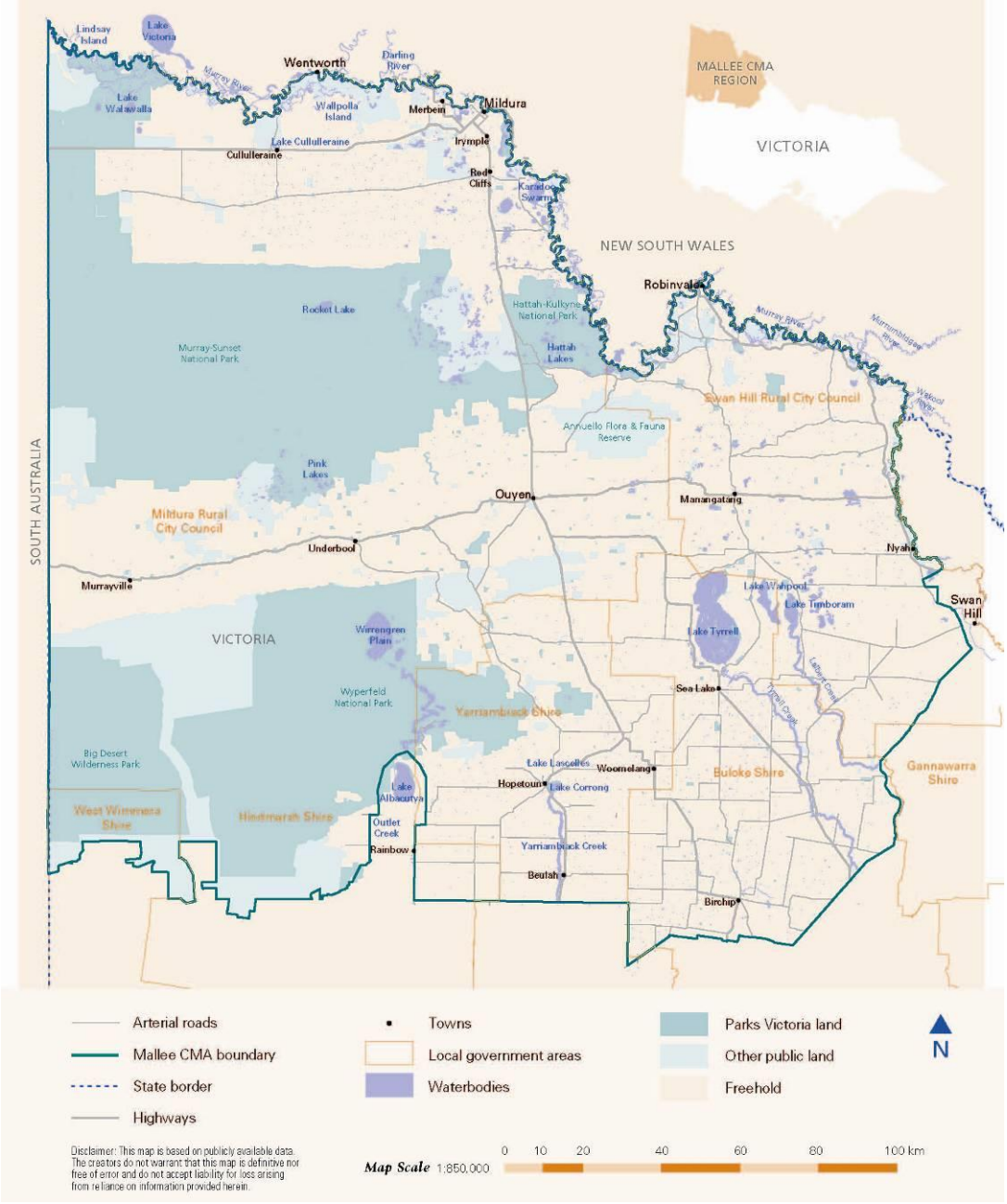


Figure 1 Map of the CMA region

In 2006 the Mallee CMA engaged consultants, Ecological Associates, to investigate water management options for the Murray River floodplain from Robinvale to Wallpolla Island. One of the major outcomes of these investigations (EA, 2006) was the development of a system of Waterway Management Units (WMUs). These divide the floodplain into management units which are areas in which water regimes can be managed independently of another WMU but which are relatively consistent in their ecological values and land uses. The Mallee CMA has based its environmental water management plans on these WMUs to achieve more effective management of hydrologically connected systems. The site for this plan is situated outside the scope of the 2006 investigation however the Mallee CMA has expanded the development of the WMUs to incorporate the waterways and wetlands of the Mallee which are not part of the Murray River floodplain. The Cardross and Koorlong Lakes WMU situated 15km south-west of Mildura in the Murray Mallee bioregion (Figure 2).

1.4. Consultation

This Plan was developed in collaboration with key stakeholders namely Parks Victoria, the Department of Environment and Primary Industries, Murray-Darling Freshwater Research Centre (MDFRC) and local interest groups. A number of meetings were held during the development phase to seek input and gather information from experts and stakeholders as well as meetings with the DEPI and other CMAs involved in the development of the template for the plans.

Table 1 Consultation Process for development of Cardross and Koorlong Lakes WMU's Environmental Water Management Plan

Meeting date	Stakeholders	Details
Ongoing	DEPI	Consultation on environmental management and project development and prescribed burn planning
Ongoing	Local residents/community	Presentation of draft plan and request for input/feedback
Ongoing	Lower Murray Water	Consultation on environmental management and delivery of water
Ongoing	MDFRC	Consultation on ecological requirements for Murray hardyhead & monitoring
Ongoing	Parks Victoria	Consultation on wildfire and prescribed burn planning

1.5. Information sources

Information used in the development of this Plan was compiled from various sources (References, Section 10) including river health and catchment strategies, consultant reports and wetland and park management plans. A number of state-wide data sets and digital mapping layers were used including the:

- Flora Information System of Victoria;
- Atlas of Victorian Wildlife;
- Victorian Biodiversity Atlas
- Bioregional Conservation Status of Ecological Vegetation Classes;
- Wetland Environments and Extent up to 1994; and
- Aerial photography
- Digital Elevation and LiDAR modelling
- Local knowledge (both research and community)

This information was supplemented by discussions with people with an intimate knowledge of the study area, its environmental values and the management and operation of the Cardross and Koorlong Waterway Management Units.

1.6. Limitations

The information sources used in the development of this report have a number of limitations. These limitations include that the data contained in the Flora Information System and the Atlas of Victorian Wildlife comes from a combination of incidental records and systematic surveys. The data varies in accuracy and reliability due to the distribution and intensity of survey efforts. In addition, the lack of knowledge about the distribution and

characteristics of invertebrates and non-vascular plant species means the data is weighted towards the less cryptic elements of flora and fauna, i.e. vascular flora and vertebrates. This report also draws on material collated from management plans, research documents and published literature. These sources vary in their age and hence the degree to which they reflect the current situation. However, the Plan is intended to be a live document and will be amended as new information becomes available.

2. SITE OVERVIEW

2.1 Catchment setting

The Cardross and Koorlong Lakes are situated approximately 15 km south-west of Mildura in the Murray Mallee bioregion. The Murray Mallee bioregion is typified by calcareous material in the form of a broad undulating sandy plains that is often associated with linear, west-east aligned, low sand dunes with intervening heavier textured swales developed from Cainozoic deposits of alluvial, aeolian and swampy deposits. The vegetation is dominated by East/West-Dune Mallee with some Chenopod Mallee and Shallow-Sand Mallee. The plains, drainage lines and groundwater discharge landscapes are dispersed with salt lakes and gypsum flats with lunettes developed on the eastern margins of the lakes. The Cainozoic deposits give rise to calcareous earths (Calcarosols), cracking clays (Vertosols), red sands (Rudosols). The vegetation is dominated by Gypseous Plains Shrubland, Saline Shrubland (Raak), Plains Grassland and Drainage-line Grassy Woodland. (DEPI website bioregions description).

The Cardross and Koorlong Lakes are a series of artificial evaporation basins which were first used in the 1930's for irrigation drainage as part of Australia's first irrigation scheme (Ryan *et al*. 2003). Excess irrigation water drained into the basins which altered the system to semi-permanent Lakes. Raddik (1996, cited in Ryan *et al*. 2003) stated the consistent supply of drainage water along with the significant depth and diverse aquatic habitat in these artificial wetlands led to Cardross Lakes becoming the most significant wetland in region and the Lakes began to support a diverse native fish assemblage.

However, improved irrigation practices in the last twenty years have significantly reduced the amount of drainage water entering the Lakes. This has reduced water levels but increased salinity levels in these artificial wetlands. As a result the Lakes now support fewer native fish species but are still one of the last remaining refuges for the listed fish species Murray hardyhead (*Craterocephalus fluviatilis*).

Murray hardyhead are listed as endangered under the Environment Protection Biodiversity Conservation Act 1999 (commonwealth), threatened under the *Flora and Fauna Guarantee Act 1988 (State) and considered critically endangered in Victoria (DEPI).* Murray hardyhead are able to survive and reproduce in saline wetlands, where other less salt-tolerant fish species are excluded (Ellis 2013). This species was formerly abundant in the mid and lower Murray-Darling River system but has suffered a significant decrease in its distribution (Lintermans 2007). Murray hardyhead are now considered extinct in New South Wales and only eight known isolated populations persist in Australia (Ellis 2013). The Cardross and Koorlong Lakes support two of the last four populations in Victoria, with the latter consisting of fish translocated from a captive maintenance program. Given the saline nature of these lakes and the resulting loss of other native fish species, the persistence and increased abundance of Murray hardyhead populations is the primary management objective at these sites.

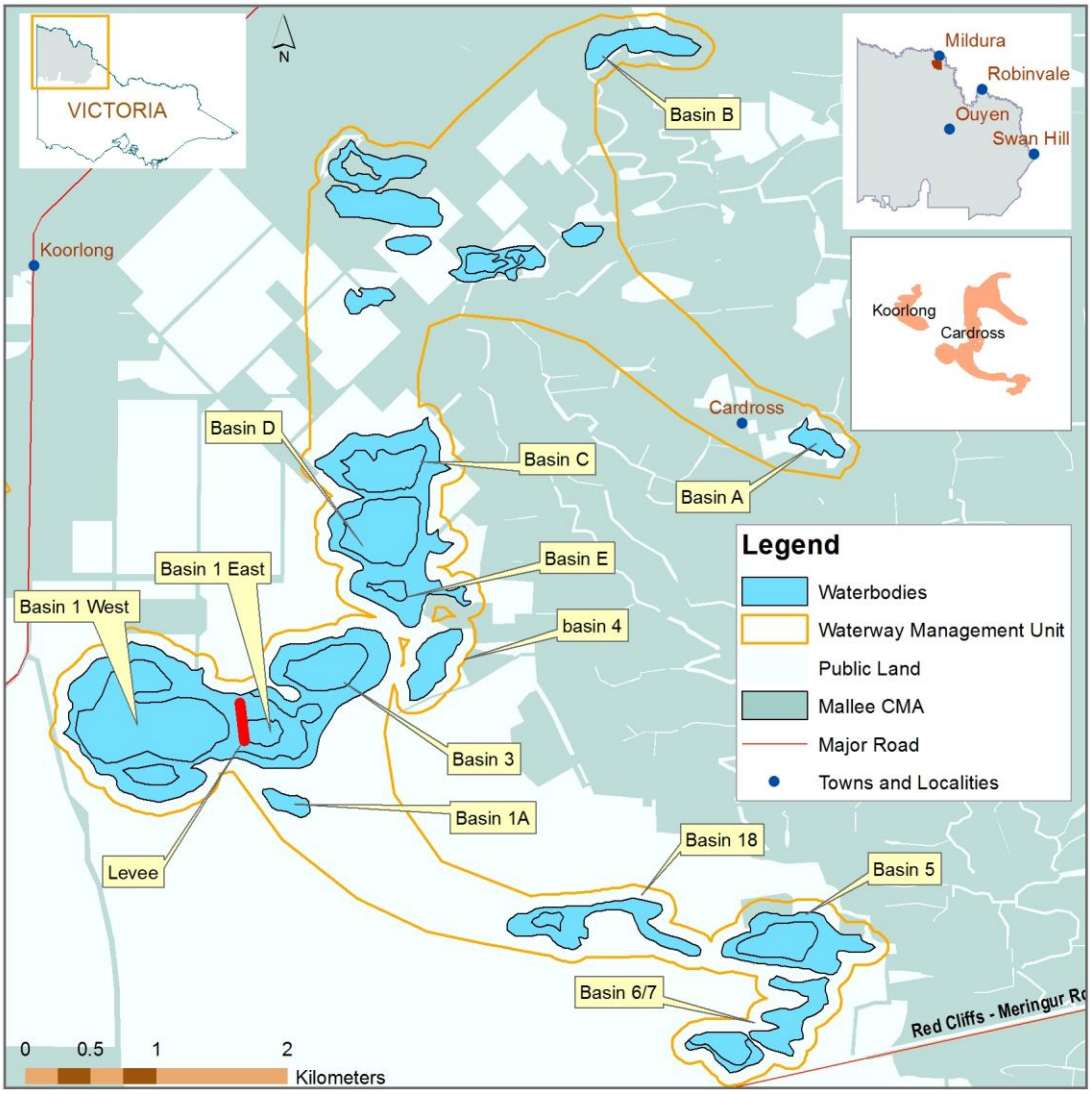


Figure 2 Cardross Waterway Management Unit

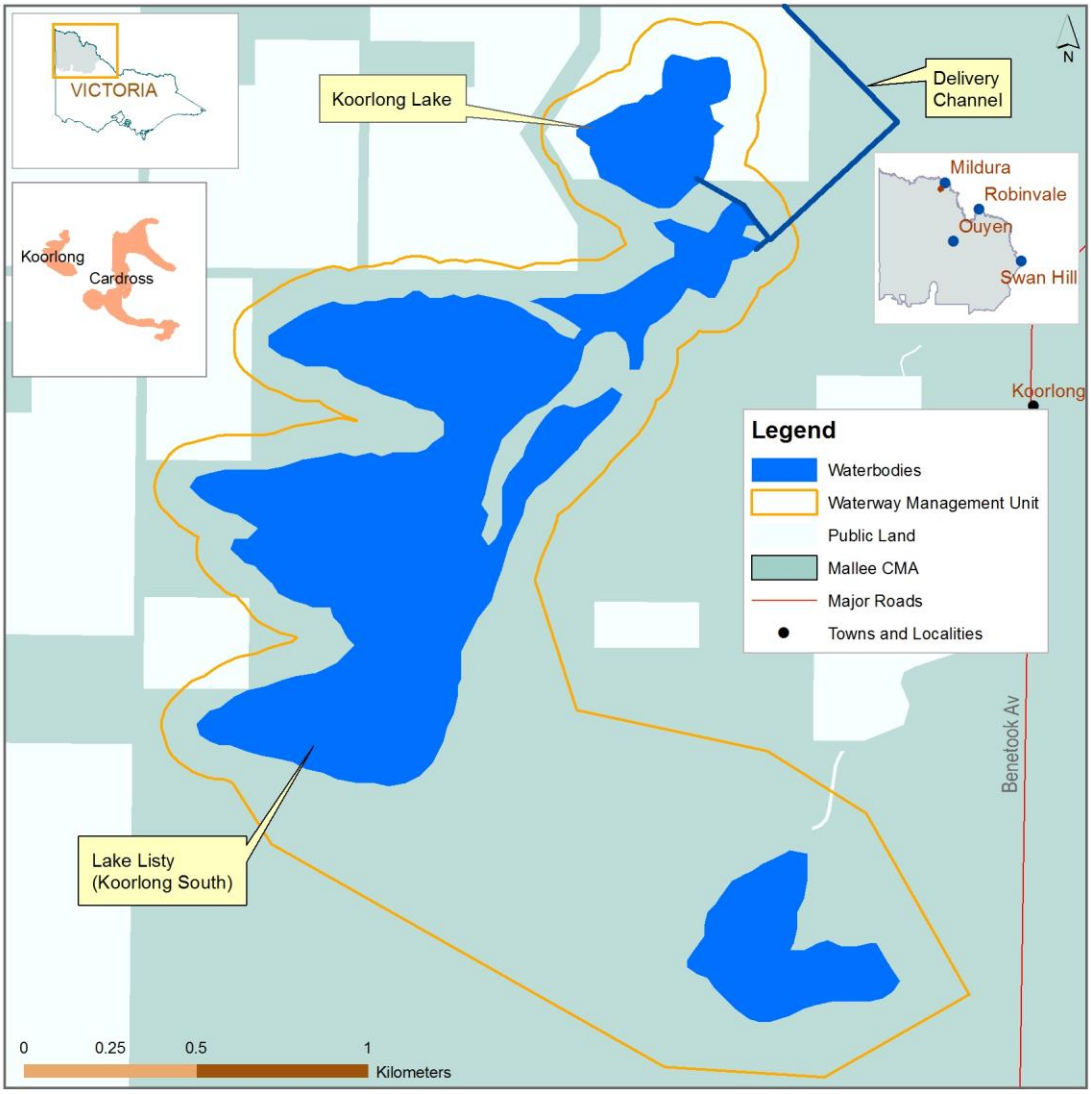


Figure 3 Koorlong Waterway Management Unit

The Waterway Management Unit boundary indicates the area for which water regimes can be managed largely independently of each other. The Cardross and Koorlong Lakes WMU's have a water requirement as a wetland complex of 554 ha but the focus for this plan is restricted to a target area within the WMU's of 93 ha, as shown in Figures 4 and 5. The target area at Cardross Lakes is restricted to Basin 1 West (73.15ha) and Basin 1 East (7.98 ha). The target area at Koorlong Lakes WMU is restricted to Koorlong Lake (11.81). The target area may be expanded in the future and constraints and proposed infrastructure are discussed fully in Sections 4 and 8.

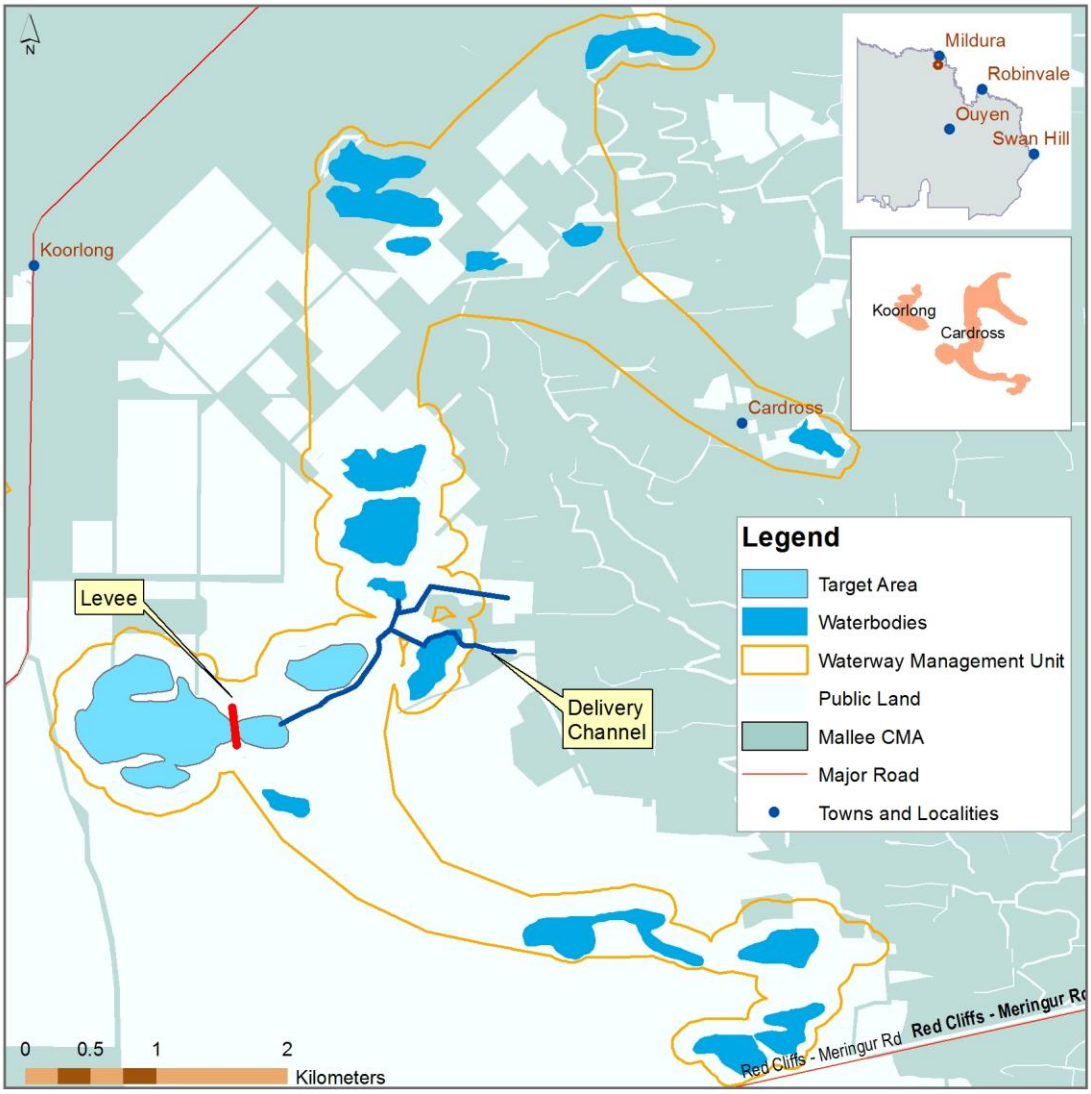


Figure 4 Achievable inundation extent of Cardross WMU without works

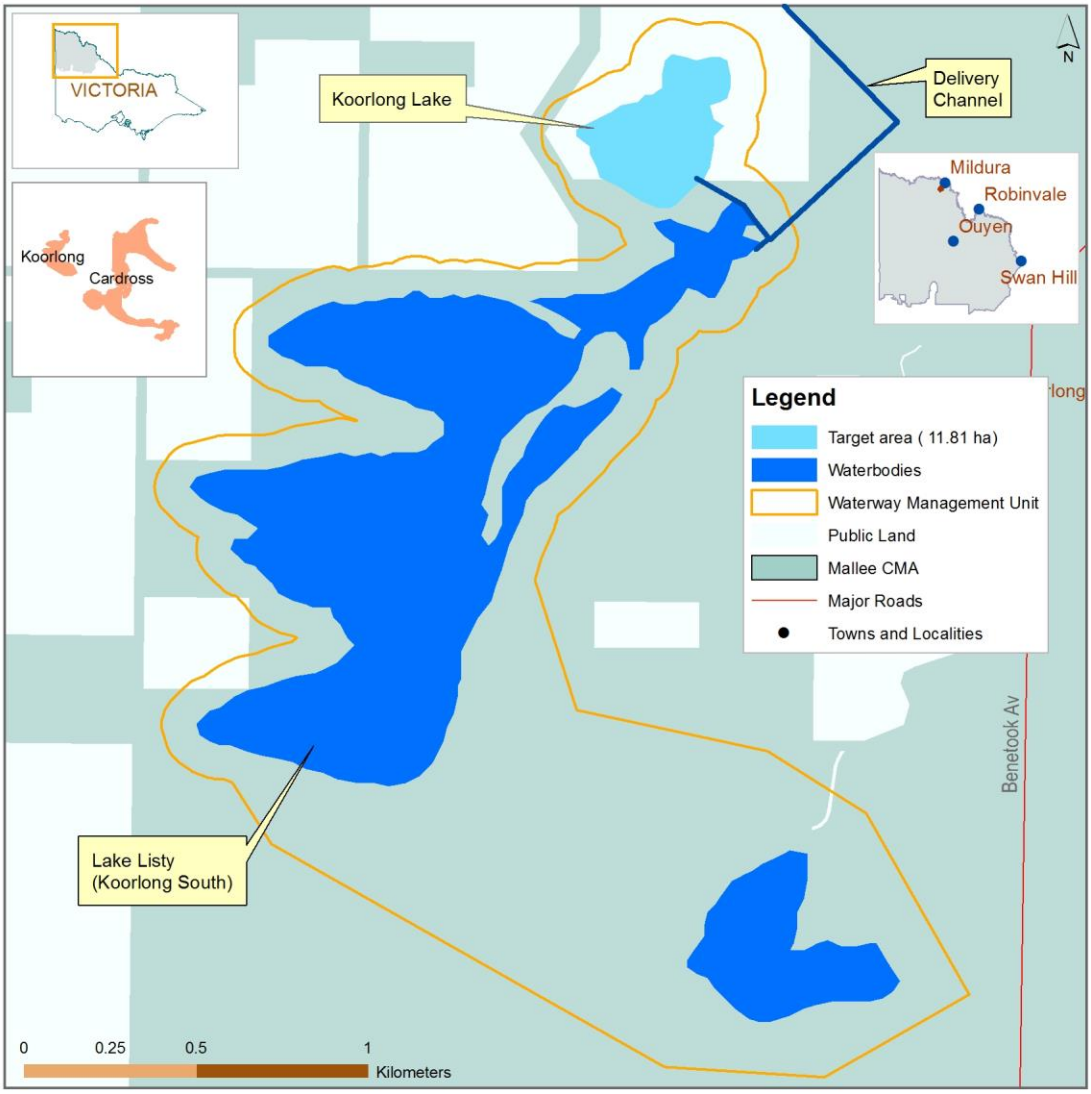


Figure 5 Achievable inundation extent of Koorlong WMU without works

2.2 Land status and management

The Cardross and Koorlong Lakes WMU's are managed as drainage basins by Lower Murray Water under the Land Conservation Council (LCC) recommendations. The Lakes are surrounded by crown and freehold land and state forest which is managed by the Department of Environment and Primary Industries.

Table 2 Stakeholders for the Cardross and Koorlong Common WMU

Group	Role
Mallee CMA	Regional environmental management
Department of Environment and Primary Industries	State level environmental water management planning, land manager, threatened species manager
Victorian Environmental Water Holder	Manager of Victoria's environmental water entitlements
Lower Murray Water	Local Water Authority
Mildura Rural City Council	Local Government

2.3 Wetland characteristics

A brief overview of the main characteristics of the target area is given in Table 3.

Table 3 Summary of target area characteristics

Characteristics	Description
Name	Cardross and Koorlong Lakes Waterway Management Units
Mapping ID within area	Basin 1 (Cardross Basin 1 East & Basin 1 West), 1A, 2, 3, 4, 5, 6/7 & 18. Basin A, B, C, D & E, Koorlong Lake, Lake Listy
Area	93 ha
Bioregion	Murray Mallee
Conservation status	Directory of Important Wetlands in Australia
Land status	LMW Drainage Basins, State Forest, Freehold and Crown Land
Land manager	LMW, DEPI
Surrounding land use	Irrigated horticulture
Water supply	Lower Murray Water supply
1788 wetland category	N/A - artificial
1994 wetland category and sub-category	Permanent Open Freshwater, Semi-permanent Saline
Wetland depth at capacity	Unknown

2.4 Environmental water

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

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

Environmental Water for the study site may be sourced from the water entitlements and their agencies listed in Table 4 and further explained in Appendix 1. Recent environmental watering which has occurred at the Cardross and Koorlong site is outlined in section 4.1.3.

Table 4 Summary of environmental water sources available to Cardross and Koorlong WMU

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

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

2.5 Legislative Policy Framework

There is a range of international treaties, conventions and initiatives, as well as National and State Acts, policies and strategies that determine management of the target area. Those with particular relevance to the site and the management of its environmental values are listed in Table 5. For the functions and major elements of each refer to Appendix 2.

Table 5 Legislation, agreements, convention and listings relevant to the target area

Legislation, Agreement or Convention	Jurisdiction
CAMBA	International
JAMBA	International
EPBC	National
Flora and Fauna Guarantee Act (FFG)	State
DEPI advisory lists	State

2.6 Related Plans and Activities

The Cardross and Koorlong Lakes WMU's have been included in various investigations including Salinity Management Plans and Land Conservation Council Reviews.

There have also been local investigations. In 2006, Mallee CMA engaged consultants Ecological Associates to investigate water management options for the floodplain of the Murray River from Robinvale to Wallpolla Island. This investigation proposed the establishment of Waterway Management Units. Waterway Management Unit boundaries indicate the area for which water regimes can be managed largely independently of each other. While Cardross and Koorlong Lakes WMU's were not considered within the EA report and are not situated on the Murray River floodplain, their establishment is based on the principles which define WMU's according to this study.

Research and monitoring focusing on the Murray hardyhead (*Craterocephalus fluviatilis*) in the Cardross and Koorlong Lakes has been ongoing since 2000. These sites are some of the last locations to still support populations of this critically endangered (DEPI) native fish. At the height of the recent drought (in 2007) the Department of Sustainability and Environment (now DEPI) instigated an Emergency Action Plan to preserve Murray hardyhead habitat effected by reduced water supply, including the Cardross Lakes (Ellis et al. 2011). Cardross Basin 1 had receded and separated into two pools (Basin 1 East and Basin 1 West) and as part of the Action Plan a levee was constructed to isolate the smaller eastern pool. This enabled water levels to be maintained within Basin 1 East through the delivery of environmental water, creating a refuge for Murray hardyhead while Basin 1 West was left to dry.

The Emergency Action Plan of 2007 also involved the establishment of a captive breeding and translocation program for Murray hardyhead. Fish from Cardross Basin 1 and Lake Hawthorn were used to create a captive population at the Murray-Darling Freshwater Research Centre laboratory in Mildura. Fish from other Victorian and South Australian populations were also collected for the captive breeding program.

The Victorian DEPI and the Mallee Catchment Management Authority (MCMA) began delivering environmental water to the Koorlong Lakes in 2009 as the site was deemed suitable for translocation of Murray hardyhead (Ellis et al. 2011). Murray hardyhead bred in the captive maintenance program were released in Koorlong Lake in November 2009, with other captive bred fish returned to Cardross Basin 1 West when it refilled in 2010 (Ellis

2013). A number of other saline wetlands in the Mallee CMA region are currently being investigated for their potential to support translocated populations of Murray hardyhead.

A National Recovery Plan for the Murray hardyhead was established in 2008. The Plan aims to identify threats to the species and determine recovery objectives and actions to ensure the long-term survival of Murray hardyhead (Backhouse *et al*. 2008).

3. WATER DEPENDENT VALUES

3.1 Environmental

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

The Cardross and Koorlong Lakes are natural depressions in the terrestrial landscape. In the 1930's these depressions were altered and infrastructure was constructed to facilitate the use of the basins for drainage as part of Australia's first community irrigation drainage scheme. This has resulted in a network of more than 30 interconnected artificial wetlands of significant biodiversity value now existing at this site. However, more recent improvements in irrigation techniques has seen less drainage flowing into the lakes causing water levels to drop and salinity levels to increase. In most wetland systems a reduction in irrigation drainage would be considered a significant environmental improvement. In the case of Cardross and Koorlong Lakes however, the reduced water supply poses a major threat to the resident aquatic fauna (Ryan *et al*. 2003). As a result, this system which Raadik & Harrington (1996, cited in Ryan *et al*. 2003) considered the most diverse native fish wetland system in Victoria, has already experienced significant decline in fish diversity. The Cardross Lakes are of national significance and are listed on the Directory of Important Wetlands (Ryan *et al*. 2003).

3.1.1 Listings and significance

Fauna

The Cardross and Koorlong Lakes WMU's consists of a complex of drainage basins that provide habitat for a large range of fauna. Native species recorded in the WMU are listed in Appendix 3. This list includes a range of water dependent species which will benefit from the wetlands in the target area receiving water on a more regular basis. Of special interest and responsibility are the water dependent species listed in legislation, agreements or conventions these are summarised in Table 6.

Table 6 Listed water dependent fauna recorded at Cardross and Koorlong Lakes

Scientific Name	Common Name	FFG status	DEPI status	EPBC status	International
Ardea modesta	Eastern Great Egret	L	V		CAMBA JAMBA
Aythya australis	Hardhead		V		
Biziura lobata	Musk Duck		V		
Oxyura australis	Blue-billed Duck	L	EN		
Chlidonias hybridus javanicus	Whiskered Tern		NT		
Stictonetta naevosa	Freckled Duck	L	EN		
Acrocephalus stentoreus	Common Reed Warbler	NL	NL	M	
Hydroprogne caspia	Caspian Tern	L	NT		CAMBA JAMBA
Phalacrocorax varius	Pied Cormorant		NT		
Chelodina expansa	Broad-shelled Turtle	L	EN		
Tandanus tandanus	Freshwater Catfish	L	EN		
Macquaria ambigua	Golden Perch		V		
Craterocephalus fluviatilis	Murray hardyhead	L	CR	EN	
Maccullochella peelii peelii	Murray Cod	L	E	VU	
Mogurnda adspersa	S'thern Purple-spotted Gudgeon	L	RE		

Legend
EPBC status: EXtinct, CRitically endangered, ENdangered, VUlnerable, Conservation Dependent, Not Listed
FFG status: Listed as threatened, Nominated, Delisted, Never Listed, Ineligible for listing
DEPI status: presumed EXtinct, Regionally Extinct, Extinct in the Wild, CRitically endangered, ENdangered, Vulnerable, Rare, Near Threatened, Data Deficient, Poorly Known, Not Listed

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

Raadik & Harrington (1996, cited in Ryan *et al*. 2003) found that the significant water depth, good water quality and diversity of aquatic habitat at Cardross Lakes made it the most significant wetland in the region, particularly for native fish. Fish surveys conducted in 1995 and 1996 revealed the presence of a small population of Southern Purple-spotted Gudgeon, along with Murray hardyhead, at Cardross Lakes. However, there is no record of the critically endangered (DEPI) Southern Purple-spotted Gudgeon being found here since 1996 and it is now considered regionally extinct in this area (Ryan *et al*. 2003), and in the state of Victoria.

A decrease in irrigation drainage to these wetlands and the associated reduction in water levels also led to a decrease in other native fish species found at the site. Table 7 shows the native fish species previously recorded at Cardross and Koorlong Lakes. Some of these species have been absent in more recent surveys at these sites. Monitoring at Cardross and Koorlong Lakes in November 2013 found Carp Gudgeon sp., Un-specked hardyhead and Australian smelt as well as Murray hardyhead present in these lakes, though no Murray hardyhead were found Cardross Basin 1 East (Ellis, I. 2013, pers. comm., 21st November). Under the appropriate watering regime implemented through environmental watering these lakes provide essential habitat for Murray hardyhead whilst also holding the potential to support a diverse range of native fish.

Table 7 Native fish species recorded at Cardross and Koorlong Lakes

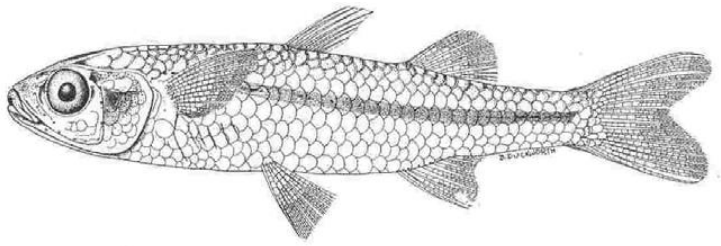
Scientific Name	Common Name	FFG status	DEPI status	EPBC status
Tandanus tandanus	Freshwater Catfish	L	EN	
Macquaria ambigua	Golden Perch		V	
Craterocephalus stercusmuscarum fulvus	Unspecked Hardyhead	L		
Craterocephalus fluviatilis	Murray hardyhead	L	CR	VU
Maccullochella peelii peelii	Murray Cod	L	E	VU
Mogurnda adspersa	S'thern Purple-spotted Gudgeon	L	RE	
Nematalosa erebi	Bony Bream			
Retropinna semoni	Australian Smelt			
Hypseleotris klunzingeri	Western Carp Gudgeon			
Philypnodon grandiceps	Flat-headed Gudgeon			
Philypnodon macrostomus	Dwarf Flat-headed Gudgeon			

Legend
EPBC status: EXtinct, CRitically endangered, ENdangered, VUlnerable, Conservation Dependent, Not Listed
FFG status: Listed as threatened, Nominated, Delisted, Never Listed, Ineligible for listing
DEPI status: presumed EXtinct, Regionally Extinct, Extinct in the Wild, CRitically endangered, ENdangered, Vulnerable, Rare, Near Threatened, Data Deficient, Poorly Known, Not Listed

Murray hardyhead

Murray hardyhead, *Craterocephalus fluviatilis,* are considered to be critically endangered in Victoria. This species, which was once abundant throughout its range, has suffered a dramatic decline. This is largely due to altered flow regimes and drought which has led to reduced connection between the Murray River and floodplain wetlands and drying of some lakes (Lintermans 2007). Altered flow regimes due to human processes and drought have impacted on water quality in waterways that historically supported Murray hardyhead (Ellis 2013), increasing salinity and degrading habitat (Lintermans 2007). Introduced species such as Eastern gambusia and Redfin perch have also impacted on Murray hardyhead through competition and predation (Ellis 2013).

Murray hardyhead generally persist in waters with elevated salinity (ranging from approximately 1,000 to 110,000 $\mu S.cm^{-1}$) and submerged vegetation. Backhouse et al. (2008) states that it is not clear if this indicates a preference for saline habitats or if it is due to the exclusion of less salt tolerant species which compete or



Murray hardyhead
Craterocephalus fluviatilis

Description
Murray hardyhead are small but highly mobile, reaching approximately 72mm in length. The colour is silver to golden on the back, with a paler underside and a silvery-black mid-lateral stripe.

Habitat & Diet
Murray hardyhead are found around the margins of wetlands and billabongs and prefer open water, shallow, slow-flowing or still habitats. They can also be found in deeper habitats with dense aquatic vegetation. This species can survive in highly saline environments. Murray hardyhead feed mainly on zooplankton, dipteran larvae/pupae and algae.

Life Cycle
Spawning takes place over an extended breeding season (Sept – Apr) but peaks in Oct – Nov. Murray hardyhead are batch spawners and lay eggs amongst submerged aquatic vegetation, such as Ruppia sp. They are considered an annual species with few individuals surviving into their second year, consequently successful annual recruitment is critical.

Threats
Increased salinity, habitat degradation, altered flow regimes which decrease connectivity between rivers and wetlands. Pest species such as Eastern gambusia and Redfin Perch which compete with and prey on Murray hardyhead and potentially habitat destruction by Carp.

Species Trajectory
The distribution of Murray hardyhead has been significantly reduced. It is now considered extinct in NSW and is a nationally threatened species. Only eight known populations remain in Australia.
Source: Lintermans 2007, Ellis 2005, Ellis 2006, Ellis 2013

prey on Murray hardyhead. Salt tolerant Ruppia is often a key aquatic macrophyte in saline wetlands where Murray hardyhead are found. Zooplankton are the main source of food for Murray hardyhead and some of these micro-crustaceans also rely on Ruppia for habitat. The biggest threat to Murray hardyhead is reduced inflows to wetlands as a result of river regulation, however at Cardross and Koorlong Lakes the reduced inflows are due to improved irrigation techniques. A reduction in inflows also has a detrimental effect on macrophyte communities in Cardross and Koorlong Lakes reducing feeding and breeding habitat for Hardyhead. As an annual species, Murray hardyhead relies heavily on successful recruitment each year. Ellis (2006, cited in Ellis 2010) states that this means even short-term changes which have a negative ecological impact on fish could have a significant effect on the long-term viability of Murray hardyhead populations. Environmental watering on an annual basis is listed as a key management action for the long-term preservation of Murray hardyhead populations (Backhouse *et al*. 2008).

The Cardross Lakes, along with Lake Hawthorn, in the Mallee region were two of last four locations to naturally support Murray hardyhead in Victoria. After years of drought Lake Hawthorn dried out in 2008-09 and the wetland was no longer able to sustain Murray hardyhead. Approximately 280 fish were collected for the captive breeding program from Lake Hawthorn before it dried out (Ellis & Pyke 2010). By 2006 Cardross Basin 1 had separated in two and Murray hardyhead were also salvaged from Basin 1 West in 2008 (Ellis & Pyke 2010) before this basin became uninhabitable due to a combination of reduced water level and quality. A levee was constructed around Basin 1 East to hold water in this area as a refuge for Murray hardyhead and environmental water has been delivered to this site since 2007. In 2010 localised rainfall and increased water availability post-drought provided a connection between these basins and allowed Murray hardyhead to repopulate Basin 1 West (Ellis *et al*. 2011).

Koorlong Lake received environmental water in 2009-10 and 2010-11 resulting in suitable water quality and habitat to support Murray hardyhead. The captive breeding program, established as part of the objectives of the Murray hardyhead National Recovery Plan, enabled captive-bred fish from Lake Hawthorn and Cardross Lakes to be released into Koorlong Lake in November 2009. Murray hardyhead have continued to survive at Koorlong Lake at low abundance (Ellis et al. 2011). The Murray hardyhead populations in Cardross and Koorlong Lakes are some of the last remaining in Victoria and have been seasonally monitored (Ellis *et al*. 2011). The conservation of these populations is be aided through environmental water delivery to the lakes.

A number of listed waterbird species occur within the Cardross and Koorlong Lakes WMU's. Of particular note are the Freckled and Blue-billed Ducks which are considered endangered in Victoria and inhabit saline wetlands with good emergent vegetation. Although these species will not be part of specific objectives at this site, it is expected that they, and other waterbirds, will benefit from environmental watering of these wetlands.

Vegetation communities

The vegetation communities within the target area are essentially made up of dryland EVC's as these wetlands have been artificially constructed in what was naturally a terrestrial landscape. The change from a dryland landscape to a wetland habitat has brought high ecological significance to the Cardross and Koorlong Lakes WMU's and management of these sites now targets wetland values. However, the delivery of environmental water to the wetlands may have extended benefits for surrounding terrestrial vegetation. The most extensive EVCs are Semi-arid Woodland and Low Chenopod Shrubland. For a full list of EVCs within the entire WMU and details on each see Appendix 4. The EVCs within the target area and their conservation status can be seen in Figures 6 and 7 and Tables 7 and 8.

Both Cardross and Koorlong Lakes support Mallee woodland EVC's (Table 7 & 8), some of declining health. Where wetlands and woodlands are combined in close proximity, conservation significance is high. 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, such as perches and nesting hollows. When flooded, the woodland floor becomes an extension of the wetland habitat, thereby extending food and shelter opportunities for aquatic fauna (EA 2007). This is particularly significant at Cardross and Koorlong Lakes as they have historically supported a diverse range of native fish and are some of the last remaining Murray hardyhead habitats in Victoria.

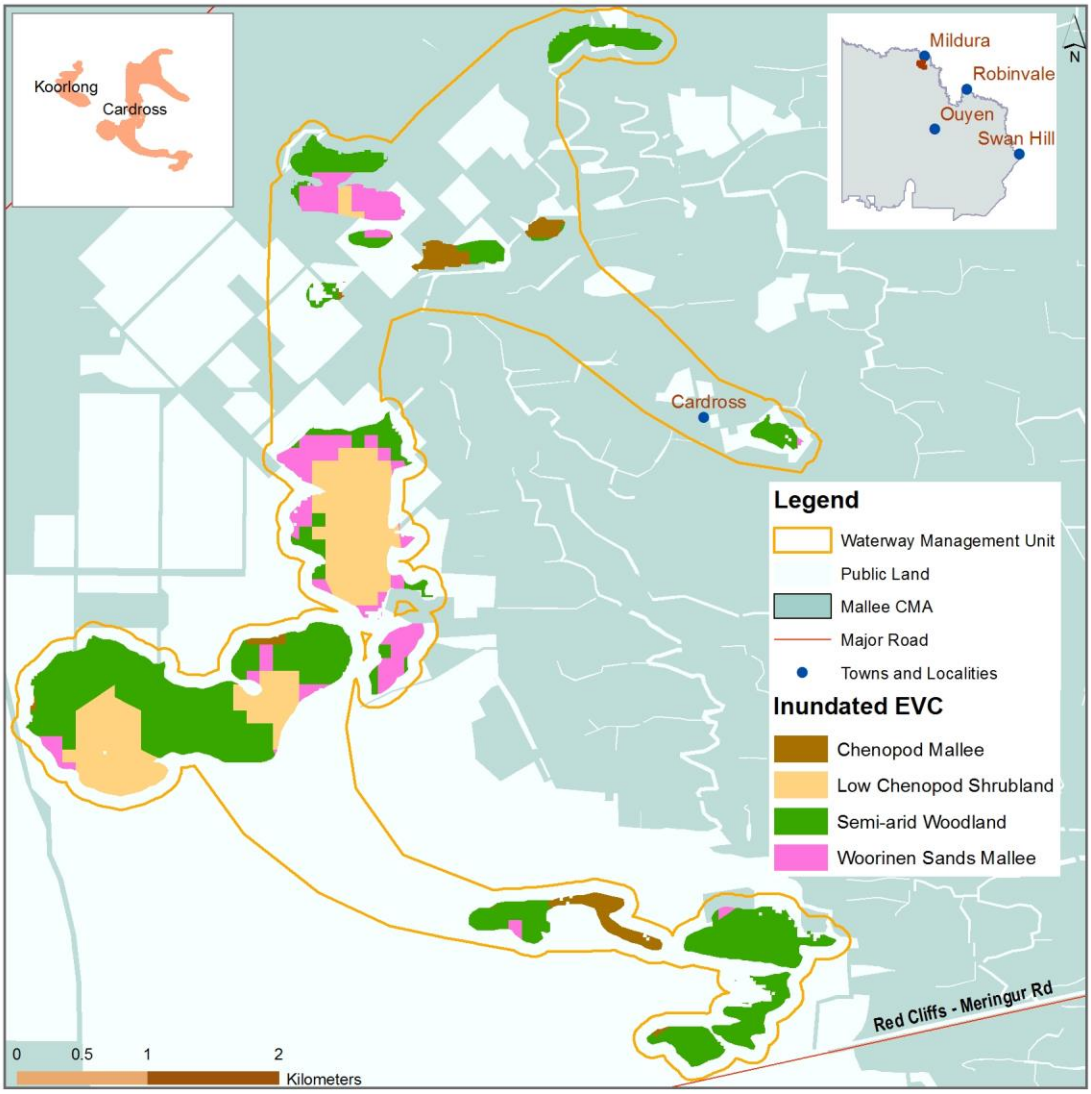


Figure 6 EVCs within the Cardross WMU

Table 8 Conservation status of water dependent EVCs in the Cardross target area

EVC no.	EVC name	Bioregional Conservation Status	Area (ha)
		Murray Mallee Bioregion	
86	Woorinen Sands Mallee	Depleted	57
97	Semi Arid Woodland	Vulnerable	242
102	Low Chenopod Shrubland	Depleted	119
158	Chenopod Mallee	Vulnerable	22

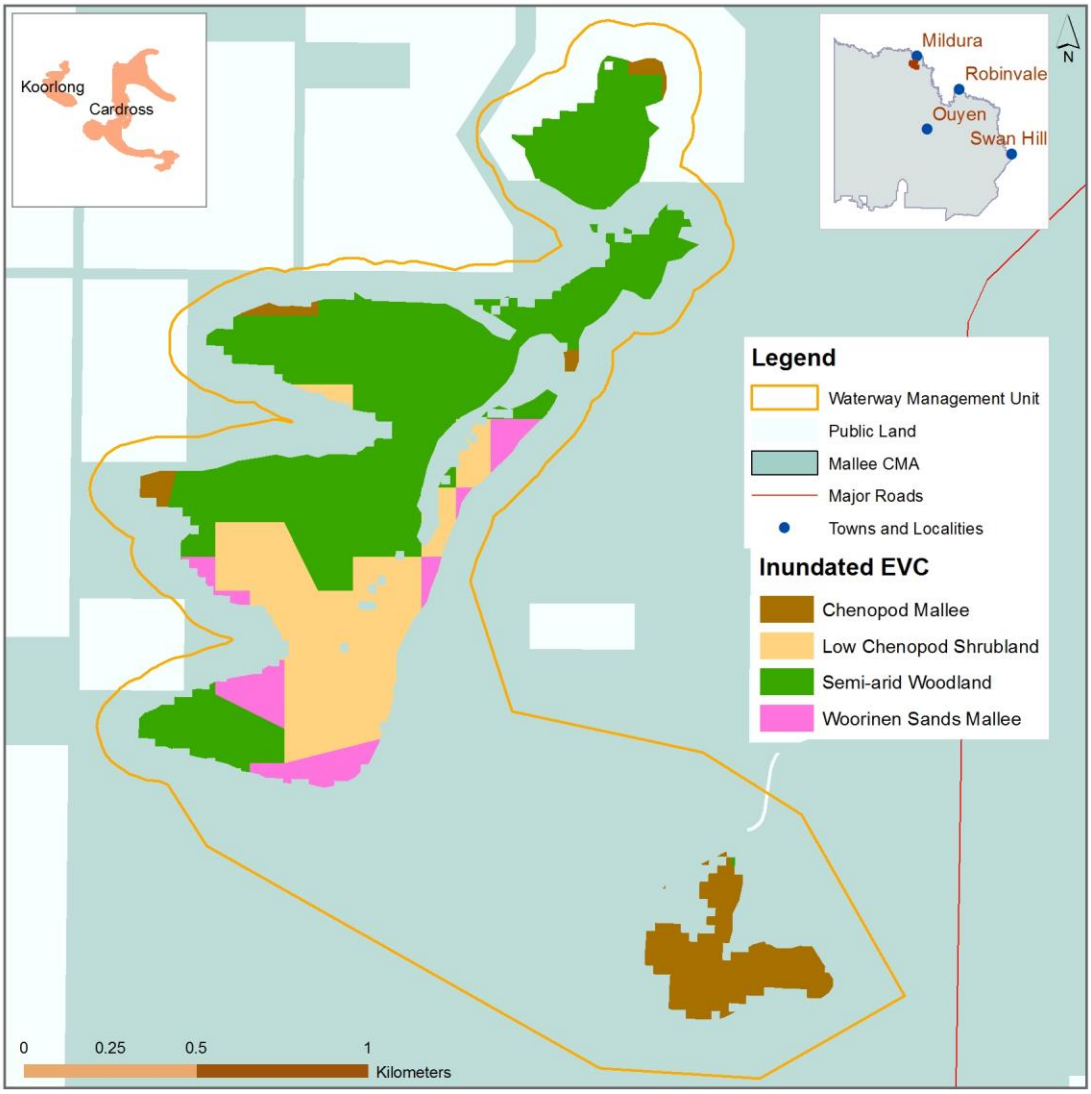


Figure 7 EVCs within the Koorlong WMU

Table 9 Conservation status of water dependent EVCs in the Koorlong target area

EVC no.	EVC name	Bioregional Conservation Status	Area (ha)
		Murray Mallee Bioregion	
86	Woorinen Sands Mallee	Depleted	7
97	Semi Arid Woodland	Vulnerable	68
102	Low Chenopod Shrubland	Depleted	26
158	Chenopod Mallee	Vulnerable	13

Flora species

Aquatic macrophytes are vital to the ecosystem at Cardross and Koorlong Lakes. These plants are rooted to the wetland floor with their canopies floating near the water surface. They rise and fall with water levels and provide a physical structure to the aquatic environment as well as providing a food source for waterbirds and habitat for fish (EA 2007). Aquatic macrophytes are highly productive wetland habitats also providing shelter for macro-invertebrates and dabbling ducks such as the Freckled Duck that graze on this vegetation and the macro-invertebrates within it (EA 2007). Aquatic macrophytes are dependent on water for growth and reproduction, and under sudden draw down these plants lose support and collapse and die quickly. 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 2007).

Salt tolerant Ruppia species are of particular importance at Cardross and Koorlong Lakes as this macrophyte species provides complex submerged aquatic vegetation for Murray hardyhead. This genus is mostly found in saline wetlands (Sainty & Jacobs 1981). As well as providing protection from predation, Hardyhead also use Ruppia for attachment of eggs during breeding. Ruppia also provides habitat for zooplankton fauna which are important dietary items for Murray hardyhead (DSE 2010). Without Ruppia the potential for fauna diversity within these wetlands is reduced (DSE 2004). This makes maintaining and improving Ruppia communities at Cardross and Koorlong Lakes particularly relevant as these saline wetlands are some of the last remaining refuges for Murray hardyhead. Ellis (2013) suggests that a reduction in Ruppia in Cardross Basin 1 East may be contributing to a decline in Murray hardyhead in this wetland. Ellis (2013, pers comm., 11th Dec) also suggests that a gradual drawdown in water level may be required for Ruppia re-establishment and found the abundance of zooplankton increased in wetlands which underwent drawdown phases. Brock (1981) states that the drying of seeds and substrate during a drawdown is likely to break seed coating and make seeds more permeable to water on rewetting of the wetland.

A full list of flora recorded at the Cardross and Koorlong Lakes site can be found in Appendix 3.

3.1.2 Wetland Classification

The Cardross and Koorlong Lakes WMU's contain more than 30 artificial drainage basins which have now become wetlands of significant ecological value. These wetlands have been classified using the Corrick-Norman wetland classification system as Permanent Open Freshwater and Semi-permanent Saline (Table 9). There has been very little decrease in these wetland types in the Murray Malle Bioregion. Semi-permanent saline wetlands are now the most common type of wetland in the Mallee CMA region. These wetlands have increased in number and area since European settlement due to river regulation, clearing of native vegetation and the use of low-lying areas for saline irrigation drainage (MCMA 2006). While this increase may not be desirable at other sites, in the case of Cardross and Koolrong Lakes this saline environment has led to the wetlands supporting significant native fish diversity.

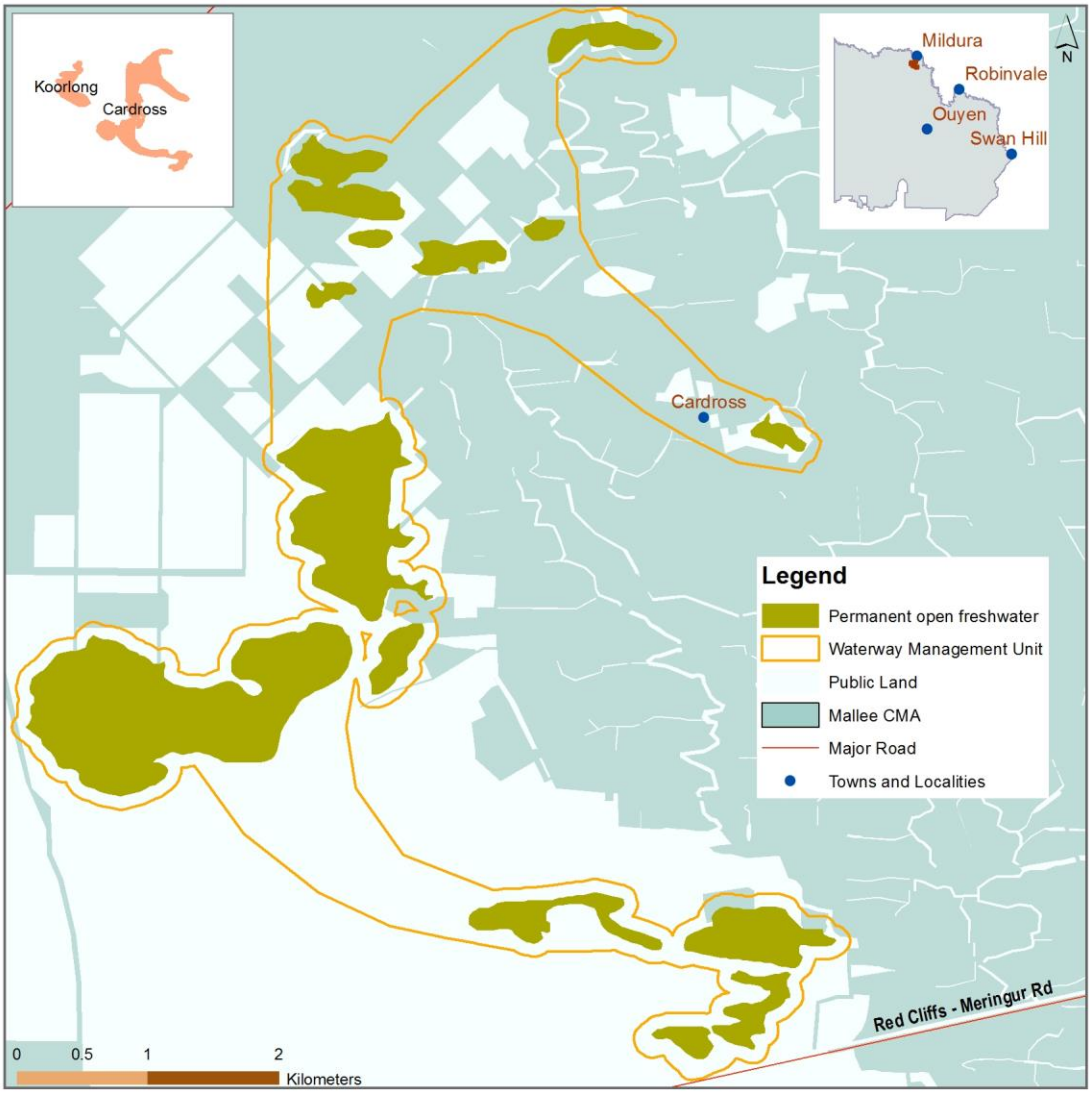


Figure 8 Wetland categories within the Cardross WMU by Corrick classification

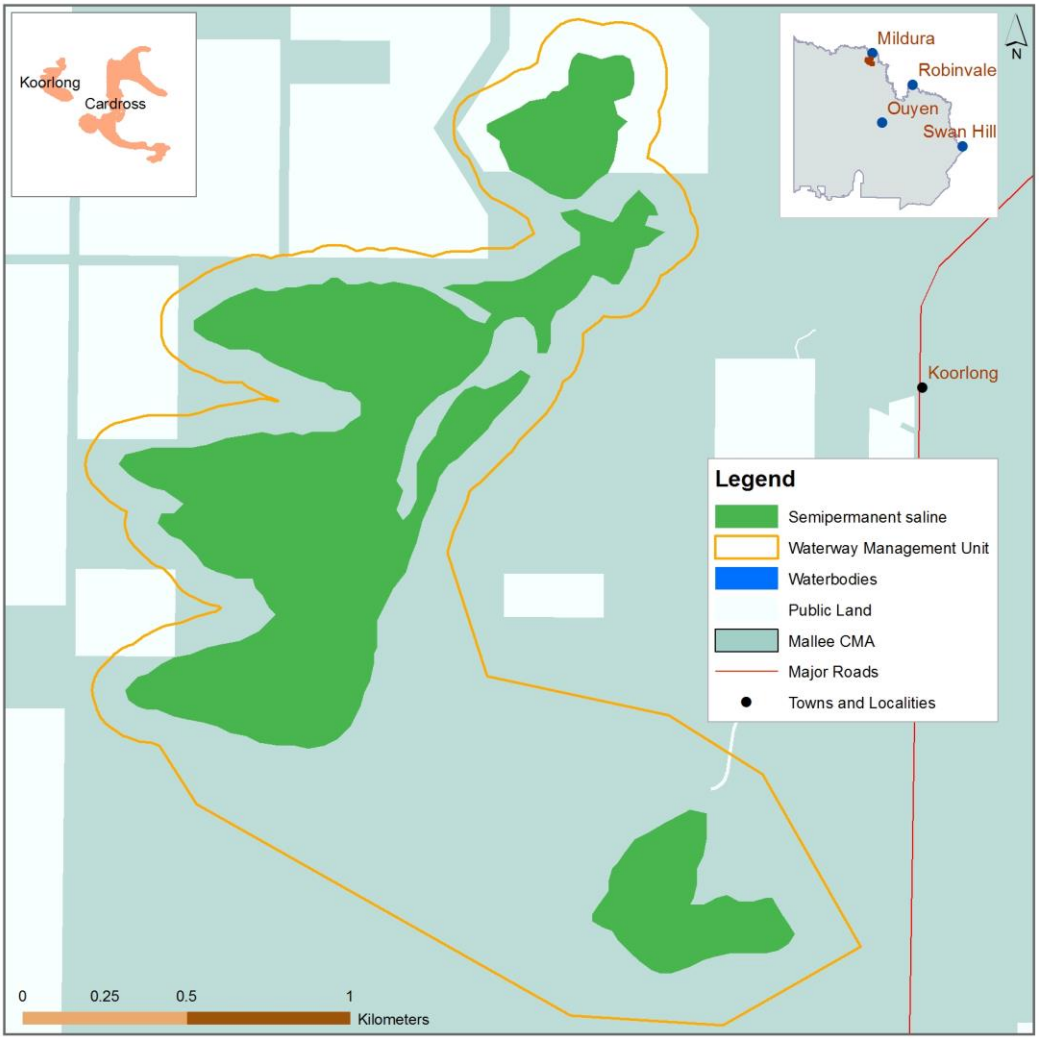


Figure 9 Wetland types within the Koorlong WMU by Corrick classification

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 Mallee Bioregion
Permanent Open Freshwater	1	81.13	-6	5	73
Semi-permanent Saline	1	11.81	-7	9	2

3.1.3 Ecosystem functions

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

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

The target area within these WMU's contain a artificial wetland complex of more than 30 wetlands which are categorised as Permanent Open Freshwater and Semi-permanent Saline. Altered water regimes in the target area due to improved irrigation techniques and dry conditions have seen a decrease in the frequency of inundation in these wetlands and therefore a decrease in the ability for these wetlands to perform these valuable ecosystem functions.

3.2 Social

3.2.2 Cultural heritage

Even though the Cardross and Koorlong Lakes are not naturally occurring wetlands they still have some cultural importance for the local indigenous people. The area is traditionally owned by the Nyeri Nyeri, Wergaia and Latji Latji people and there are a number of hearths and artefact scatters throughout the area. Earthen ovens (*hearths)* are listed and some cultural sites have been documented and records are held by Aboriginal Affairs Victoria. A contingency plan (Appendix 7) is in place should any further evidence of cultural heritage sites be discovered during site visits or works.

While the Cardross Lakes were originally established as part of Australia's first irrigation drainage scheme, the Lakes were also an important recreational area for local people. The lakes were used as a community swimming pool in the early 1900's. Australia's first registered inland life-saving club was at Cardross and this group, along with Cardross Rowing Club were situated at Cardross Lake (MRCC 2011). Chandler (1979, cited in ARI 2002) states that a kiosk, diving platform and lawns were constructed to facilitate the use of the lake as a swimming pool, along with caretakers quarters.

3.2.3 Recreation

Cardross Lakes are no longer used as a community swimming pool. However, the lakes are still used for recreational fishing, duck hunting and bird watching. Dirt bike riding is common at these sites and is a concern for natural values management.

3.3 Economic

The Cardross and Koorlong Lakes WMU's have been used for grazing, irrigation and stock and domestic in the past. Koorlong Lake was originally used as a natural rainwater catchment to support the Mildura Sheep Station (Murdoch, F. 2013, pers comm.). In the 1930's the natural depressions at these sites were altered and infrastructure was constructed to facilitate the use of the basins for drainage as part of Australia's first community irrigation drainage scheme.

3.4 Significance

The environmental, social and economic values outlined indicate the significance of this site. While these values do not constitute Cardross and Koorlong Lakes as being pristine sites, the historical status of Cardross Lakes as once containing the diverse native fish wetland in the state makes these lakes significant. However, the significant biodiversity values of these wetlands has suffered through reduced irrigation drainage, increasing salinity and the recent drought and some diversity, particularly native fish species, has been lost. This makes management for a wide range of fish species difficult as they would need to be reintroduced to the system and would require greater volumes of environmental water

to maintain fresh wetlands of suitable habitat. The wetlands, in their current state, still provide essential habitat for some of the states most endangered species however, particularly Murray hardyhead which prefer these saline conditions. As Cardross and Koorlong Lakes are two of only eight sites to still support the nationally listed Murray hardyhead these wetlands are of national significance and will be managed to maintain the Murray hardyhead population.

The Cardross and Koorlong Lakes are important cultural sites for the local indigenous people with a number of hearths and artefact scatters throughout the area. There are also significant European footprints, with defined evidence such as the establishment of these artificial wetlands as the first irrigation drainage scheme in Australia and as the site of the country's first inland life-saving club. These social and cultural values are important to local communities of the area. The values contained within the Cardross and Koorlong Lakes WMU's and specifically the target area for this plan makes this area a priority for protection and enhancement through environmental water management. Of particular significance are the native fish communities which inhabit the artificial wetlands throughout the target area. The presence of Murray hardyhead and the Ruppia communities which support them are the primary focus of this plan.

4. 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 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 and rivers.

The target area within the Cardross and Koorlong Waterway Management Units is located 15km south west of Mildura. These wetlands are relatively unique in that they are not naturally occurring and have no connection to the Murray River. The lakes were established in the 1930's as part of Australia's first irrigation drainage scheme and rely on this drainage inflow to sustain water levels within the lakes.

4.1 Water management and delivery

The Cardross Lakes are a series of connected basins which were historically used to provide irrigation drainage disposal for the Red Cliffs Irrigation District (SKM 2002). A total area of 904 ha of land drained into the Cardross Lakes basins, excluding Basin 5 (Ryan *et al*. 2003). Prior to the establishment of a pipeline system to the Red Cliffs area, excess irrigation water drained freely to the Lakes via channels. Increased irrigation efficiency in the district has led to decreased inflows to the Lakes and increased salinity levels (SKM 2002). The Lakes are now managed by Lower Murray Water.

Drainage inflows to the Cardross system gravitate from Basins A and B, which are at the highest elevation, then to Basins C, D and E. Flows then pass through an earthen channel to Basins 3, 2 and 1. Drainage water from Basin 4 also gravitates via a channel to Basin 1. Basin 1 incorporates Basins 2 and 3 when water levels are high enough but as water levels drop these basins may become isolated from one another. Ryan et al. (2003) predicted the frequency of disconnection between these basins was expected to increase as irrigation drainage inflows continued to decrease. Basin 1 is now divided by a levee with the section east of the levee known as Basin 1 East and the section west of the levee known as Basin 1 West.

Basin 1A is a terminal basin that is connected to southern end of Basin 1 via an open channel. Water only reaches Basin 1A when water levels in Basin 1 reach approximately EL 40.9m. Basin 5 is located 3km south-east of Basin 1 and receives excess irrigation flows. Basin 5 outflows to Basin 18 when full via an open channel and these basins are not connected to any other basins in the system (SKM 2002). Environmental water is delivered to Cardross Lakes through a channel to Basins E and 3 (Ellis 2013). This water is now all diverted directly to Basin 1.

The Koorlong Lakes are also a system of irrigation drainage basins close to Cardross Lakes, although the two systems are not connected. Koorlong Basin at the northern end of the system was originally a natural rainwater catchment area that had a tank constructed on site to retain water in the early days of Mildura Sheep Station. This was then called Irymple Tank. The drainage infrastructure that flows into Koorlong Lake (or Irymple Tank) was constructed in the 1930's when the Red Cliffs drainage scheme was established. This lake now receives drainage from 1062 ha of land in the First Mildura Irrigation Trust (FMIT) 2a district and 422 ha of land in the FMIT 2c district (LMW 2013).

The larger Lake Listy (or Koorlong South Lake) receives water from Koorlong Lake during

periods of high drainage via a connecting channel (Ellis 2013). This basin also receives drainage from 277 ha of land in the FMIT 2b district. The Koorlong Lakes also receive some storm water run-off from nearby residential properties (LMW 2013).

4.1.1 Environmental watering

Environmental water is delivered to the Cardross and Koorlong Lakes through Lower Murray Water infrastructure from the Red Cliffs Irrigation District. As these sites have no connection to the Murray River environmental water allocations are the only source of water apart from irrigation drainage and stormwater. Water delivery for irrigation, which uses the same infrastructure, has prior right and environmental water delivery is subject to interruption as a result of this.

Environmental watering at Cardross Lakes was originally provided to support the diverse native fish communities at this site up until 2001/2002. In 2004 Murray hardyhead became the focus of the environmental watering program at this site. In 2007 the Department of Sustainability and Environment (now DEPI) set up an Emergency Action Plan to preserve Murray hardyhead habitat effected by reduced water supply, including Cardross Lakes (Ellis et al. 2011). The Plan was established to try to prevent the extinction of Murray hardyhead which were at this time limited to four populations in Victoria and three in South Australia (Ellis 2008). This Action Plan resulted in delivery of environmental water supply to Cardross Lakes.

As part of the 2007 Action Plan a channel to allow diversion of environmental and drainage water directly to Basin 1 was constructed. A levee was later constructed to reduce environmental water requirements and confine delivery to a small section of Basin 1 (now referred to as Cardross Basin 1 East) for the management of Murray hardyhead. Cardross Basin 1 East received environmental water from the Victorian River Murray Flora and Fauna Bulk Entitlement since 2007 to sustain the Murray hardyhead population at this site. Cardross Basin 1 West was dry for almost two years before being reconnected to Basin 1 East in July 2010. Environmental water has since been used to maintain the connection and water levels in Basins 1 East and West with approximately 1026.7ML delivered to these basins in 2012-2013 (Ellis 2013).

DSE (now DEPI) and the Mallee Catchment Management Authority (MCMA) began delivering environmental water to the Koorlong Lakes in 2009 as the site was deemed suitable for translocation of Murray hardyhead and fish were released to Koorlong Lake later that year (Ellis et al. 2011). Water levels in Koorlong Lake have been sustained through drainage and stormwater inflows since 2010/11.

Environmental watering has continued at Cardross and Koorlong Lakes with Murray hardyhead in mind and in accordance with recommendations in the National Recovery Plan for this species.

Table 11 A summary of recent environmental watering events in Cardross WMU
*the cost of delivery is dependent on factors such as fuel prices, river heights, site access, type of pump required, volume to be pumped etc

Water year	Inflow source	Total Volume (ML)		Cost of delivery ($)
		Cardross	Koorlong	
1997/98	Victorian River Murray Flora and Fauna Bulk Entitlement	800	0	*$30-45/ML
1998/99		1000	0	
1999/00		1200	0	
2001/02		1766.8	0	
2002/03		1997.1	0	
2003/04		2005.2	0	
2004/05		1702	0	
2005/06		1060.1	0	
2006/07		810.1	0	
2007/08		145.7	0	
2008/09		138.524	0	
2009/10		119.066	93.235	
2010/11		1012.726	36.028	
2011/12		820.602	0	
2012/13		1026.662	0	

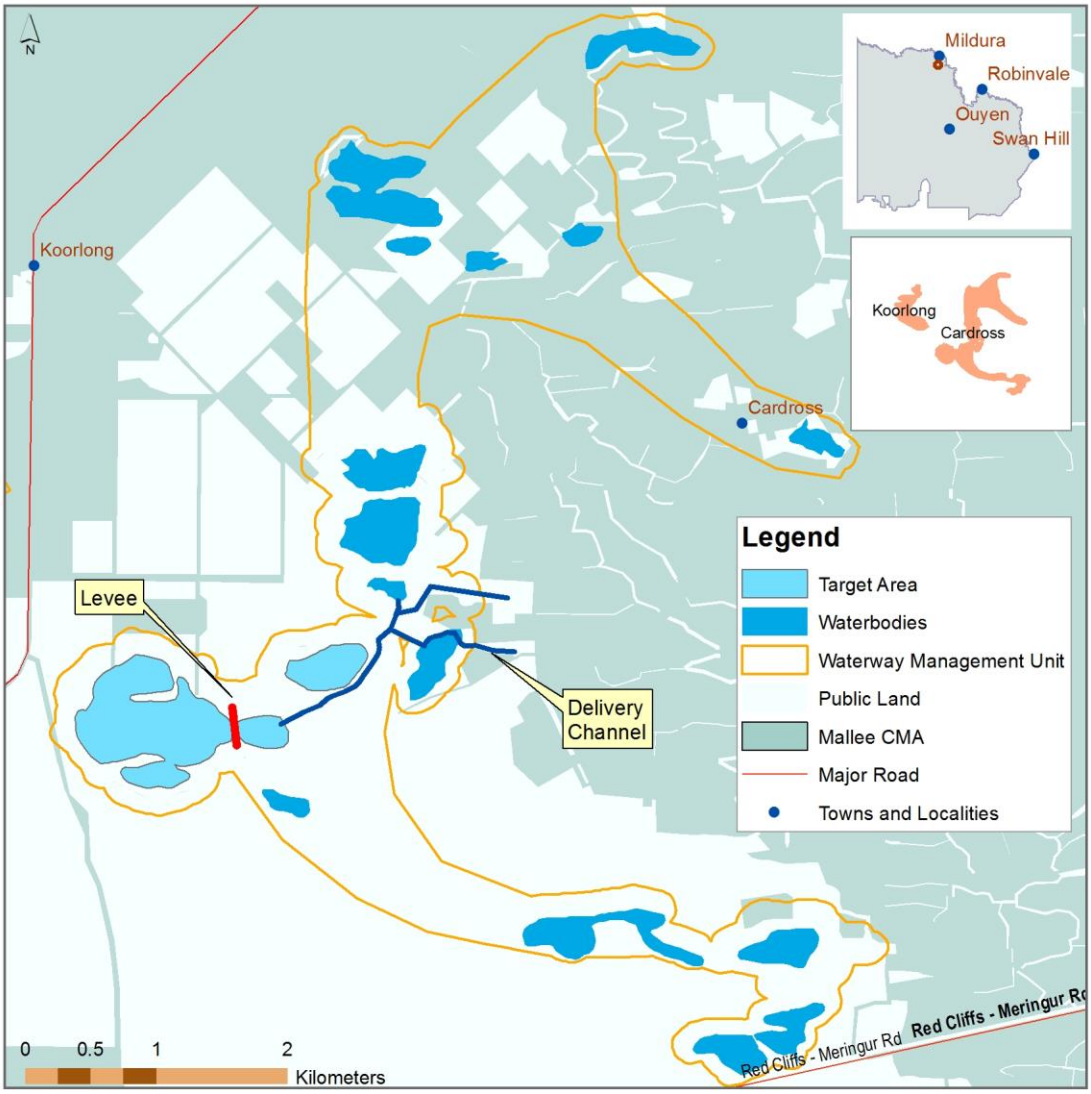


Figure 10 Inundation extent of environmental water events at Cardross Lakes

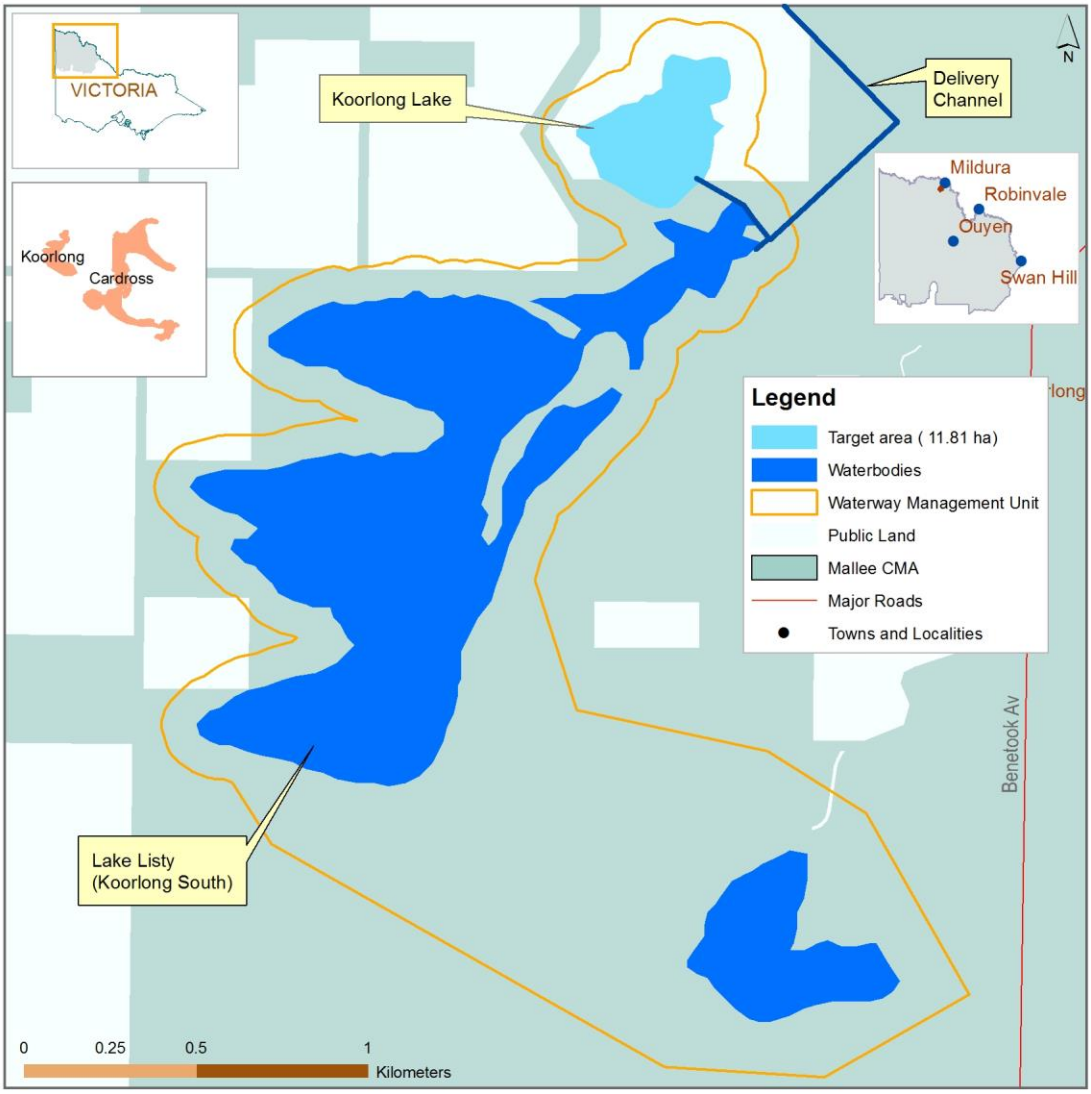


Figure 11 Inundation extent of environmental water events at Koorlong Lakes

5. THREATS AND CONDITION

5.1 Water dependent threats

The values for the target area of the Cardross and Koorlong Lakes WMU's are described in section 3. Some of the threats which may have an impact on the Cardross and Koorlong Lakes WMU's include:

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

The main threat to the Cardross and Koorlong wetlands is the changed water regime due to improvements to water delivery infrastructure and more efficient water-use on surrounding irrigated properties. As artificial basins constructed for irrigation drainage, Cardross Lakes rely on this inflow as their only source of water other than environmental allocations. With a reduction in drainage and recent dry conditions the lakes have been under significant stress affecting productivity and wetland function.

The Koorlong Lakes receive some storm water inflow as well as irrigation drainage and Koorlong Lake has remained self-sufficient since it last received environmental water in 2010/11. However, without the saline water inflows to Lake Koorlong from the local irrigation drainage network this wetland would require further environmental water delivery. Annual freshwater top-ups of this kind may lead to freshening of the system, similar to the current conditions at Cardross Basin 1. For this reason is essential that the connection of Koorlong Lakes to the drainage network is maintained.

The historical use of Cardross and Koorlong Lakes as irrigation drainage basins led to issues with increased salinity. Although increased salinity can be detrimental to surrounding vegetation, levels in Cardross and Koorlong Lakes need to be maintained appropriately for Murray hardyhead at these sites. In fact, the Cardross Lakes are now becoming fresher due to reduced irrigation drainage entering the Lakes and repeated addition of freshwater (Ellis 2013). Although this freshwater, provided through environmental water delivery, is essential for Murray hardyhead, the associated issue of lowering salinity is a serious management issue and the transportation of salt into the Cardross Lakes is being investigated to address this. Murray hardyhead tolerate moderately saline conditions, although lower levels may be required to facilitate breeding and recruitment (Backhouse *et al*. 2008). Ellis (2013) suggests Murray hardyhead can tolerate a range of approximately 1,000 to 110,000 $\mu S.cm^{-1}$ although low EC may actually benefit competitive species. The ability of Hardyhead to tolerate elevated salinity levels gives them an advantage over competitive introduced species such as Carp and Eastern gambusia. Elevated salinity levels are also required to support the Ruppia habitat which Murray hardyhead rely on. If the saline nature of Cardross Lakes cannot be maintained into the future their viability as Murray hardyhead refuges may be lost. Various translocation sites in the Mallee region are being assessed to address this.

Ellis (2013) suggests that the maintenance of a high water level in Cardross Basin 1 East has reduced salinity levels in the basin. Ellis (2013) further suggests these less saline conditions have led to a reduction in Ruppia in the basin which may be contributing to a decline in Murray hardyhead. Ellis (2013, pers comm., 11th Dec) also states that a gradual drawdown in water level may be necessary for Ruppia re-establishment and found the abundance of zooplankton increased in wetlands which underwent drawdown and rewetting phases. No Murray hardyhead have been recorded in Cardross Basin 1 East since June 2012 (Ellis 2013).

Introduced fauna such as Common Carp pose a serious threat to the ecology of Cardross Lakes. Carp have been found to contribute to the loss of aquatic vegetation and increased turbidity, resulting in loss of habitat for waterfowl (Purdy & Loyn 2008). This species also competes with the native fish for habitat and food as well as having a detrimental effect on water quality (MCMA 2003). This is of particular concern given that these wetlands are one of the last remaining sites containing Murray hardyhead. However, managing salinity levels for Hardyhead can also help control carp which are less salt tolerant.

Introduced *Gambusia holbrooki* (Mosquito fish) are considered to have imposed significant competitive pressure on Murray hardyhead populations at Cardross Basin 1 East and West and Koorlong Lake. This aggressive introduced species has been observed to chase adult and juvenile Hardyhead from their preferred habitat and also prey on Murray hardyhead larvae (Ellis *et al*. 2011).

Cumbungi has encroached on fringing wetland vegetation and Ruppia habitat at Cardross Lakes (Ellis 2012). This plant uses large amounts of water and can alter the wetland character, reduce plant diversity and obstruct water flow (Roberts & Marston 2011). Indeed, the growth of Cumbungi in a delivery channel in the past created a blockage to environmental water delivery at this site (Ellis 2008). Environmental water may be useful in managing this species by maintaining ponding at high enough levels to submerge the dense Cumbungi stands for prolonged periods. Managing water levels to allow a drop over summer can also disconnect Cumbungi from the wetlands and allow for treatment. A list of exotic flora and fauna species identified in the Cardross and Koorlong Lakes WMU's are listed in Appendix 3.

5.2 Current condition

One method for assessing the current condition of a wetland is the Index of Wetland Condition (IWC) developed by DEPI. The IWC defines wetland condition as the state of the biological, physical, and chemical components of the wetland ecosystem and their interactions. The condition of three of the wetlands within the target area of the Cardross and Koorlong Lakes WMU (see map Appendix 6) was assessed in December 2009.

The IWC has five sub-indices based on the catchment of the wetland and its fundamental characteristics: physical form, hydrology, water properties, soils and biota. Each sub-index is given a score between 0 and 20 based on the assessment of a number of measures. The overall IWC score is not a simple summation of the sub-index scores. A formula is used that weights each sub-index according to the contribution it makes to the overall condition of the wetland. The wetland hydrology sub-index for example contributes more to the overall score than the soils sub-index. Further information on the IWC scoring is provided in Appendix 6.

The overall IWC rating for three wetlands assessed in this WMU in December 2009 was poor (Table 12).

Table 12 IWC sub index and overall score for three wetlands in the target area

Wetland	**Wetland #7329010030** Cardross Lakes Basin 1 (East & West)						**Wetland # 7329025045** Cardross Lakes Basins C, D & E				**Wetland #732902805** Cardross Lakes Basin 4	
Site	**Site 1**		**Site 2**		**Site 3**		**Site 1**		**Site 2**		**Site 1**	
IWC sub-index	**Score**	**Category**	**Score**	**Category**	**Score**	**Category**	**Score**	**Category**	**Score**	**Category**	**Score**	**Category**
Wetland catchment	4.5	Poor	8	Poor	4.5	Poor	7	Poor	7	Poor	8.5	Moderate
Physical form	20	Excellent	20	Excellent	18	Excellent	20	Excellent	20	Excellent	18	Excellent
Hydrology	0	Very Poor	0	Very Poor	0	Very Poor	0	Very Poor	0	Very Poor	0	Very Poor
Water properties	7	Poor	10.33	Moderate	13.67	Good	5	Poor	10.33	Moderate	8.33	Moderate
Soils	19.5	Excellent	19.5	Excellent	19.9	Excellent	19.35	Excellent	19.85	Excellent	19.75	Excellent
Biota	11.3	Poor	18.94	Excellent	3.99	Very Poor	4.02	Very Poor	5.96	Very Poor	3.76	Very Poor
Overall IWC score	**4**	**Poor**	**6**	**Poor**	**3**	**Poor**	**3**	**Poor**	**4**	**Poor**	**3**	**Poor**

The hydrology scores were very poor for each site and the biota ratings were poor to very poor at each site, with the exception of one site at Cardross Lake which scored excellent for biota. Hydrology was considered to be very poor due to a reduction in water reaching the wetlands as a result of improved irrigation practices and dry conditions. These altered conditions are also reflected in the poor biota score which indicates a lack of diversity and abundance of the species expected to be present in these wetlands.

Recent surveys of Cardross and Koorlong Lakes failed to capture any Murray hardyhead in Basin 1 East. Salinity levels in this basin may be too low to inhibit pest species and to support Ruppia and Murray hardyhead. A small number of Murray hardyhead were recorded in Cardross Basin 1 West but the presence of Ruppia was limited to seedlings only. As Basin 1 East no longer supports Murray hardyhead it is vital that Basin 1 West is not allowed to dry out or the Cardross Lakes population may be lost entirely (Ellis, I. 2013, pers comm., 11th December).

Murray hardyhead continue to survive at Koorlong Lake and although established through translocaion, this site may be the most secure population in the Mallee region. This lake supports Ruppia and the Murray hardyhead population within it appear to be breeding well and slowly increasing in number. However, further increases in Murray hardyhead numbers are required if individuals are to be taken from Koorlong Lake for translocation to other sites (Ellis , I. 2013, pers comm., 11th December).

The altered water regime is considered the major threat for the target area of the Cardross and Koorlong Lakes WMU's and is the primary factor behind the development of this environmental water management plan.

5.3 Condition trajectory

Management intervention has already begun in the Cardross and Koorlong Lakes WMU's. Environmental watering events began at Cardross Lakes in 1997, initially to maintain native fish diversity and later for Murray hardyhead specifically, and at Koorlong Lakes in September 2009 to support Murray hardyhead populations.

If this intervention is not continued the benefits from these watering events to aquatic macrophyte and zooplankton communities may not be sustained. Salinity levels within the lakes may increase, possibly beyond the tolerance of Murray hardyhead and Ruppia species. Water levels will decrease and eventually the lakes may dry out. Ryan *et al.* (2004) suggest that Cardross Basins1, 2 and 3 would most likely dry out completely and the likelihood of regeneration of aquatic macrophyte communities through seed bank would decrease with each year the wetlands remained dry. This would result in loss of Ruppia communities and Murray hardyhead populations at these sites could be lost entirely under these conditions.

6. MANAGEMENT OBJECTIVES

6.1 Seasonally adaptive approach

Victoria has adopted an adaptive and integrated management approach to environmental management. A key component of this approach for environmental watering is the 'seasonally adaptive' approach, developed through the Northern Region Sustainable Water Strategy and incorporated into the Victorian Waterway Management Strategy.

The seasonally adaptive approach identifies the priorities for environmental watering, works and complementary measures, depending on the amount of water available in a given year. It is a flexible way to deal with short-term climatic variability and helps to guide annual priorities and manage droughts. The approach is outlined in Table 13.

The seasonally adaptive approach has been used to guide the watering regime under various climatic scenarios. In drier periods, restricted water resource availability will potentially limit the number of ecological objectives which can realistically be provided through environmental water management. However, these ecological objectives can be achieved in wetter periods as water resource availability increases.

Table 13 The seasonally adaptive approach to river and wetland management (DEPI, 2009)

	Drought	Dry	Average	Wet to very wet
Long-term ecological objectives	Long-term objectives to move towards ecologically healthy rivers - set through regional river health strategies and sustainable water strategies and reviewed through the 15-year resource review			
Short-term ecological objectives	• Priority sites have avoided irreversible losses and have capacity for recovery	• Priority river reaches and wetlands have maintained their basic functions	• The ecological health of priority river reaches and wetlands has been maintained or improved	• The health and resilience of priority river reaches and wetlands has been improved
Annual management objectives	• Avoid critical loss • Maintain key refuges • Avoid catastrophic events	• Maintain river functioning with reduced reproductive capacity • Maintain key functions of high priority wetlands • Manage within dry-spell tolerances	• Improve ecological health and resilience	• Maximise recruitment opportunities for key river and wetland species • Minimise impacts of flooding on human communities • Restore key floodplain linkages
Environmental water reserve	• Water critical refuges • Undertake emergency watering to avoid catastrophic events • Provide carryover (for critical environmental needs the following year) • If necessary, use the market to sell or purchase water	• In priority river reaches provide summer and winter baseflows • Water high priority wetlands • Provide river flushes where required to break critical dry spells • Provide carryover (for critical environmental needs the following year) • If necessary, use the market to sell or purchase water	• Provide all aspects of the flow regime • Provide sufficient flows to promote breeding and recovery • Provide carryover to accrue water for large watering events • If necessary, use the market to sell or purchase water	• Provide overbank flows • Provide flows needed to promote breeding and recovery • If necessary, use the market to sell or purchase water
River and wetland catchment activities	• Protect refuges (including stock exclusion) • Increase awareness of the importance of refuges • Enhanced monitoring of high risk areas and contingency plans in place • Investigate feasibility of translocations • Environmental emergency management plans in place • Protect high priority river reaches and wetlands through fencing; pest, plant and animal management; and water quality improvement works • Implement post-bushfire river recovery plans	• Protect refuges • Protect high priority river reaches and wetlands through fencing, revegetation, pest plant and animal management, water quality improvement and in-stream habitat works • Environmental emergency management plans in place • Improve connectivity • Implement post-bushfire river recovery plans	• Protect and restore high priority river reaches and wetlands through fencing, revegetation, pest plant and animal management, water quality improvement and in-stream habitat works • Monitor and survey river and wetland condition • Improve connectivity between rivers and floodplain wetlands	• Protect and restore high priority river reaches and wetlands through fencing, revegetation, pest plant and animal management, water quality improvement and in-stream habitat works • Monitor and survey river and wetland condition • Improve connectivity between rivers and floodplain wetlands • Emergency flood management plans in place • Implementation of post-flood river restoration programs

6.2 Management goal

The overall goal proposed for Cardross and Koorlong Waterway Management Units target area has been developed through consultation with various experts and stakeholders including DEPI, Parks Victoria, and local residents. The goal considers the values the wetland supports and the potential threats that need to be managed. This includes consideration of the values the wetland has historically supported and the likely values it could support into the future.

Cardross and Koorlong Waterway Management Unit management goal

To provide a water regime to maintain and improve Murray hardyhead populations and the Ruppia aquatic habitat which supports them.

6.3 Ecological and hydrological objectives

6.3.1 Ecological objectives

Ecological objectives represent the desired ecological outcomes of the site based on the key values outlined in section 3. In line with the Victorian Waterway Management Strategy (VWMS) the ecological objectives are expressed as the target condition or functionality for each key value. The ecological objectives involve establishing one of the following trajectories of each key value, which is related to the present condition or functionality of the value:

- maintain
- improve
- protect
- re-instate

Table 14 Ecological objectives for the target area

Ecological objective	Site	Justification (value based)
Maintain Murray hardyhead populations	Koorlong Lakes	As a critically endangered (DEPI) species the downward trend in Murray hardyhead populations across Victoria must be stopped as a first priority.
Improve Murray hardyhead populations	Cardross & Koorlong Lakes	An improvement in the Murray hardyhead numbers at these sites is the next required progression towards ensuring the persistenceand recovery of this species. An increase in numbers will also allow harvesting of individuals for translocation to new sites.
Maintain Ruppia community	Koorlong Lakes	Maintaining and improving the health of Ruppia communities is of particular significance for Murray hardyhead but will also benefit other aquatic fauna, frogs and waterbirds through increased habitat and foraging opportunities.
Improve Ruppia community	Cardross & Koorlong Lakes	An improvement in Ruppia is the next required progression towards increasing habitat for Murray hardyhead and other aquatic fauna at these sites. Ruppia could also be harvested for translocation to other sites if these populations increase.

The first ecological objective is to maintain the Murray hardyhead and Ruppia communities at Koorlong Lakes. The second objective aims to see an increase in Murray hardyhead abundance and Ruppia communities at Cardross and Koorlong Lakes. Attainment of the ecological objectives is anticipated to have wider benefits for the target area and is expected to result in: :

- Improving wetland productivity and zooplankton communities
- Better control of cumbungi and pest fish species through management of water and salinity levels
- Improvement of fringing emergent vegetation
- An increase in habitat and foraging grounds for other aquatic and semi-aquatic species

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

6.3.2 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 firstly maintaining the health of the Murray hardyhead and Ruppia communities and then improving the health of these communities where possible.

In order for Cardross and Koorlong Lakes to support Murray hardyhead populations water will need to remain in these wetlands on a permanent basis. This will require annual environmental water inflows to the lakes to maintain adequate levels to allow Murray hardyhead to complete their life cycle and increase in abundance. Environmental watering should commence from August to October to coincide with Hardyhead breeding season (October – November). Water levels should be high enough to inundate exposed sediments to promote a rise in zooplankton as a food source for breeding Murray hardyhead. Water levels should be allowed to decrease through summer to expose wetland sediments and fringing vegetation whilst also maintaining Ruppia beds within the wetlands. This disconnection between the wetland and the fringing vegetation would also allow for Cumbungi control. Low water levels in Autumn could also provide opportunity for Gambusia control (Ellis 2013).

Although continuous flooding may seem appropriate for aquatic macrophytes such as Ruppia seasonal variation in water levels is also beneficial for these plants. Brock (1981) states that the drying of seeds and substrate during a dry phase in ephemeral wetlands habitats is likely to break the seed coating and make seeds more permeable to water on rewetting of the wetland. These aquatic species may persist in wetlands that are frequently flooded but if complete drying of the wetland occurs over summer they will die off and be replaced by lake bed herbs (EA 2007). Roberts & Marston (2011) states a slow drawdown of water level is required to prevent collapse of plants. Ellis (2013, pers comm., 11th Dec) supports this, suggesting a gradual drawdown phase is essential for Ruppia establishment. Drawdown of water level in the wetlands is proposed to occur naturally through evaporation.

The recommended seasonal water levels for each of the key Lakes are listed in Table 15. These figures have been determined through close monitoring and consideration of the requirements of Murray hardyhead and Ruppia species described above. Although these water levels are recommended for best management of Murray hardyhead and Ruppia communities they may not always be achieved depending on water availability, delivery constraints and climatic conditions.

Table 15 Hydrological objectives for Cardross and Koorlong Waterway Management Units (Ellis 2013)

Wetland Name	Preferred timing of inflows	Min Water level (late Dec - Aug)	Optimal high water level (late Aug -mid Dec)
Cardross Basin 1 West (73.15 ha)	Aug - Oct	37.2 mAHD	>38.5mAHD
Cardross Basin 1 East (7.98 ha)	Aug - Oct	37.3mAHD	>38.0mAHD
Koorlong Lake (11.81 ha)	Aug - Oct	36.7mAHD	>38.0mAHD

6.3.3 Watering regime

The wetland watering regime has been derived from the ecological and hydrological objectives and is limited by these specific objectives. To allow for adaptive and integrated management, the watering regime is framed using the seasonally adaptive approach. This means that a watering regime is identified for optimal conditions, as well as the minimum tolerable watering scenario. The minimum watering regime is likely to be provided in drought or dry years and the optimum watering regime in average or wet conditions. There is no maximum water regime in this case as management for Murray hardyhead and Ruppia communities would be jeopardised by watering above the optimal regime.

However, 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.

Minimum watering regime

Provide environmental water to the target areas each year from August to October to above the minimum recommended level. Allow the water level to decrease slowly over summer, ensuring it does not fall below the identified minimum level.

Optimal watering regime

Provide environmental water to the target area each year from August to October to the recommended optimal level to inundate fringing vegetation. Allow the water level to decrease slowly over summer to (but not below) the recommended minimum water level.

7. POTENTIAL RISKS OF AND MITIGATION MEASURES FOR ENVIRONMENTAL WATERING

A table of potential risks and means for mitigating these is used as the basis for assessing the risk of environmental water delivery at this site. The terms for values that may be impacted come from the Aquatic Value Identification and Risk Assessment (AVIRA) Report (Peters, 2009).

The table identifies potential risks, events that could cause such risks, the outcomes of such risks, and the actual values that could subsequently be impacted by each risk. Mitigation strategies for each event are also identified.

Table 16 Potential risks associated with environmental water delivery

#	Risk	Description	Potential Impacts								Mitigation
			Environmental					Social		Economic	
			Fish *Water regime does not support breeding and feeding requirements*	**Birds** *Water regime does not support breeding and feeding requirements*	**Amphibians** *Water regime does not support breeding and feeding requirements*	**Invertebrate** *Water regime does not support breeding and feeding requirements*	**Native aquatic flora** *Watering requirement does not support establishment and growth.*	Reduced public access and use	Degradation of cultural heritage sites	Flooding of adjacent land	
1	Required watering regime not met	Flood duration too long or short	✓	✓	✓		✓	✓			Determine environmental water requirements based on seasonal conditions and to support potential bird breeding events Monitor flood duration to inform environmental water delivery Monitor the ecological response of the wetland to flooding Add or drawdown water where appropriate or practical
		Flood timing too late or early	✓	✓	✓		✓	✓			Liaise with Goulburn-Murray Water to seek optimum timing of water delivery Monitor flood timing to inform environmental water delivery Monitor the ecological response of the wetland to flooding
		Flooding depth too shallow or deep	✓	✓			✓	✓	✓	✓	Determine environmental water requirements based on seasonal conditions and to support potential bird breeding events Monitor flood depth to inform environmental water delivery Liaise with adjoining landowners prior to and during the delivery of environmental water to discuss and resolve potential or current flooding issues Add or drawdown water where appropriate or practical
		Flood frequency too long or short	✓	✓	✓	✓	✓	✓			Prioritise water requirements of wetlands in seasonal watering proposals according to their required water regimes and inundation history Monitor the condition of the wetland Monitor the ecological response of the wetland to flooding

2	Poor water quality	Low dissolved oxygen	✓	✓			✓				Monitor dissolved oxygen levels and the ecological response of the wetland to flooding Add or drawdown water where appropriate or practical
		High turbidity	✓				✓				Monitor turbidity levels and the ecological response of the wetland to flooding Add or drawdown water where appropriate or practical
		High water temperature	✓				✓				Monitor water temperature and the ecological response of the wetland to flooding Add or drawdown water where appropriate or practical
		Increased salinity levels	✓		✓	✓	✓				Monitor salinity levels and the ecological response of the wetland to flooding Add or drawdown water where appropriate or practical
		Increased nutrient levels									Monitor nutrient and Blue Green Algae levels, and the ecological response of the wetland to flooding Place public warning signs at the wetland if BGA levels are a public health risk Add or drawdown water where appropriate or practical
		Increased organic matter	✓				✓				Implement the required water regime
3	Pest aquatic plant and animal invasion	Introduction of pest fish	✓		✓	✓	✓				Monitor the ecological response of the wetland to flooding Install a carp screen Implement an appropriate drying regime
		Growth and establishment of aquatic pest plants	✓	✓	✓	✓	✓				Monitor the abundance of native and pest aquatic plants Control pest plants in connected waterways Spray or mechanically remove pest plants Implement an appropriate drying regime

8. ENVIRONMENTAL WATER DELIVERY INFRASTRUCTURE

8.1 Constraints

The existing arrangements (Section 4.1) allow 554 ha of land to be inundated by environmental watering in the Cardross and Koorlong Lakes WMU's (Figures 12 and 13). However, inundation of this extent is considered to be unsustainable, inefficient use of environmental water and would be severely limited by allocation amounts, security of supply and delivery capacity. Instead inundation at these sites will be limited to priority basins that currently support Murray hardyhead populations. This will include Cardross Lakes Basin 1 East and West and Koorlong Lake with a total area of 93 ha.

8.2 Infrastructure recommendations

Proposed works that may be considered in the future include piping of the open channels that deliver water to Cardross and Koorlong Lakes (Figures 12 and 13). These infrastructure upgrades would facilitate more efficient use of water and negate some of the issues associated with pest plant and animals such as cumbungi stands establishing in open channels and inhibiting inflows.

The installation of a regulator at between Cardross basins C and D is also being considered as these basins (Figure 12), along with Lake Listy, are being investigated to establish their suitability as Murray hardyhead habitat. A regulator on the delivery channel to Koorlong Lake is also proposed (Figure 13) to enable water to be diverted to Lake Listy to facilitate better control over the water regime in Koorlong Lake and enable watering of Lake Listy should Murray hardyhead be translocated there. Currently water only flows to Lake Listy from Koorlong Lake during periods of high irrigation drainage.

The costs involved in such infrastructure upgrades are being investigated and funding for detailed designs is currently being sought.

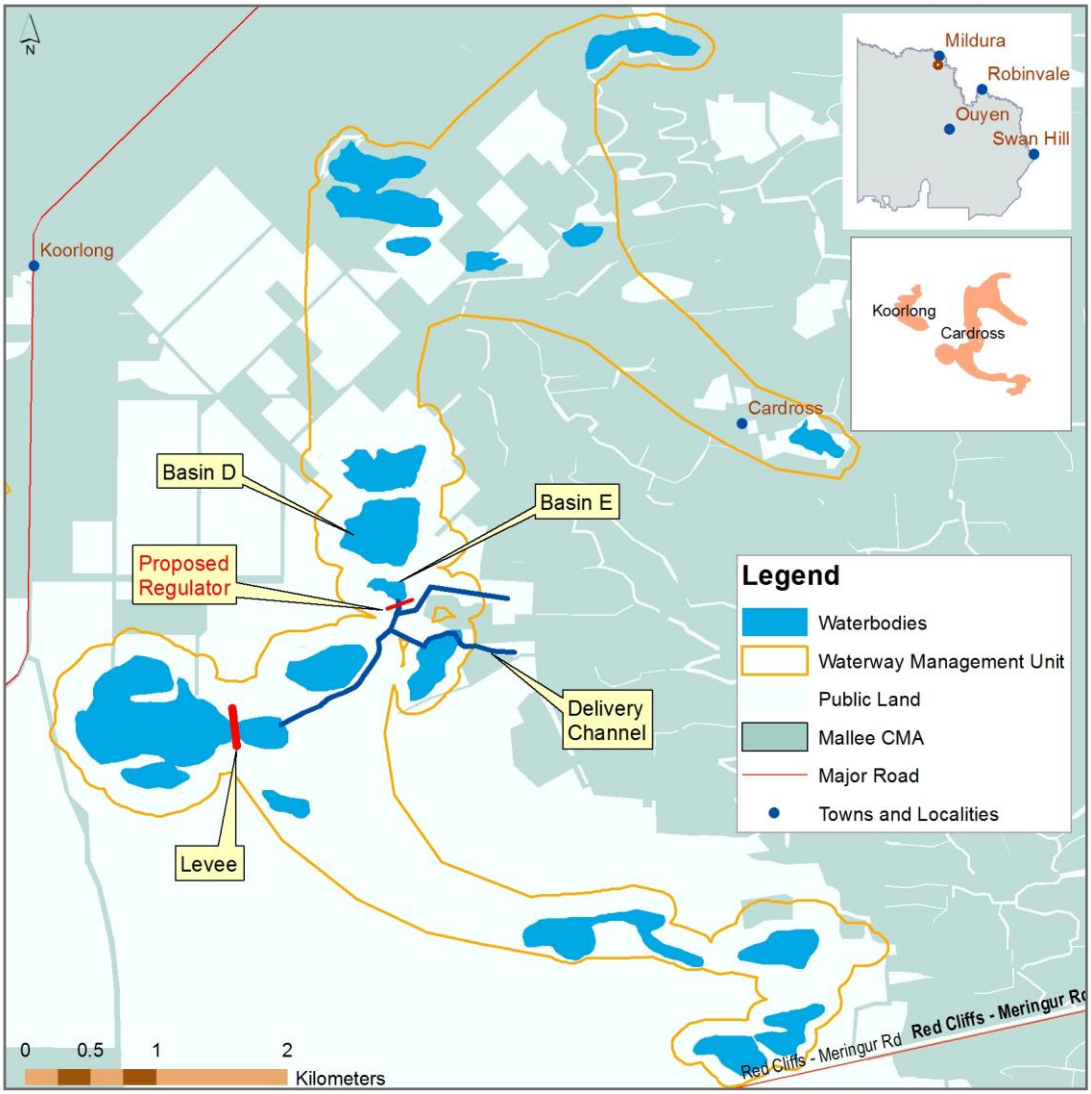


Figure 12 Proposed infrastructure at Cardross Lakes WMU

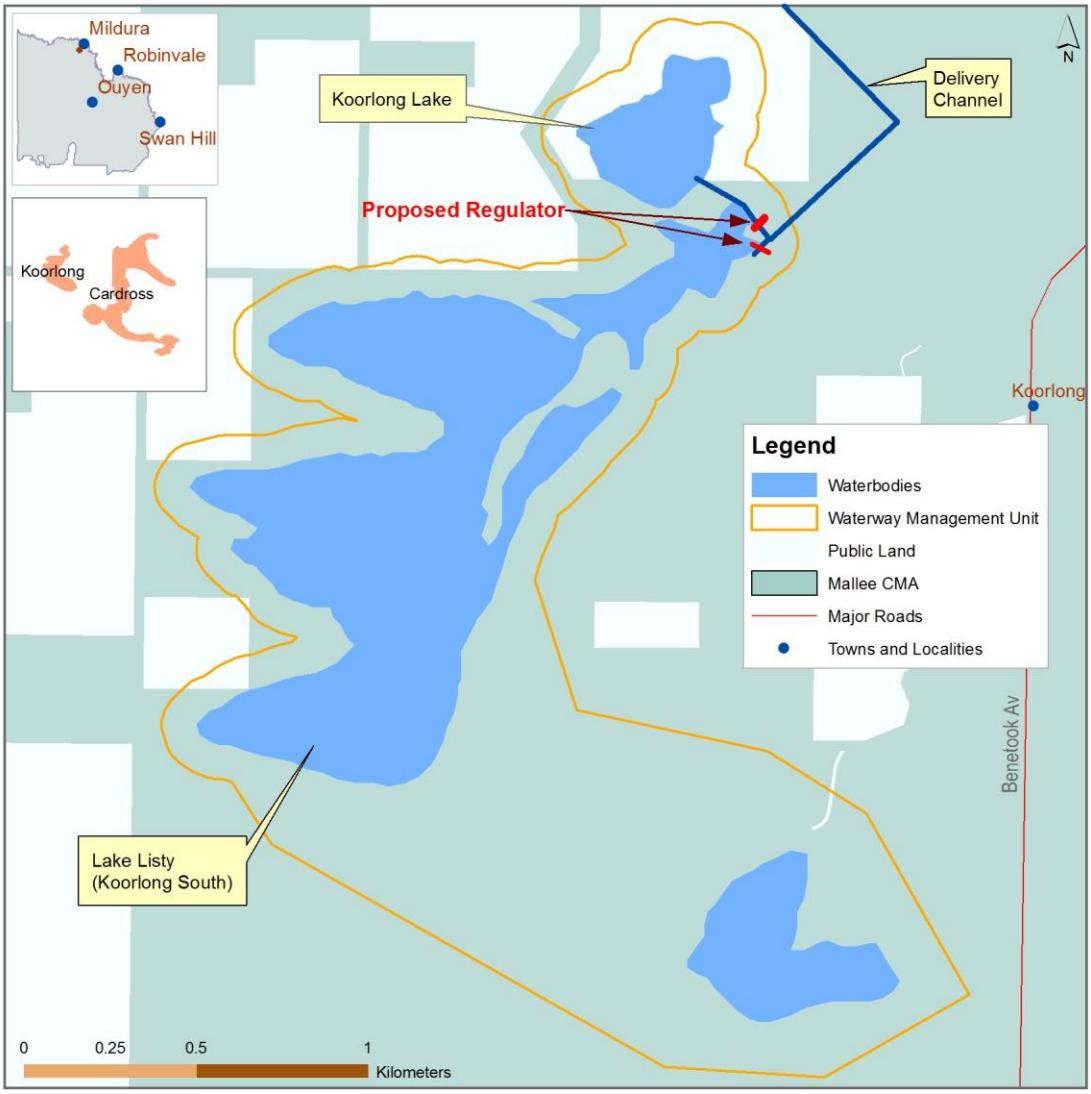


Figure 13 Proposed works Koorlong Lakes WMU

9. 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 17.

Table 17 Table 17 Knowledge gaps and recommendations for the target area

Knowledge and data gaps	Action recommended	Responsibility
Suitability of Cardross Basins C, D & E and Lake Listy as Murray hardyhead habitat	Survey, data collection and monitoring	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
Conceptual and detail designs for the management works	Engage consultants to carry out investigations and designs	
Condition of Koorlong Wetlands	Assess using Index of Wetland condition method	
Role of wetland on fish breeding and population	Monitoring of fish population	
Accurate depth and volumes for the wetland	Install depth gauges and bathymetric survey	
Nesting habits of birds at the site	Data collection and monitoring	
Impacts of climate variability	Data collection and monitoring	
Understanding of causes of poor condition	Data collection and monitoring	
Fauna presence for each wetland – especially fish	Survey, data collection and monitoring	
Flora presence for each wetland – especially aquatic flora	Survey, data collection and monitoring	

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APPENDIX 1: ENVIRONMENTAL WATER SOURCES

Sources of environmental water potentially available for this site under current arrangements and in the future.

Commonwealth Environmental Water Holder (CEWH)

Under *Water for the Future* the Commonwealth Government committed $3.1 billion to purchase water in the Murray-Darling Basin over 10 years. The Commonwealth Environmental Water Holder will manage their environmental water.

The Commonwealth Water Act 2007 identified that "the Commonwealth Environmental Water Holder must perform its functions for the purpose of protecting or restoring environmental assets so as to give effect to relevant international agreements". Wetlands listed as of International Importance (Ramsar) are considered priority environmental assets for use of the commonwealth environmental water (DEWHA 2008).

Victorian Environmental Water Holder (VEWH)

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

- the Victorian River Murray Flora and Fauna Bulk Entitlement; and
- future Northern Victoria Irrigation Renewal Project Environmental Entitlement.

In 1987 an annual allocation of 27600 ML of high security water was committed to flora and fauna conservation in Victorian Murray wetlands. In 1999, this became a defined entitlement for the environment called the Victorian River Murray Flora and Fauna Bulk Entitlement.

The Northern Victoria Irrigation Renewal Project (NVIRP) water savings are predicted to provide up to 75 GL as a statutory environmental entitlement, which will be used to help improve the health of priority stressed rivers and wetlands in northern Victoria (DEPI, 2008). The entitlement will have properties which enable the water to be used at multiple locations as the water travels downstream (provided losses and water quality issues are accounted for); meaning that the water can be called out of storage at desired times to meet specific environmental needs.

The Living Murray Initiative (TLM)

The Living Murray (TLM) was established in 2002 as a partnership of the Commonwealth, NSW, Victorian, South Australian and ACT governments. The long term goal of this program is to achieve a healthy working Murray River system for the benefit of all Australians.

In 2004, under the 'First Step' decision, Ministers from TLM partner governments committed to recover a long term average of 500 GL of water to improve environmental outcomes at six Icon Sites. The recovery of the 500 GL target is now nearing completion and this water can be used for environmental watering at any of the following six Icon Sites: River Murray Channel, Barmah–Millewa Forest, Gunbower–Koondrook–Perricoota Forest, Hattah Lakes, Chowilla Floodplain and Lindsay–Wallpolla Islands, Lower Lakes, and Coorong and Murray Mouth.

Donations

People who hold water entitlements sometimes donate water to their local catchment management authority for environmental use. Additionally, people have donated money to non-governmental organisations to buy temporary water allocation for environmental use. While the scale of donated water is generally small relative to other water sources, it can provide a valuable contribution, especially in times of critical needs.

River Murray Unregulated Flow (RMUF)

Unregulated flows in the River Murray system are defined as water that cannot be captured in Lake Victoria and is, or will be, in excess of the required flow to South Australia. If there is a likelihood of unregulated flow event in the River Murray system, the Authority provides this advice to jurisdictions The Upper States then advise the Authority on altered diversion rates and environmental releases within their existing rights to unregulated flows.

Based on the information received from Jurisdictions, the Authority reassesses the event and, if necessary, limits Upper States' access to ensure that the unregulated flow event is not over committed. The Authority then issues formal unregulated flow advice to jurisdictions including any limits to States access.

Depending on the volume of water remaining, the Authority advises EWG and the Water Liaison Working Group (WLWG) on the availability and volume of RMUF. Whilst there is a range of measures that can be undertaken by Upper States as part of their 'prior rights' during unregulated flows, RMUF events are prioritised solely for the environment.

APPENDIX 2: LEGISLATIVE FRAMEWORK

International agreements and conventions

Ramsar Convention on Wetlands (Ramsar)

The Australian Government is a Contracting Party to the convention, which is an inter-governmental treaty whose mission is "the conservation and wise use of all wetlands through local, regional and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world".

Bilateral migratory bird agreements

Australia is a signatory to the following international bilateral migratory bird agreements:

- Japan-Australia Migratory Bird Agreement (JAMBA);
- China-Australia Migratory Bird Agreement (CAMBA); and
- Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).

These agreements require that the parties protect migratory birds by:

- limiting the circumstances under which migratory birds are taken or traded;
- protecting and conserving important habitats;
- exchanging information; and
- building cooperative relationships.

Convention on the Conservation of Migratory Species of Wild Animals (Bonn)

This convention (known as the Bonn Convention or CMS) aims to conserve terrestrial, marine and avian migratory species throughout their range. It is an intergovernmental treaty, concluded under the aegis of the United Nations Environment Programme, concerned with the conservation of wildlife and habitats on a global scale. The Convention was signed in 1979 in Bonn, Germany, and entered into force in 1983.

Commonwealth legislation

Environment Protection and Biodiversity Conservation Act 1999 (EPBC)

This is the key piece of legislation pertaining to biodiversity conservation within Australia. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places – defined in the EPBC Act as matters of national environmental significance.

Water Act 2007 (Commonwealth Water Act)

This establishes the Murray-Darling Basin Authority (MDBA) with the functions and powers, including enforcement powers, needed to ensure that Basin water resources are managed in an integrated and sustainable way.

Aboriginal and Torres Straight Islander Heritage Protection Act 1984

This aims to preserve and protect areas and objects in Australia and Australian waters that are of particular significance to indigenous people from injury or desecration.

State legislation and listings

Flora and Fauna Guarantee Act 1988 (FFG)

This is the key piece of Victorian legislation for the conservation of threatened species and communities and for the management of potentially threatening processes.

Advisory lists of rare or threatened species in Victoria (DEPI)

Three advisory lists are maintained by DEPI for use in a range of planning process and in setting priorities for actions to conserve biodiversity. Unlike other threatened species lists, there are no legal requirements or consequences that flow from inclusion of a species on an advisory list. The advisory lists comprise:

- Advisory List of Rare or Threatened Plants In Victoria – 2005
- Advisory List of Threatened Vertebrate Fauna in Victoria – 2007
- Advisory List of Threatened Invertebrate Fauna in Victoria – 2009

Environmental Effects Act 1978

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

Planning and Environment Act 1987

This controls the removal or disturbance to native vegetation within Victoria by implementation of a three-step process of avoidance, minimisation and offsetting.

Water Act 1989 (Victorian Water Act)

This is the key piece of legislation that governs the way water entitlements are issued and allocated in Victoria. The Act also identifies water that is to be kept for the environment under the Environmental Water Reserve. The Act provides a framework for defining and managing Victoria's water resources.

Aboriginal Heritage Act 2006

All Aboriginal places, objects and human remains in Victoria are protected under this Act.

Other relevant legislation

The preceding legislation operates in conjunction with the following other Victorian legislation to influence the management and conservation of Victoria's natural resources as well as outline obligations with respect to obtaining approvals for structural works:

- Environment Protection Act 1970
- Catchment and Land Protection Act 1994
- Heritage Act 1995
- Conservation, Forests and Lands Act 1987
- Land Act 1958
- Heritage Rivers Act 1992
- Wildlife Act 1975
- Murray Darling Basin Act 1993
- National Parks Act 1975
- Parks Victoria Act 1998
- Forests Act 1958

APPENDIX 3: FLORA AND FAUNA SPECIES LIST

Flora – Native flora recoeded within 5 km of Cardross and Koorlong Lakes

Scientific Name	Common Name	FFG	DEPI	EPBC
Abutilon otocarpum	Desert Lantern		v	
Acacia ligulata	Small Cooba			
Acacia oswaldii	Umbrella Wattle			
Acacia stenophylla	Eumong			
Acacia victoriae	Bramble Wattle		r	
Amyema miquelii	Box Mistletoe			
Atriplex eardleyae	Small Saltbush			
Atriplex leptocarpa	Slender-fruit Saltbush			
Atriplex limbata	Spreading Saltbush	L	v	
Atriplex lindleyi	Flat-top Saltbush			
Atriplex lindleyi subsp. inflata	Corky Saltbush			
Atriplex nummularia	Old-man Saltbush			
Atriplex papillata	Coral Saltbush		r	
Atriplex pumilio	Mat Saltbush			
Atriplex vesicaria	Bladder Saltbush			
Austrodanthonia caespitosa	Common Wallaby-grass			
Austrostipa scabra	Rough Spear-grass			
Brachyscome ciliaris	Variable Daisy			
Brachyscome lineariloba	Hard-head Daisy			
Calandrinia volubilis	Twining Purslane		r	
Carpobrotus modestus	Inland Pigface			
Chenopodium nitrariaceum	Nitre Goosefoot			
Chloris spp.	Windmill Grass			
Cullen pallidum	Woolly Scurf-pea	L	e	
Cynodon dactylon	Couch			
Dianella longifolia s.l.	Pale Flax-lily			
Digitaria ammophila	Silky Umbrella-grass		v	
Disphyma crassifolium subsp. clavellatum	Rounded Noon-flower			
Dissocarpus biflorus var. biflorus	Twin-flower Saltbush		r	
Dodonaea viscosa subsp. angustissima	Slender Hop-bush			
Einadia nutans subsp. nutans	Nodding Saltbush			
Enchylaena tomentosa var. tomentosa	Ruby Saltbush			
Eragrostis australasica	Cane Grass		v	
Eragrostis setifolia	Bristly Love-grass		v	
Eremophila longifolia	Berrigan			
Eucalyptus largiflorens	Black Box			
Exocarpos aphyllus	Leafless Ballart			
fam. Poaceae gen. Tragus	Burr-grass			
Frankenia serpyllifolia	Bristly Sea-heath		r	
Goodenia pusilliflora	Small-flower Goodenia			
Leiocarpa leptolepis	Pale Plover-daisy	L	e	
Leptochloa fusca subsp. fusca	Brown Beetle-grass		r	
Maireana appressa	Grey Bluebush			
Maireana brevifolia	Short-leaf Bluebush			
Maireana pentagona	Hairy Bluebush			
Maireana pyramidata	Sago Bush			
Malacocera tricornis	Goat Head		r	
Minuria cunninghamii	Bush Minuria		r	
Minuria integerrima	Smooth Minuria		r	
Muehlenbeckia florulenta	Tangled Lignum			

Muehlenbeckia horrida subsp. horrida	Spiny Lignum		r	
Paspalidium constrictum	Knottybutt Grass			
Picris squarrosa	Squat Picris		r	
Pittosporum angustifolium	Weeping Pittosporum			
Ptilotus polystachyus var. polystachyus	Long Tails		e	
Rhagodia spinescens	Hedge Saltbush			
Ruppia megacarpa	Sea Tassel			
Ruppia polycarpa	Water Tassel			
Sarcozona praecox	Sarcozona		r	
Sclerolaena diacantha	Grey Copperburr			
Sclerolaena tricuspis	Streaked Copperburr			
Senecio glossanthus s.l.	Slender GrounDEPIl			
Senna form taxon 'coriacea'	Broad-leaf Desert Cassia			
Sida ammophila	Sand Sida		v	
Sida trichopoda	Narrow-leaf Sida			
Solanum esuriale	Quena			
Sporobolus mitchellii	Rat-tail Couch			
Tecticornia indica	Brown-head Glasswort			
Tecticornia pergranulata	Blackseed Glasswort			
Tecticornia pruinosa	Bluish Glasswort			
Thysanotus baueri	Mallee Fringe-lily			
Tragus australianus	Small Burr-grass		r	
Vittadinia spp.	New Holland Daisy			

Flora – Exotic

Scientific Name	**Common Name**
Asparagus officinalis	Asparagus
Aster subulatus	Aster-weed
Avena spp.	Oat
Avena sterilis subsp. ludoviciana	Sterile Oat
Brassica tournefortii	Mediterranean Turnip
Bromus rubens	Red Brome
Chondrilla juncea	Skeleton Weed
Emex australis	Spiny Emex
Hordeum murinum s.l.	Barley-grass
Hypochaeris glabra	Smooth Cat's-ear
Lactuca serriola	Prickly Lettuce
Lamarckia aurea	Golden-top
Lycium ferocissimum	African Box-thorn
Medicago polymorpha	Burr Medic
Melilotus indicus	Sweet Melilot
Mesembryanthemum nodiflorum	Small Ice-plant
Opuntia cardiosperma	Riverina Pear
Opuntia spp.	Prickly pear
Osteospermum clandestinum	Tripteris
Parapholis incurva	Coast Barb-grass
Psilocaulon granulicaule	Wiry Noon-flower
Rostraria pumila	Tiny Bristle-grass
Schismus barbatus	Arabian Grass
Silene apetala var. apetala	Mallee Catchfly
Sonchus oleraceus	Common Sow-thistle
Spergularia diandra	Lesser Sand-spurrey
Spergularia rubra s.l.	Red Sand-spurrey

Vulpia myuros	Rat's-tail Fescue

Fauna – Native species found within 5km of Cardross and Koorlong Lakes

Scientific Name	Common Name
Acanthagenys rufogularis	Spiny-cheeked Honeyeater
Acanthiza chrysorrhoa	Yellow-rumped Thornbill
Acanthiza nana	Yellow Thornbill
Acanthiza uropygialis	Chestnut-rumped Thornbill
Accipiter fasciatus	Brown Goshawk
Acrocephalus stentoreus	Clamorous Reed Warbler
Aegotheles cristatus	Australian Owlet-nightjar
Anas castanea	Chestnut Teal
Anas gracilis	Grey Teal
Anas rhynchotis	Australasian Shoveler
Anas superciliosa	Pacific Black Duck
Anhinga novaehollandiae	Darter
Anthochaera carunculata	Red Wattlebird
Anthus novaeseelandiae	Australasian Pipit
Aphelocephala leucopsis	Southern Whiteface
Aquila audax	Wedge-tailed Eagle
Ardea modesta	Eastern Great Egret
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
Barnardius zonarius barnardi	Mallee Ringneck
Barnardius zonarius zonarius	Australian Ringneck
Biziura lobata	Musk Duck
Cacatua galerita	Sulphur-crested Cockatoo
Cacomantis flabelliformis	Fan-tailed Cuckoo
Charadrius ruficapillus	Red-capped Plover
Chelodina expansa	Broad-shelled Turtle
Chenonetta jubata	Australian Wood Duck
Cheramoeca leucosternus	White-backed Swallow
Cherax destructor destructor	Common Yabby
Chlidonias hybridus javanicus	Whiskered Tern
Chroicocephalus novaehollandiae	Silver Gull
Chrysococcyx basalis	Horsfield's Bronze-Cuckoo
Chrysococcyx osculans	Black-eared Cuckoo
Cincloramphus cruralis	Brown Songlark
Cincloramphus mathewsi	Rufous Songlark
Cinclosoma castanotus	Chestnut Quail-thrush
Circus approximans	Swamp Harrier
Cladorhynchus leucocephalus	Banded Stilt
Climacteris affinis	White-browed Treecreeper
Climacteris picumnus victoriae	Brown Treecreeper (south-eastern s
Colluricincla harmonica	Grey Shrike-thrush
Coracina novaehollandiae	Black-faced Cuckoo-shrike
Coracina papuensis	White-bellied Cuckoo-shrike

Corcorax melanorhamphos	White-winged Chough
Corvus coronoides	Australian Raven
Corvus mellori	Little Raven
Cracticus nigrogularis	Pied Butcherbird
Cracticus torquatus	Grey Butcherbird
Craterocephalus fluviatilis	Murray hardyhead
Cuculus pallidus	Pallid Cuckoo
Cygnus atratus	Black Swan
Daphoenositta chrysoptera	Varied Sittella
Dicaeum hirundinaceum	Mistletoebird
Dromaius novaehollandiae	Emu
Egretta novaehollandiae	White-faced Heron
Elanus axillaris	Black-shouldered Kite
Elseyornis melanops	Black-fronted Dotterel
Eolophus roseicapilla	Galah
Epthianura albifrons	White-fronted Chat
Epthianura aurifrons	Orange Chat
Epthianura tricolor	Crimson Chat
Erythrogonys cinctus	Red-kneed Dotterel
Falco berigora	Brown Falcon
Falco cenchroides	Nankeen Kestrel
Falco longipennis	Australian Hobby
Falco peregrinus	Peregrine Falcon
Falcunculus frontatus	Crested Shrike-tit
Fulica atra	Eurasian Coot
Gallinula tenebrosa	Dusky Moorhen
Geopelia cuneata	Diamond Dove
Geopelia striata	Peaceful Dove
Grallina cyanoleuca	Magpie-lark
Gymnorhina tibicen	Australian Magpie
Haliastur sphenurus	Whistling Kite
Heteronotia binoei	Bynoe's Gecko
Hieraaetus morphnoides	Little Eagle
Himantopus himantopus	Black-winged Stilt
Hydroprogne caspia	Caspian Tern
Hypseleotris klunzingeri	Western Carp Gudgeon
Lalage sueurii	White-winged Triller
Lerista muelleri	Mueller's Skink
Lialis burtonis	Burton's Snake-Lizard
Lichenostomus ornatus	Yellow-plumed Honeyeater
Lichenostomus penicillatus	White-plumed Honeyeater
Lichenostomus virescens	Singing Honeyeater
Maccullochella peelii peelii	Murray Cod
Macquaria ambigua	Golden Perch
Macrobrachium australiense	Australian Freshwater Prawn
Malacorhynchus membranaceus	Pink-eared Duck
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
Megalurus gramineus	Little Grassbird
Melanodryas cucullata cucullata	Hooded Robin
Melithreptus brevirostris	Brown-headed Honeyeater

Melopsittacus undulatus	Budgerigar
Menetia greyii	Grey's Skink
Merops ornatus	Rainbow Bee-eater
Microcarbo melanoleucos	Little Pied Cormorant
Microeca fascinans	Jacky Winter
Milvus migrans	Black Kite
Mogurnda adspersa	Southern Purple-spotted Gudgeon
Myiagra inquieta	Restless Flycatcher
Nematalosa erebi	Bony Herring
Neophema chrysostoma	Blue-winged Parrot
Ninox novaeseelandiae	Southern Boobook
Northiella haematogaster	Blue Bonnet
Nymphicus hollandicus	Cockatiel
Ocyphaps lophotes	Crested Pigeon
ord. Phalacrocoraciformes fam. Phalacrocora	Cormorant's
ord. Podicipediformes fam. Podicipedidae	Grebes
Oreoica gutturalis gutturalis	Crested Bellbird
Oxyura australis	Blue-billed Duck
Pachycephala inornata	Gilbert's Whistler
Pachycephala pectoralis	Golden Whistler
Pachycephala rufiventris	Rufous Whistler
Pardalotus punctatus	Spotted Pardalote
Pardalotus striatus	Striated Pardalote
Pelecanus conspicillatus	Australian Pelican
Petrochelidon ariel	Fairy Martin
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
Phaps chalcoptera	Common Bronzewing
Philypnodon grandiceps	Flat-headed Gudgeon
Philypnodon macrostomus	Dwarf Flat-headed Gudgeon
Phylidonyris albifrons	White-fronted Honeyeater
Platalea flavipes	Yellow-billed Spoonbill
Platycercus elegans flaveolus	Yellow Rosella
Plectorhyncha lanceolata	Striped Honeyeater
Podiceps cristatus	Great Crested Grebe
Poliocephalus poliocephalus	Hoary-headed Grebe
Pomatostomus ruficeps	Chestnut-crowned Babbler
Pomatostomus superciliosus	White-browed Babbler
Porphyrio porphyrio	Purple Swamphen
Psephotus haematonotus	Red-rumped Parrot
Psephotus varius	Mulga Parrot
Retropinna semoni	Australian Smelt
Rhipidura albiscarpa	Grey Fantail
Rhipidura leucophrys	Willie Wagtail
Smicrornis brevirostris	Weebill
Stagonopleura guttata	Diamond Firetail
Stictonetta naevosa	Freckled Duck
Strepera versicolor	Grey Currawong
Struthidea cinerea	Apostlebird
Tachybaptus novaehollandiae	Australasian Grebe

Tadorna tadornoides	Australian Shelduck
Taeniopygia guttata	Zebra Finch
Tandanus tandanus	Freshwater Catfish
Threskiornis molucca	Australian White Ibis
Threskiornis spinicollis	Straw-necked Ibis
Tiliqua rugosa	Stumpy-tailed Lizard
Todiramphus sanctus	Sacred Kingfisher
Tringa nebularia	Common Greenshank
Tringa stagnatilis	Marsh Sandpiper
Turnix velox	Little Button-quail
Tyto javanica	Pacific Barn Owl
Underwoodisaurus milii	Thick-tailed Barking Gecko
Vanellus miles	Masked Lapwing
Zosterops lateralis	Silvereye

Fauna – Exotic

Scientific Name	**Common Name**
Carassius auratus	Goldfish
Columba livia	Rock Dove
Cyprinus carpio	Carp
Gambusia holbrooki	Eastern Gambusia
Passer domesticus	House Sparrow
Perca fluviatilis	Redfin
Rattus rattus	Black Rat
Sturnus vulgaris	Common Starling
Turdus merula	Common Blackbird

APPENDIX 4: ECOLOGICAL VEGETATION CLASSES

Description of each EVC in the Cardross and Koorlong Lakes WMU

EVC no.	EVC name	Bioregional Conservation Status	Description
		Murray Mallee	
102	Low Chenopod Shrubland	Depleted	Chenopod shrubland to 1 m tall occupying broad, flat alluvial terraces occur along the Murray River, west from Mildura to the border. Also found in narrow bands fringing raak and saline lakes such as Lake Tyrell and on relict lakebed surfaces such as Pine Plains. The field layer is characterised by succulents and a suite of annual herbs.
86	Woorinen Sands Mallee	Depleted	Mallee shrubland to 7 m tall, typically supporting a hummock grass (Triodia spp.) dominated understorey. This EVC could be considered intermediate between the heavier soil mallee woodlands and the lighter sandy soil mallee vegetation predominant on Lowan (siliceous) sand.
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. In undisturbed remnants this EVC is characterised by the dominance of saltbushes and semi-succulent understorey shrubs.
97	Semi-arid Woodland	Vunerable	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.

APPENDIX 5: INDEX OF WETLAND CONDITION METHOD

Sub-indices

The table below shows what is measured for each of the six sub-indices and how each sub-index is scored. The sections below describe this in greater detail. Further information can be found on the IWC website (www.DEPI.vic.gov.au/iwc).

IWC sub-indices and measures

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

Scoring method

Each subindex is given a score between 0 and 20 based on the assessment of a number of measures as outline above. Weightings are then applied to the scores as tabulated below. The maximum possible total score for a wetland is 38.4. For ease of reporting, all scores are normalised to an integer score out of 10 (i.e. divide the total score by 38.4, multiply by 10 and round to the nearest whole number).

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

Five wetland condition categories have been assigned to the sub-index scores and total IWC scores as tabulated over page. The five category approach is consistent with the number of categories used in other condition indices such as the Index of Stream Condition. Biota sub-index score categories were determined by expert opinion and differ to those of the other sub-indices.

Non-biota sub-index score range	Biota sub-index score range	Total score range	Wetland condition category
0-4	0-8	0-2	Very poor
5-8	9-13	3-4	Poor
9-12	14-16	5-6	Moderate
13-16	17-18	7-8	Good
16-20	19-20	9-10	Excellent
N/A	N/A	N/A	Insufficient data

APPENDIX 6 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 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