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Richardson's Lagoon
Environmental Water Management Plan

North Central Catchment Management Authority

NORTH CENTRAL
Catchment Management Authority
Connecting Rivers, Landscapes, People

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EXECUTIVE SUMMARY

This Environmental Water Management Plan investigates and documents existing knowledge about Richardson's Lagoon. Its aim is to assist in the development of environmental watering proposals for the consideration of Environmental Water Holders. It is not a holistic management plan for the site, but is focused on specific environmental water management at Richardson's Lagoon.

The following information is provided in the Plan to facilitate appropriate environmental water management at Richardson's Lagoon into the future.

Richardson's Lagoon (also known as Baillieu's Lagoon) is a 120 hectare deep freshwater marsh located on the Murray River floodplain within a 248 hectare State Wildlife Reserve, managed by Parks Victoria. The reserve provides a range of ecological habitats, including open water and reed habitats through the channel of the wetland, floodplain River Red Gum communities and floodplain Black Box habitat.

The wetland is considered regionally significant and provides habitat for a range of fauna species listed under Victorian State legislation. It is also known to support species which are listed under international migratory agreements. The vegetation communities of the reserve are considered depleted, endangered or vulnerable within the Murray Fans Bioregion.

Prior to regulation, Richardson's Lagoon would have received water from the Murray River in high flow events. The wetland was maintained with water as part of the Rochester Campaspe Irrigation Areas through to the late-1990s. In 2000 it was allowed to dry completely and began a cycle of wetting and drying. This type of management is considered more conducive to maintaining and improving ecological condition than providing the wetland with only continuously wet conditions.

An Index of Wetland Condition assessment was completed for Richardson's Lagoon in January 2010 (during an extended dry phase). The wetland was found to be in good condition overall. The wetland received environmental water between 2010 and 2012 and its flora and fauna are responding well to the current conditions. Due the lack of surface water connectivity to the Murray River, it is important that environmental water continues to be provided to the wetland in accordance with its recommended watering regime.

Background information and local technical input was used to determine an environmental water management goal and appropriate watering regime for Richardson's Lagoon. These are summarised below:

Richardson's Lagoon environmental water management goal

To provide an appropriate water regime that targets the maintenance of varying habitats through Richardson's Lagoon to support a range of fauna species and habitat functions including waterbird resting, nesting and feeding. This will be achieved through the provision of:

- Various reed-dominated environments and open water habitats
- River Red Gum floodplain habitats and associated communities and Spike-sedge Wetland communities
- Black Box floodplain communities.

Optimal watering regime

Provide two wetland fill events (plus maintenance of water for three seasons each) every ten years.

Fill the channels of the wetland in winter of year one. Top up to 89m AHD during spring to target inundation of floodplain environments higher in the wetland (allow wetland to drawdown for up to two weeks prior to re-topping to 89m AHD).

Allow wetland to naturally draw down to approximately 88m AHD during summer. Provide another top up during spring of year two to ~88.7m AHD, ensuring that the water remains predominantly in channel and does not re-wet Black Box communities.

Top up wetland in spring of year three to inundate the River Red Gum zone of the floodplain and allow water to draw down over summer.

Allow wetland to dry completely over the next two years, and allow wetland to remain completely dry for one season (year six) prior to re-wetting.

A risk identification process was undertaken to investigate potential risks associated with environmental water delivery and associated site management at Richardson's Lagoon. Detailed risk assessments will be undertaken prior to delivering environmental water to the site in any given season. This will be detailed in the environmental watering proposal for the site which is undertaken on an annual basis.

Knowledge gaps and recommendations are provided which will assist in improving knowledge about environmental water management and ecological outcomes achieved at Richardson's Lagoon. Investment in these recommendations should be considered along with the provision of environmental water to the site.

Community consultation was also undertaken as part of developing this plan. Interviews with community members were focussed on collecting information in relation to the wetland, its values and the environmental watering regime recommendations. The community consultation component of developing the plan was essential in ensuring that the plan is meaningful and robust into the future.

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North Central CMA is grateful for input provided to this Environmental Water Management Plan, particularly from members of the local technical group:

- Mark Tscharke (Parks Victoria)
- Shelley Heron (Kellogg Brown and Root)
- Emer Campbell (North Central CMA)
- Ross Stanton (Goulburn-Murray Water)
- Andrea Joyce (formally Department of Sustainability and Environment).

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ABBREVIATIONS

BE	Bulk Entitlement
Bonn	The Convention on the Conservation of Migratory Species of Wild Animals (also known as the Bonn Convention or CMS)
CAMBA	China-Australia Migratory Bird Agreement
CEWH	Commonwealth Environmental Water Holder
CMAs	Catchment Management Authorities
DEPI	Department of Environment and Primary Industries
DPI	Department of Primary Industries
DSE	Department of Sustainability and Environment
EVC	Ecological Vegetation Class
EWMP	Environmental Water Management Plan
FSL	Full Supply Level
GL	Gigalitre (one billion litres)
G-MW	Goulburn-Murray Water
IWC	Index of Wetland Condition
JAMBA	Japan-Australia Migratory Bird Agreement
MDBA	Murray-Darling Basin Authority (formerly Murray-Darling Basin Commission, MDBC)
ML	Megalitre (one million litres)
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

1. INTRODUCTION

1.1. Background

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

Environmental watering in Victoria has historically been supported by management plans that document key information such as the watering requirements for a site, predicted ecological responses and any water delivery arrangements. State and Commonwealth environmental watering programs now have the potential to extend watering beyond those sites that have been traditionally watered in the past. It is important that there is a consistency in planning for environmental watering across both jurisdictions and therefore, new plans are required which will reflect this.

Environmental Watering Management Plans (EWMP or Plans) are currently being developed by Victorian Catchment Management Authorities for all current and future environmental watering sites throughout northern Victoria. It is intended that the Plans will provide a tool for consistent, transparent and informed management of environmental water across all sites.

1.2. Purpose

The purpose of this Plan is to investigate and document all existing knowledge about Richardson's Lagoon to facilitate the development of proposals for environmental watering for consideration by the Victorian and/or Commonwealth Environmental Water Holders.

Critical information provided within the Plan for each site will include:

- management responsibilities
- environmental, social and economic values
- existing water delivery arrangements including recent delivery records and any identified issues
- environmental condition and threats
- environmental objectives
- recommended water regimes to meet objectives under a range of climatic conditions
- any potential risks
- delivery system constraints and any opportunities to improve delivery with infrastructure changes
- identification of any knowledge gaps and recommendations to resolve.

This document is the Environmental Water Management Plan for Richardson's Lagoon in the North Central Catchment Management Authority (North Central CMA) region. The Plan is not a holistic management plan for the site, but rather is focused on specific environmental water management at the site.

1.3. Site location

The North Central CMA region is approximately three million hectares in size, bordered by the Murray River to the north, and the Central Highlands to the south. The region includes the Campaspe, Loddon, Avoca and Avon-Richardson rivers and a number of significant wetland

complexes, including Gunbower Forest, Kerang Lakes, Avoca Marshes and the Boort Wetlands (refer to Figure 1).

Richardson's Lagoon (also known as Baillieu's Lagoon) is a cut-off meander of the Murray River, west of Echuca in Northern Victoria. The wetland is approximately 120 hectares, and is contained within a 248 hectare park reserve. It is located on the border between the Rochester Campaspe and Torrumbarry Irrigation Areas, and has historically received outfalls from the Lockington Main Drain.

Figure 1: North Central CMA region

1.4. Consultation

Specific consultation in the development of this plan was undertaken with a local technical group at a workshop held on 16 June 2011. Members represented at this workshop were: Mark Tscharke (Parks Victoria – Land Manager), Ross Stanton (Goulburn-Murray Water), Shelley Heron (KBR), Emer Campbell (North Central CMA), Andrea Joyce, and Bridie Velik-Lord (North Central CMA). Representatives from regional DEPI were unable to attend the workshop. Outcomes and key discussion points from the workshop are presented in Appendix 7.

Consultation was also undertaken with adjoining landholders and community members who have had a long association with the wetland and proven interest in maintaining its environmental value (refer to Appendix 10). Other stakeholders were directly engaged to provide technical and historic information including G-MW, Field & Game Association, bird observers and field naturalists. A summary of the information sourced from this process is provided in Appendix 9.

1.5. Information sources

Information used in the development of this Plan has been compiled from various sources including scientific reports, management plans, Geographic Information System (GIS) layers, and stakeholder knowledge. A full list of information sources used can be found in the reference section of this Plan.

1.6. Limitations

The information sources used in the development of this Plan have some limitations. In particular, the management plans and reports relied upon vary in age and therefore the degree to which they reflect the current situation. Every effort has been made to use best available information in the development of this Plan, and it is acknowledged that there is an ongoing intention to update the Plan as new information and knowledge become available.

2. SITE OVERVIEW

2.1. Catchment setting

Richardson's Lagoon reserve is located on the Murray River floodplain, between Echuca and Torrumbarry. It is a cut-off meander of the Murray River and SKM (1999) describe Richardson's Lagoon as a deep freshwater marsh.

When flooded to target levels, Richardson's Lagoon consists of open water channel habitat (approximately two metres deep), as well as shallower habitat through River Red Gum and Black Box dominated flats where water spills from the channels. The target area comprises a defined channel system through the wetland reserve which is approximately 36 hectares, with a more extensive wet-dry habitat is approximately 84 hectares. The whole wetland reserve is approximately 248 hectares in size.

Land use surrounding Richardson's Lagoon reserve (Figure 2) is agricultural, supporting irrigated and dryland grazing, dairying and horticulture production.

While the wetland can receive inundation from high Murray River flows, its main source of water is from environmental water deliveries. Richardson's Lagoon can receive water through a fixed pontoon pump directly from the Murray River.

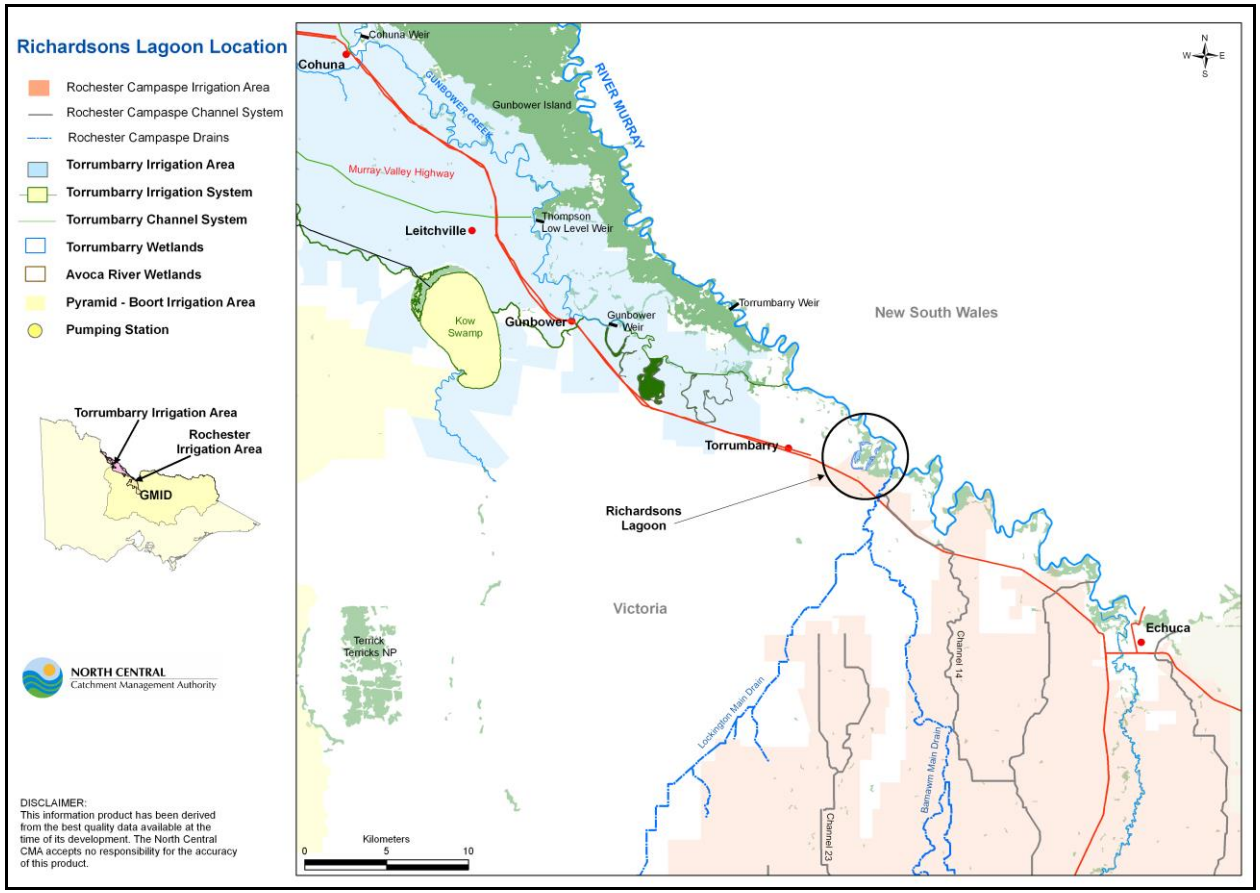

Figure 2: Richardson's Lagoon location

2.2. Land status and management

Richardson's Lagoon is a State Wildlife Reserve and is managed by Parks Victoria. The regional water corporation is Goulburn-Murray Water (G-MW) and the regional environmental water manager is North Central CMA. Parks Victoria operates the pump supplying environmental water to the site during filling events, and G-MW accounts for the water used. Maintenance of the pump infrastructure is currently funded by DEPI through North Central CMA.

Table 1 describes key stakeholders with possible involvement in the management of Richardson's Lagoon, and Table 2 shows a summary of the site characteristics of Richardson's Lagoon.

Table 1: Agencies and stakeholder groups with a responsibility or interest in the environmental water management of Richardson's Lagoon

Agency / Stakeholder Group	Responsibility / Interest
Commonwealth Environmental Water Holder	Management of Commonwealth environmental water entitlements.
Department of Environment and Primary Industries	Provision of financial, policy and strategic support for the management of public and private land (including wetlands). Management of hunting licensing on public land including Richardson's Lagoon. Currently manage environmental water entitlements on behalf of the Minister for Environment. Management of recreational duck hunting on Richardson's Lagoon. Liaison with hunters and community groups. Provision of technical and extension support for the sustainable management of agriculture surrounding Richardson's Lagoon. Approval of EWMPs
Field and Game Australia	A voluntary organisation formed by hunters to promote responsible firearm ownership and ethical hunting.
Campaspe Shire Council	Local council for area including Richardson's Lagoon. Responsible for regulation of local development through planning schemes and on-ground works.
Goulburn-Murray Water	Rural water corporation responsible for the management of water-related services in the irrigation area of northern Victoria. Resource manager responsible for making seasonal allocations in the region.
Local community	Recreational users of Richardson's Lagoon, including passive recreational pursuits (walking, bird watching), hunting.
Local landholders	Management of private land surrounding Richardson's Lagoon.
Murray-Darling Basin Authority	Responsible for preparing, implementing and enforcing the Murray-Darling Basin Plan. Responsible for planning integrated management of water resources across the Murray-Darling Basin.
North Central CMA	Coordination and monitoring of natural resource management programs in north central Victoria. Local operational management of the Environmental Water Reserve to rivers and wetlands including Richardson's Lagoon.
Parks Victoria	Custodian and land manager of Richardson's Lagoon.
Victorian Environmental Water Holder	Management of Victorian environmental water holdings. Due to be operational from July 1 2011.
Yorta Yorta Traditional Owners	Traditional owners of the area encompassing Richardson's Lagoon.

2.3. Wetland characteristics

Wetlands in Victoria are currently classified using a system developed by Corrick and Norman which includes information on water depth, water permanency and salinity (Corrick and Norman 1980 in DSE 2007b) (refer to Appendix 1 for further information about the wetland categories). Wetlands through Victoria were mapped and classified between 1975 and 1994 and developed into spatial GIS layers. These layers represent the wetland characteristics at the time of mapping (referred to as Wetlands 1994 layer), as well as a categorisation of the wetland characteristics prior to European settlement (referred to as Wetlands 1788 layers) (DSE 2007b).

Under the Wetlands 1994 layer, Richardson's Lagoon is classified as a shallow open water wetland, meaning the wetland is mainly open water and a permanent duration (however there may be periods of drying) (DSE 2007b). This classification differs to an investigation completed by SKM in 1999 which describes the wetland as a deep freshwater marsh (characterised by inundation to a depth of 1-2 metres throughout the year). The difference in classification can be attributed to the historic management of Richardson's Lagoon maintaining the wetland with water from the irrigation system, resulting in permanent inundation through the channel section of the wetland during the mapping timeframe.

For the purpose of this Plan, the classification given by SKM (1999) is considered more representative of current targets for environmental water management at Richardson's Lagoon due to the important wetting and drying cycles to maintain ecosystem function, as well as recognising the three wetland zones which will be targeted by environmental water management (open water, marsh areas and floodplain). Further information about the ecological components of the Richardson's Lagoon is provided in Section 3 and additional detail of the history of Richardson's Lagoon is provided in Section 4.

The wetland area mapped in the Wetlands 1994 layer refers only to the channel area that has been permanently inundated. As such, Richardson's Lagoon is currently mapped with a total area of 38.54 hectares. In reality, the area targeted for environmental watering is approximately 120 hectares in size which includes floodplain areas beside and above the wetland itself. Table 2 describes the wetland characteristics of Richardson's Lagoon.

Table 2. Summary of Richardson's Lagoon and floodplain characteristics

Characteristics	Description
Name	Richardson's Lagoon (Ballieu's Lagoon)
Mapping ID (Wetland 1994 layer)	7825 803097; 7825 810092; 7825 815100
Area	120ha of wetland and adjacent floodplain within 248ha reserve
Bioregion	Murray Fans
Conservation status	State Wildlife Reserve, Regionally Significant Wetland
Land status	State Wildlife Reserve (proposed Wildlife Area [VEAC 2008])
Land manager	Parks Victoria
Surrounding land use	Irrigated and dryland grazing, dairying and horticulture
Water supply	Fixed pontoon pump directly on Murray River which feeds water into the Link Channel, outfalling to the wetland
1788 wetland category	Permanent open water
1994 wetland category and sub-category	Shallow open water (less than 5m)
Current classification (SKM 1999)	Deep freshwater marsh
Wetland and floodplain target capacity	1,834ML at 89m AHD (FSL) (Chislett 2010 in Maher 2010)
Wetland depth at target capacity	3.5m maximum depth (Chislett 2010 in Maher 2010)

2.4. Environmental water

Environmental water available for use at Richardson's Lagoon can come from a number of sources, as detailed in Table 3 and expanded in Appendix 2.

Table 3. Environmental water that may be used at Richardson's Lagoon.

Water entitlement	Environmental water management agency
Bulk Entitlement (River Murray – Flora and Fauna) Conversion Order 1999 (incl. Amendments Orders and Notices 2005, 2006, 2007 and 2009)	Environment Minister / Victorian Environmental Water Holder
River Murray Unregulated Flows	Environment Minister / Victorian Environmental Water Holder
Commonwealth Environmental Water Holdings	Commonwealth Environmental Water Holder

Water availability from all these water sources will vary from season to season, according to climatic conditions, volumes held in storage, carryover entitlements and priorities of entitlement holders.

2.5. Legislative and policy framework

There are a range of international treaties, conventions and initiatives, as well as National and Victorian State Acts, policies and strategies that direct management of wetlands within Northern Victoria. Those which may have particular relevance to Richardson's Lagoon and the management of its environmental and cultural values are listed below. For the functions and major elements of each refer to Appendix 3.

International treaties, conventions and initiatives:

- Convention on Wetlands (Ramsar) 1971
- China Australia Migratory Birds Agreement (CAMBA) 1986
- Republic of Korea Australia Migratory Birds Agreement (ROKAMBA) 2002
- Japan Australia Migratory Birds Agreement (JAMBA) 1974
- Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention) 1979

Commonwealth legislation and policy:

- *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* (Part IIA)
- *Australian Heritage Commission Act 1975* (Register of the National Estate)
- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- *Native Title Act 1993*
- *Water Act 2007*
- Wetlands Policy of the Commonwealth Government of Australia 1997
- A Framework for Determining Commonwealth Environmental Watering Actions 2009

Victorian legislation:

- *Aboriginal Heritage Act 2006*
- *Catchment and Land Protection Act 1994*
- *Water Act 1989*
- *Wildlife Act 1975*
- *Flora and Fauna Guarantee Act 1988* (FFG Act)
- State Environment Protection Policy (Waters of Victoria) 2003
- State Environment Protection Policy (Groundwaters of Victoria) 1997

Victorian policy, codes of practice, charters and strategies:

- North Central Regional Catchment Strategy (North Central CMA 2003)
- Northern Region Sustainable Water Strategy (DSE 2009b)
- Our Water Our Future (DSE 2004b)
- Victorian threatened flora and fauna species (advisory list).

2.6. Related plans and activities

The environmental values of Richardson's Lagoon have been long recognised, particularly in light of the threat posed by many years of permanent water due to the almost continuous inflows from the Lockington-Bamawm Drainage system, and the reliance of the wetland for neighbouring properties to pump water from the wetland. The Department of Natural Resources and Environment (DNRE) identified the need for changes in the management of water regimes in Richardson's Lagoon to reduce the incidence of Blue-Green Algae blooms (Thomas 1996). The direction to allow the wetland to episodically dry rather than being permanently inundated was undertaken in part to address these water quality issues.

In June 1999 an environmental management plan was developed for Richardson's Lagoon and Murphy's Swamp (SKM 1999), with a focus on nutrient management. Richardson's Lagoon has a long history of nutrient inputs from irrigation drainage and effluent inflows from the adjacent dairy (SKM 1999). Nutrient loads in the sediment of the lagoon are believed to be high, as characterised by the high incidence of algal blooms. The need for a long dry phase that results in deep cracking of the clay at the base of the wetland has been recognised for some years (SKM 1999; Thomas 1996).

Parks Victoria constructed an upgraded outlet structure with carp screen for the wetland in the early 2000s. This structure was able to be secured to prevent unauthorised opening and allowed the wetland to commence its first complete drying phase for at least 15 years. Additionally, two adjacent landowners who were reliant on the wetland for stock and domestic supplies were assisted by Parks Victoria to access alternative supplies. This further facilitated the wetland receiving a drying phase.

Environmental water was provided to Richardson's Lagoon in 2003-04 and 2004-05 however these attempts at filling the wetland were hampered during the irrigation season by the need to utilise the Torrumbarry Estate pump and irrigation supply system during a time when it was required by the landholder. As a result, inflows were spasmodic and occurred over a prolonged period of time, without the wetland reaching Full Supply Level on both occasions (DSE 2005a).

An independent water source, a floating pump and supply system was constructed in 2006-07 by DSE (now DEPI), using funds generated from the sale of environmental water (DSE [A. Joyce], pers. comm. 12/07/2010). This system first became fully operational in 2010, once maintenance activities had been undertaken on the pump.

In 2007-08, Torrumbarry Estate was successful in obtaining a Commonwealth Community Water Grant to allow for a more efficient irrigation delivery system that by-passed the shared Link Channel and allowed environmental water delivery to occur separately from the delivery of irrigation water. This new system also allowed the channel feeding Richardson's Lagoon to be wetted and dried at times that more closely matched the preferred water regimes for Richardson's Lagoon, prevented carp build up in the Link Channel and allowed for restoration of riparian vegetation along the channel.

A detailed hydrological assessment was completed in 2010 on Richardson's Lagoon (Maher 2010). This document reviewed the 2010 winter-spring component of the 2010-11 environmental watering event at Richardson's Lagoon to create a water balance model and accurate rating curve for the wetland to generate information about the water requirements of this site.

Environmental water from the Bulk Entitlement (River Murray – Flora and Fauna) Conversion Order 1999 and River Murray Unregulated Flows was provided to Richardson's Lagoon between June 2010 and December 2012.

3. WATER DEPENDENT VALUES

3.1. Environmental

3.1.1. Listings and significance

Richardson's Lagoon is a regionally significant wetland (SKM 1999). Its particular value comes from its ability to provide significant waterbird habitat on the Murray River floodplain, with abundant breeding and roosting sites (SKM 1999). Waterbirds recorded on the site are of both state and national significance and include cormorants (Pied, Little Pied, Great and Little Black), Great Egret, White-necked Heron, Nankeen Night Heron, Ibis, Royal and Yellow spoonbills and brolga (SKM 1999). Additionally the site hosts numerous duck species when holding water.

Table 4 details the legislation, agreements, conventions and listings that are relevant to Richardson's Lagoon (based on information generated through DSE [2011a]). As can be seen, historic ecological values of Richardson's Lagoon include one international listing (CAMBA) and two Victorian State listings. There are however, other flora and fauna species that have been recorded at Richardson's Lagoon, some of which are listed species (refer to Table 5).

Table 4. Legislation, agreements, convention and listings relevant to the site, or species recorded at Richardson's Lagoon.

Legislation, Agreement or Convention	Jurisdiction	Listed
Ramsar Convention on Wetlands	International	×
Japan Australia Migratory Birds Agreement (JAMBA)	International	×
China Australia Migratory Birds Agreement (CAMBA)	International	✓
Korea Australia Migratory Birds Agreement (ROKAMBA)	International	×
Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)	International	×
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	National	×
Flora and Fauna Guarantee Act 1988 (FFG Act)	State	✓
DSE advisory lists	State	✓

3.1.2. Fauna

Richardson's Lagoon provides habitat for a range of fauna species and communities (Figure 3 shows cygnets at the site during 2010-11). A number of these species are considered threatened under various legislation (as detailed in Section 2.5).

Table 5 shows listed fauna species recorded at Richardson's Lagoon, and has been generated through DEPI threatened species mapping service (DSE 2011a) and waterbird monitoring undertaken during 2010-11. As discussed earlier, the species presented below are only those that are considered significant. There are numerous other species that have been recorded utilising Richardson's Lagoon, including numerous waterbird and terrestrial bird species, turtles, reptiles and mammal species.

Table 5. Listed fauna species recorded at the site.

Common name	Scientific name	Type	International agreements	EPBC status	FFG status	DSE status
Australasian Shoveler[1]	*Anas rhynchotis*	B				VU
Azure Kingfisher [2]	*Alcedo azurea*	B	NL	NL	NL	NT
Blue-billed Duck	*Oxyura australis*	B			L	EN
Brolga [1]	*Grus rubicunda*	B	NL	NL	L	VU
*Brown Treecreeper [1]	*Climacteris picumnus victoriae*	B	NL	NL		NT
Diamond Firetail^	*Stagonopleura guttata*	B	NL	NL	L	VU
Eastern Great Egret [2]	*Ardea alba*	B	J/C	NL	L	VU
Freckled Duck	*Stictonetta naevosa*	B	NL	NL	L	EN
*Grey-crowned Babbler [1]	*Pomatostomus temporalis temporalis*	B	NL	NL	L	EN
Hardhead [2]	*Aythya australis*	B	NL	NL	NL	VU
Intermediate Egret[1]	*Ardea modesta*	B			L	EN
Little Egret	*Egretta garzetta*	B	NL	NL	L	T
Magpie Goose [2,3]	*Anseranas semipalmata*	B	NL	NL	L	NT
Murray Spiny Crayfish [1]	*Euastacus armatus*	I	NL	NL	L	NT
Musk Duck[2,3]	*Biziura lobata*	B	NL	NL	NL	VU
Nankeen Night Heron [2]	*Nycticorax caledonicus hillii*	B	NL	NL	NL	NT
Pied Cormorant [2]	*Phalacrocorax varius*	B	NL	NL	NL	NT
River Snail [1]	*Notopala sublineata*	I	NL	NL	L	CR
Royal Spoonbill [2]	*Platalea regia*	B	NL	NL	NL	NT
White-bellied Sea-Eagle [1]	*Haliaeetus leucogaster*	B	C	NL	L	VU

[1] Source: DSE 2011a and Australian Ecosystems 2012

[2] Source: Waterbird monitoring undertaken by DSE and Parks Victoria

[3] Species observed breeding during 2010-12

* Species not considered water-dependent

Legend

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

International: Camba, Jamba, Rokamba, Bonn, Not Listed

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

EPBC presence: Known to occur, Likely to occur, May occur, Not Listed

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

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

Figure 3. Cygnets at Richardson's Lagoon during environmental water delivery, October 2010.

Figure 4. Wallabies at Richardson's Lagoon during environmental water delivery, October 2010.

3.1.3. Flora

Vegetation communities

Richardson's Lagoon is located in the Murray Fans Bioregion, which occurs in northern Victoria along the Murray River, north of the Victorian Riverina Bioregion. The Murray Fans Bioregion is characterised by a flat to gently undulating landscape on recent unconsolidated sediments with evidence of former stream channels, old river meanders and palaeochannels and broad floodplain areas associated with major river systems and prior streams (DPI 2009).

There are five Ecological Vegetation Classes (EVCs) at Richardson's Lagoon reserve. The conservation status of these in the Murray Fans bioregion is presented in Table 6 (described in more detail in Appendix 4).

The EVCs characteristic of Richardson's Lagoon include:

- Eucalypt forest with understorey dominated by large sedges and containing a composition indicative of occasional shallow flooding (Sedgy Riverine Forest) (DSE 2011b)
- Low sedgy vegetation, typical treeless but sometimes with thickets of saplings or scattered mature River Red Gums (Spike-sedge wetland) (DSE 2011b)
- Eucalypt woodland (Black Box) occurring on elevated terraces (Riverine Chenopod Woodland) (DSE 2011b)
- River Red Gum forest with groundlayer dominated by graminoids (Grassy Riverine Forest) (DSE 2011b)
- Grassy or sedgy woodland with large, inter-tussock spaces containing a range of annual or geophytic herbs (Plains Woodland) (DSE 2011b).

An Index of Wetland Condition (IWC) assessment was undertaken in 2012, where the majority of this wetland was also assessed as Billabong Wetland Aggregate (EVC 334), as it was composed of a mixture of components of wetland EVCs at a fine scale. Recognisable components of this aggregate at the wetland included Aquatic Herbland (EVC 653), Aquatic Sedgeland (EVC 308), Tall Marsh (EVC 812), Dwarf Floating Aquatic Herbland (EVC 949) and Floodway Pond Herbland (EVC 810). The balance of the wetland was assessed as Floodway Pond Herbland/Riverine Swamp Forest Complex (EVC 945), which occurred in more shallowly inundated sections of the wetland (Australian Ecosystems 2012).

Many dead and living old-growth Eucalyptus camaldulensis (River Red Gum) trees surrounded the wetland, which are an important habitat feature. The overall IWC biota score for Richardson's Lagoon was recorded as 12.45, indicating the vegetation was in poor condition (Australian Ecosystems 2012).

The wetlands were surrounded by a range of terrestrial EVCs, the distribution of which is determined largely by soil types and positioning within the floodplain. Two large source bordering dunes occur on the eastern side of Richardson's Lagoon. The deep, relatively fertile sands of these dunes support EVC Sand Ridge Woodland (EVC 264), which has a canopy of Callitris gracilis subsp. murrayensis (Slender Cypress-pine) and Acacia salicina (Willow Wattle) and supports a population of the endangered Santalum lanceolatum (Northern Sandalwood) (Australian Ecosystems 2012).

Table 6. Ecological vegetation classes recorded at the site

EVC no.	EVC name	Source	Bioregional Conservation Status (Murray Fans Bioregion)
803	Plains Woodland	2012	Endangered
264	Sand Ridge Woodland	2012	Endangered
295	Riverine Grassy Woodland	2012	Vulnerable
945	Floodway Pond Herbland-Riverine	2012	Depleted

EVC no.	EVC name	Source	Bioregional Conservation Status (Murray Fans Bioregion)
	Swamp Forest Complex		
334	Billabong Wetland Aggregate	2012	Vulnerable
918	Submerged Aquatic Herbland	2012	Not determined, likely to be Vulnerable
653	Aquatic Herbland	2012	Depleted
308	Aquatic Sedgeland	2012	Vulnerable
821	Tall Marsh	2012	Depleted
810	Floodway Pond Herbland	2012	Vulnerable
949	Dwarf Floating Aquatic Herbland	2012	Not determined, likely to be Least Concern
816	Sedgy Riverine Forest	2005	Depleted
803	Plains Woodland	2005	Endangered
819	Spike-sedge Wetland	2005	Vulnerable
103	Riverine Chenopod Woodland	2005	Endangered
106	Grassy Riverine Forest	2005	Depleted

Wetland EVC' s recorded by Australian Ecosystems (2012) included Aquatic Sedgeland (EVC 308), Aquatic Herbland (EVC 653), Tall Marsh (821), Dwarf Floating Aquatic Herbland (949), Floodway Pond Herbland (810) and Floodway Pond Herbland/Riverine Swamp Forest Complex (EVC 945).

The diversity of the vegetation communities in the wetland and on the higher elevated areas through the reserve area mean that the wetland supports a range of different fauna species and communities that require different habitat characteristics (e.g. wading waterbirds, terrestrial birds). This vegetation diversity also provides some complexity for management with environmental water as the interactions of the various communities and their water requirements will need to be managed accordingly.

Flora species

Common species found by SKM (1999) at Richardson's Lagoon include River Red Gum (*Eucalyptus camaldulensis*), Black Box (*E. largiflorens*), Moonah (*Melaleuc lanceolata*), Sweet Bursaria (*Bursaria spinosa*), White Cypress Pine (*Callitris glaucophylla*), Hooked Needlewood (*Hakea tephrosperma*), Weeping Pittosporum (*Pittosporum angustifolium*), Willow Wattle (*Acacia salicinia*) and Long Leaf Emu Bush (*Eremophilla longifolia*). Sandalwood (*Santalum lanceolatum*) occurs on the sandhills around the wetland (SKM 1999). This species is listed under the FFG Act and is considered Endangered in Victoria (DSE 2005b).

Australian Ecosystems (2012) conducted an ecological survey at Richardson's Lagoon. A total of 162 vascular plant species were observed across Richardson's Lagoon, 102 of which were indigenous. Three listed rare or threatened plant species were recorded and are presented in Table 7 below.

Table 7. Significant flora species recorded at Richardson's Lagoon

Common name	Scientific name	EPBC status	FFG status	DSE status
Native Couch	*Cynodon dactylon var. pulchellus*			PK
Northern Sandalwood	*Santalum lanceolatum*		L	EN
Branching Groundsel	Senecio cunninghamii var. cunninghamii			R

Source: Australian Ecosystems 2012
Conservation Status
EPBC status: EXtinct, CRitically endangered, ENdangered, VUlnerable, Conservation Dependent, Not Listed
EPBC presence: Known to occur, Likely to occur, May occur, Not Listed
FFG status: Listed as threatened, Nominated, Delisted, Never Listed, Ineligible for listing
DSE status: presumed EXtinct, Regionally Extinct, Extinct in the Wild, CRitically endangered, ENdangered, Vulnerable, Rare, Near Threatened, Data Deficient, Poorly Known, Not Listed

There are other flora groups of importance within the wetland and reserve area. These include reeds and rushes (including Giant Rush [*Juncus* ingens])which are important habitat components for

waterbird breeding, roosting and feeding. They also provide habitat for macroinvertebrates, frogs and insects etc. that are food sources for both waterbird species and reptiles such as turtles.

3.1.4. Wetland depletion and rarity

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

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

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

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

Comparison between the wetland layers has demonstrated the impact of European settlement and development on Victorian wetlands. This has been severe, with approximately one-third of the state's wetlands being lost since European settlement; many of those remaining are threatened by continuing degradation from salinity, drainage and agricultural practices (ANCA 1996). Across the state, the greatest losses of original wetland area have been in the freshwater meadow (43 per cent), shallow freshwater marsh (60 per cent) and deep freshwater marsh (70 per cent) categories (NRE 1997).

Under the mapping described above, Richardson's Lagoon is classified as a shallow open water wetland. As was noted earlier, from a hydrologic and ecological perspective, Richardson's Lagoon is representative of a deep freshwater marsh (SKM 1999). Table 8 shows Richardson's Lagoon in relation to the total areas of deep freshwater marshes in the respective regions. As the wetland is large in size, Richardson's Lagoon provides important habitat within the Murray Fans bioregion. The wetland accounts for 6.1% of the total area of deep freshwater marsh within the bioregion (Table 8).

Table 8. Current area of the site's classification in the region

Classification	Region			
	North Central CMA region	Goulburn-Murray Irrigation District	Murray Fans bioregion	Victoria
Deep freshwater marsh (ha)	5,000	7,416	1,951	55,006
Richardson's Lagoon (ha)	120	120	120	120
Richardson's Lagoon as a proportion of the regional total	2.4%	1.6%	6.1%	0.2%

3.1.5. Ecosystem functions

Wetlands are considered ecologically important due to their role in maintaining biological diversity, promoting biochemical transformation and storage and decomposition of organic materials (DSE 2007b). They also provide crucial habitats for flora, invertebrates, fish, birds, reptiles, amphibians and mammals, improve water quality through filtration, control floods, regulate carbon levels and provide significant cultural and recreational values (DSE 2007b).

Richardson's Lagoon is known to provide all the ecosystem functions outlined above, as well as the following:

- critical habitat in the floodplain area, and ability to provide drought refuge and breeding habitat for waterbirds
- priority wetland for species use and ecosystems functions.

3.2. Social

3.2.1. Cultural heritage

The traditional owner group of area including Richardson's Lagoon is the Yorta Yorta. Richardson's Lagoon is considered an area of high Cultural Heritage Sensitivity (DPI 2011). GeoVic online mapping service (DPI 2011) identifies scarred trees (e.g. Figure 5), artifact scatters, oven, mounds and hearths that have been surveyed and recorded at Richardson's Lagoon. SKM (1999) note that scarred trees, middens and a burial site are present in the reserve area.

Figure 5. Scarred tree at Richardson's Lagoon, October 2010.

3.2.2. Recreation

Richardson's Lagoon is used for passive recreational pursuits including camping, bird watching, scenic driving and occasionally fishing (SKM 1999). It is also used extensively by hunters during duck-hunting season (SKM 1999). The ability to provide these recreational values rely heavily on the wetland being in an appropriate ecological condition, through the provision of environmental water.

3.3. Economic

The economic value of a particular wetland to the regional economy can be quite difficult to measure. For the purpose of this Plan, a general discussion of the economic benefit of wetlands is provided, based on ACF (2010).

There are direct and indirect uses of wetlands which generate economic benefit on a local, regional and wider scale (ACF 2010). Direct uses of Richardson's Lagoon include the income generated from recreational pursuits and tourism, while indirect 'uses' include ecosystem services such as groundwater recharge, nutrient treatment and carbon storage (DEWHA 2010). In addition, other values can be placed on Richardson's Lagoon, including its economic value to surrounding communities generated through duck hunting, camping and fishing.

4. HYDROLOGY AND SYSTEM OPERATIONS

The hydrology of a wetland will affect the chemical and physical aspects of that wetland (North Central CMA 2009). The chemical and physical aspects will in turn influence the flora and fauna communities that the wetland supports (DSE 2007b). A wetland's hydrology is determined by surface and groundwater inflows and outflows in addition to precipitation and evapotranspiration (Mitsch and Gosselink, 2000 in DSE 2007b). Duration, frequency and seasonality (timing) are the main components of the hydrological regime for wetlands and rivers. Appendix 5 details the recent watering history of Richardson's Lagoon.

4.1. Water management and delivery

4.1.1. Pre-regulation

Prior to regulation, it is believed that Richardson's Lagoon was a deep, semi-permanent wetland that received regular inundation from Murray River flows during winter and spring (SKM 1999). Being a relatively deep wetland at greater than 2m deep in parts, the lagoon would have held water for lengthy periods of time, drying out completely only on an irregular basis (SKM 1999).

4.1.2. Post-regulation

Richardson's Lagoon has historically been associated with the Rochester Campaspe Irrigation Areas. The lagoon was maintained artificially with water to the 1980s and was used as part of the irrigation system by diverters during summer (Maher 2010; SKM 1999). In 1992 a fixed crest weir was constructed by G-MW on the Lockington Main Drain which allowed outfall water from the Lockington and Bamawm Main Drains to enter the wetland (Figure 6) (SKM 1999).

Additionally, structure was constructed which allowed water from Richardson's Lagoon to be discharged to the Murray River (Figure 7) (SKM 1999). The wetland has had a history of algal blooms and poor water quality, due to the high nutrient levels in drainage flows and outfall water from landuse activities (particularly dairying) (SKM 1999).

Figure 6. Fixed crest weir historically used to pool water from Locking ton Main drain and force it into Richardson's Lagoon. DSE (A. Joyce) 2005.

Figure 7. Outlet structure from Richardson's Lagoon to Murray River

Water can enter the wetland by natural flood flows from the Murray River, however the river needs to carry significant volumes of water before overtopping into the wetland (during 2010-11, flows on the Murray River at Torrumbarry peaked at 52,589ML/day on 22 December 2010 and overtopping into Richardson's Lagoon did not occur, likely due to the levees and elevated roads within the reserve). There are also a series of levees on the northern wetland boundary which isolate the wetland from the Murray River, limiting water exchange between the two systems (SKM 1999).

Richardson's Lagoon was allowed to dry completely in 2000, and then began its current cycle of wetting, and complete drying. The wetland no longer receives drainage water. A fixed pontoon

pump was constructed on the Murray River in 2005 to provide environmental water to Richardson's Lagoon (Figure 8). Funding for the pump was sourced from the temporary sale of environmental water from the Bulk Entitlement (River Murray – Flora and Fauna) Conversion Order 1999, and purchased by DSE (DSE [A. Joyce], pers. comm. 12/07/2010). While operating the pump is primarily the responsibility of Parks Victoria, ownership still sits with DSE and it is responsible for paying electricity and maintenance costs under current arrangements.

Figure 8. Fixed pontoon pump on Murray River to provide water to Richardson's Lagoon. DSE (A. Joyce)

The pump has a capacity of approximately 30ML/day and water then passes into an underground pipe system, travels for approximately 1km along a powerline reserve before outfalling to the 'Link Channel' (Figure 9). This channel feeds water to the outfall structure to the wetland proper (Figure 10). This operation was undertaken due to inadequacies of previous arrangements whereby a regulator was shared with private diverters and there was a subsequent lack of control over the quality and quantity of water, as well as the timing of delivery (SKM 1999). The current arrangement for environmental water delivery means that water can be delivered directly from the Murray River (including the use of River Murray Unregulated Flows) without the reliance on the irrigation system.

Figure 9. Pipe outfalling to Link Channel before entering wetland proper.

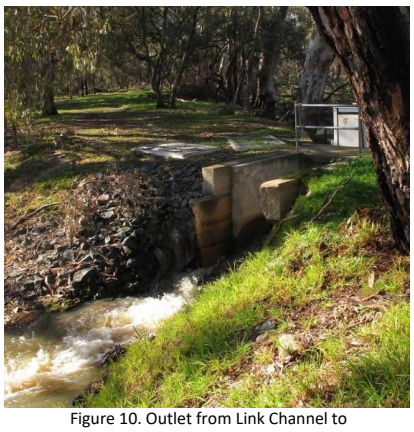

Figure 10. Outlet from Link Channel to Richardson's Lagoon.

5. CONDITION AND THREATS

5.1. Current condition

An Index of Wetland Condition (IWC) assessment was undertaken at Richardson's Lagoon in January 2010 and April 2013. The IWC defines wetland condition as the state of the biological, physical, and chemical components of the wetland ecosystem and their interactions (refer to Appendix 6 for further information about the IWC process) (DSE 2007b).

The method undertaken under the IWC involves measuring five sub indices based on the catchment of the wetland and its fundamental characteristics of physical form, hydrology, water properties, soil and biota. Table 9 shows the IWC scores for Richardson's Lagoon assessed in 2010 and 2012. It highlights that the wetland was considered in good condition overall, with the main concern relating to hydrology and wetland biota (the diversity, health and weediness of the native wetland vegetation). The 2010 result is likely due to the dry phase and drought conditions experienced at the time of sampling in 2010. The 2012 assessment was focused on biota, which indicated that the vegetation was in poor condition (Australian Ecosystems, 2012).

Table 9. Index of Wetland Condition scores recorded for Richardson's Lagoon (January 2010 and April 2012).

IWC Sub-Index	Score 2010	Condition Category	EVC Assessment (2012)	Result	Condition Category
Wetland catchment	12.5 / 20	Good	Floodway Pond Herbland Z1	6.9	
Physical form	20.0 / 20	Excellent	Floodway Pond Herbland Z2	16.0	
Hydrology	10.0 / 20	Moderate	Billabong Wetland Aggregate Z1	13.8	
Water properties	17.0 / 20	Excellent	Billabong Wetland Aggregate Z2	14.4	
Soils	18.7 / 20	Excellent	Floodway Pond Herbland	1.6	
Biota	16.0 / 20	Moderate			
Overall IWC Score	**8.0 / 10**	**Good**	**Wetland condition biota score**	**12.45**	**Poor**

There is some concern about the soils through the base of Richardson's Lagoon, relating to their ability (and likelihood) to produce Acid Sulphate Soils (ASS). During a desktop review, Richardson's Lagoon was prioritised along with 19 other sites in the North Central CMA region to be further investigated. In March 2009, field tests were conducted to determine whether ASS were considered a real threat to the ecological integrity of the wetlands. Results showed that a number of trigger levels were exceeded. Electrical conductivity (EC) of the soil was recorded as 2,390µS/cm (high soil EC is considered greater than 1,000µS/cm), soil pH ranged between 3.7 and 5.7 (extreme soil pH is considered to be less than 4), and soil sulphate was recorded as 6,255mg/kg (soil sulphate is considered high when it exceeds 500mg/kg).

During the environmental watering event of 2010-11, there was some uncertainty as to whether these soil characteristics would result in the production of acid water. Therefore, data loggers were installed in the bed of Richardson's Lagoon to measure water quality during the watering event. There has been no evidence of acid water forming at the wetland.

5.2. Water dependent threats

General threats to the wetlands analysed through the Plan process have been informed by the Aquatic Value Identification and Risk Assessment (AVIRA) process developed by DSE (DSE 2009a). The threat categories are outlined below and these have been used to identify specific threats and their likelihood of impacting Richardson's Lagoon (shown in Table 10).

Altered water regime (specifically relating to a changed water regime):

The hydrology of a wetland is an important component to consider for the overall ecological functioning of a site. Hydrology drives the development of wetland soils and the biotic communities (DSE 2009a).

AVIRA (DSE 2009a) specify that activities with the potential to cause a change in water regime are those that:

- change the flow regime of the water source of the wetland
- interfere with the natural connectivity of flow to and from the wetland
- involve disposal of water into the wetland or extraction of water from the wetland
- change wetland depth and, therefore, alter the duration of inundation by changing the rate of evaporation (DSE 2005c in DSE 2009a).

Altered physical form (specifically relating to reduced wetland area and altered wetland form):

Physical form of a wetland is related to the wetland area and wetland bathymetry (DSE 2005c in DSE 2009a). AVIRA notes the key threats to physical form as being (DSE 2009a):

- reduction in wetland area (through drainage or infilling)
- alteration in wetland form – depth, shape, bathymetry (through excavation, landforming or sedimentation).

AVIRA also notes that the realisation of the threats listed above can modify the availability of wetland for biota through changes in water depth and its resultant impact on duration and inundation area (DSE 2005c, DSE 2006b in DSE 2009a).

Poor water quality (specifically relating to degraded water quality):

Degrading water quality in this instance is particularly focused on landuse activities which impact the water in, or entering the wetland. Within the wetland itself, examples of landuse activities which can degrade the water quality include livestock grazing, feral animals and aquaculture (DSE 2009a). Catchment land practices with potential to degrade wetland water quality include clearing of vegetation, land uses such as agriculture or urbanisation, fire, poor irrigation practices and point source discharges (DSE 2009a). Both these aspects may be manifested by changes in several physical and chemical water properties (e.g. nutrient enrichment, salinisation and turbidity) (DSE 2005c in DSE 2009a).

Degraded habitats (soil disturbance in particular):

The soils of wetland habitats are vital component for the wetland to function as a whole. It provides the physical substrate which aquatic vegetation requires to establish, and provides habitat for benthic invertebrates and microorganisms (DSE 2009a). The threatening processes which can impact wetland soils include pugging by livestock and feral animals, human trampling, driving of vehicles in the wetland and carp disturbance (DSE 2009a), resulting in soil disturbance which can reduce water storage capacity of soil, can have negative impacts on some invertebrates and increase turbidity during wetland filling events (DSE 2008e in DSE 2009a).

Exotic flora and fauna (including terrestrial and aquatic species):

The presence of exotic flora (i.e. species introduced from outside Australia) in the terrestrial and aquatic zones of wetlands causes harm when the extent of the exotic species replaces the native EVC components. When this occurs, there can be a threat to biodiversity and primary production of the wetland, increasing the land and water degradation and impacting the native flora and fauna species of the site (DSE 2009a).

Exotic fauna species can also pose a threat to the biodiversity of wetlands, along with its primary production potential (DSE 2009a). This occurs when the exotic species disturb the functioning of the native vegetation and/or displace native fauna species.

Reduced connectivity (reduced wetland connectivity):

Wetland connectivity is most likely to occur where there are a series of habitat areas arranged in close proximity through the landscape, for example the Kerang wetland complex and the Boort wetland complex (DSE 2009). DEWHA and DAFF (2008) in DSE (2009a) define connectivity as 'the location and spatial distribution of natural areas in the landscape to provide species and populations with access to resources (food, breeding sites and shelter), increase habitat availability and facilitate population processes (dispersal, migration, expansion and contraction) and enable ecological processes (evolution, water, fire and nutrients)'.

When connectivity is reduced through a landscape, there is less opportunity for population to move from one spot to another in the search for food, habitat and population processes.

Table 10. Possible threats and likelihood of detrimental impacts occurring at Richardson's Lagoon.

Threat	Likelihood of detrimental impact on Richardson's Lagoon (as compared to pre-regulation condition)	Comment
Altered water regime	High	The regulation of the Murray River and presence of levees along Richardson's Lagoon mean that a lack of natural flood flows enter the wetland.
Altered physical form	Low	Physical form has not changed significantly from historical, and is unlikely to alter significantly.
Poor water quality	Low / Unknown	Since the wetland has been taken out of the irrigation system and no longer receives drainage flows, the only source of water provided to the wetland is directly from the Murray River. The potential for producing acid water from Acid Sulphate Soils is currently being investigated.
Degraded habitats	Low	Low likelihood of habitat degradation occurring.
Exotic flora and fauna	Medium	Particularly relating to predation by exotic fauna on water-dependent native species recruitment (e.g. fox predation on birds and turtles).
Reduced connectivity	Medium	Connectivity has reduced as compared to natural conditions, however there are still opportunities for amphibious and terrestrial fauna species in particular to move through the landscape (e.g. turtles to, and from Murray River). Species and propagules dependent on water for moving are selectively disadvantaged, and will only reach the site in major floods.

5.3. Condition trajectory

Since the wetland has been allowed to dry completely in recent years and has been taken out of the irrigation discharge system, Richardson's Lagoon is considered to be on an improving trajectory. This is highlighted by the land manager considering the wetland to currently be in its best condition (M. Tscharke, pers. comm. 2011). Regular wetting and drying cycles for Richardson's Lagoon should be encouraged and as the wetland is disconnected from the Murray River in all but high flows/flood events, its water-dependent condition needs to be managed through the strategic provision of environmental water.

6. MANAGEMENT OBJECTIVES

6.1. Management goal

The environmental water management goal for Richardson's Lagoon has been based on information produced in SKM (1999), Maher (2010), and local recommendations for the site (as developed in the regional technical workshop), and has relied heavily on the varying habitats of the wetland.

Richardson's Lagoon environmental water management goal

To provide an appropriate water regime that targets the maintenance of varying habitats through Richardson's Lagoon to support a range of fauna species and habitat functions including waterbird resting, nesting and feeding. This will be achieved through the provision of:

- Various reed-dominated environments and open water habitats
- River Red Gum floodplain habitats and associated communities and Spike-sedge Wetland communities
- Black Box floodplain communities.

6.2. Ecological and hydrological objectives

6.2.1. Ecological objectives

Ecological objectives are the desired ecological outcomes of the site. In line with the draft policy Victorian Strategy for Healthy Rivers, Estuaries and Wetlands (VSHREW), the ecological objectives are based on the key values of the site (as outlined in Section 3) (e.g. Campbell et al. 2005). 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 for each key value, which is related to the present condition or functionality of the value (informed by Marquis-Kyle and Walker 1994; Campbell et al. 2005).

Protect – retain the biodiversity and/or the ecosystems at the existing stages of succession.

Improve – improve the condition of existing ecosystems by either returning an area of land to an approximation of the natural condition or to a known state.

Maintain – maintain the biodiversity and/or ecosystems while allowing natural processes of regeneration, disturbance and succession to occur.

Reinstate – reintroduce natural values that can no longer be found in an area.

Reduce - reduce the abundance and cover of undesirable exotic species that impact upon native values.

The ecological objectives developed for Richardson's Lagoon are based on optimising the ecological values that the wetland provides, particularly relating to its ability to support a range of fauna species, and diversity of flora communities. The ecological objectives are described in Table 11 and have been reviewed by the regional technical workshop participants.

Table 11. Ecological objectives for the site

Ecological objective	Justification (value based)
Maintain deep water channels through the bed of the wetland with aquatic macrophytes and maintain healthy population of native aquatic reeds and rushes around the deep channels.	Provision of habitat (including nesting areas on top or below aquatic vegetation) and food source for herbivorous waterbird species, particularly ducks. Provision of feeding opportunities for piscivorous and invertebrate feeders including grebes, ducks and cormorants. Provision of habitat diversity through the wetland.
Maintain Spike-sedge Wetland (EVC 819) in floodplain areas. Promote dominance of the groundlayer in these areas by sedge species.	Provision of habitat for waterbird species to roost and feed, and provide areas for other fauna species (e.g. turtles) to feed and nest).
Maintain eucalypt floodplain woodland (Black Box) in the areas higher in the wetland reserve.	Provision of vegetation diversity which supports a range of water dependent and non-water dependent fauna species.

6.2.2. Hydrological objectives

Hydrological objectives describe the components of the water regime required to achieve the ecological objectives at this site. The hydrological objectives are derived from an understanding of the local hydrology, using a 'landscape logic' for the site (Figure 11 and Figure 12).

The most recent operating arrangements for Richardson's Lagoon were developed in 1999 and particularly focused on the need to implement a drying phase (SKM 1999). SKM (1999) recommended annual fluctuations with water at approximately 89m AHD during spring, dropping to 88m AHD during summer and increasing to 88.7m AHD in winter, then increasing to 89m AHD again during late winter and early spring. Further, it was recommended that water should not be allowed to fall below 88m AHD unless it was followed by an extended dry phase (i.e. when considering water level variation during the wet phase, water level should only vary at ranges above 88m AHD) (SKM 1999).

In order to maintain the target diversity of ecological habitats within Richardson's Lagoon, it will be necessary to ensure water remains at specific levels for duration and at frequencies appropriate for each of the target habitats (refer to Table 12). For example, the deep channel should be kept full for up to two years. However, inundation in the higher zones where Black Box communities are present should not occur more than once every seven years on average, and should last for less than four months. Therefore, management of the wetland with environmental water will have to take an adaptive approach, depending on what is observed at a local scale.

Richardson's Lagoon should be drawndown naturally over two seasons, and remain completely dry for another season prior to re-wetting. In the whole water management regime, variation in water levels is critical to creating a diversity of habitats and achieving a beneficial ecological outcome. SKM (1999) discusses the importance of fluctuating water levels to enable the growth of submerged aquatic macrophytes by allowing light to penetrate through the water column to areas of the substrate that would otherwise remain bare if water was permanently maintained at higher water levels.

Water enters the wetland from the south-eastern corner of the wetland (Figure 11), and moves its way through the depression to the north, and around to the west. As such, once the wetland is nearing full during the initial fill-event, it is recommended that water delivery be suspended for at least two weeks to allow the water to settle, prior to providing the wetland with an additional top up. From the 2010 filling event, it was found that approximately 700ML of water was required by the wetland before the east and the west arms of the wetland reached the same water level (Maher 2010).

Table 12 details the hydrological objectives for Richardson's Lagoon.

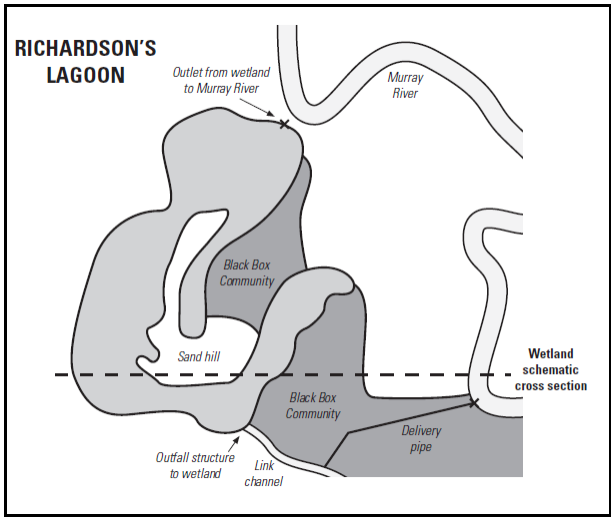

Figure 11. Schematic representation of Richardson's Lagoon.

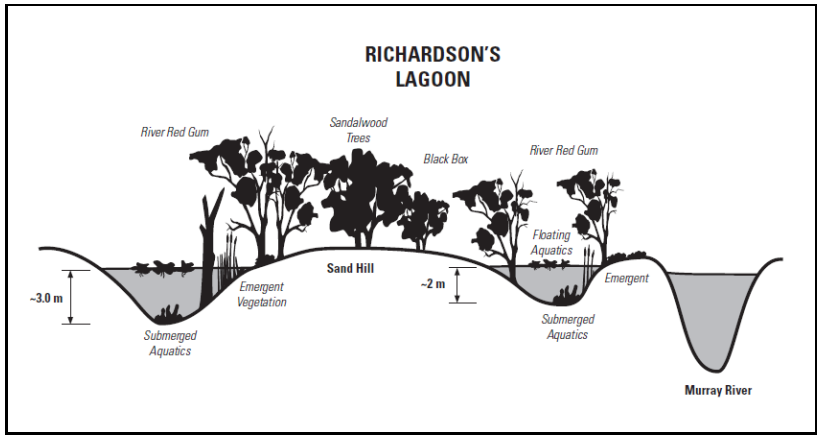

Figure 12. Schematic representation of the ecological components of Richardson's Lagoon.

Table 12. Hydrological objectives for the site.

Ecological objective	Water management area	Hydrological objectives						
		Recommended frequency of events (number per 10 years)[1]	Duration of flooding (months	Preferred timing of inflows	Target supply level (m ADH)	Volume to fill to target supply level[2] (ML)	Volume to maintain at TSL[3] (ML)	Total volume per event[4] (ML)
Maintain deep water channels through the bed of the wetland with aquatic macrophytes and maintain healthy population of native aquatic reeds and rushes around the deep channels.	Bed	Between annual inundation and three events per ten years will promote growth[A].	Between 24 and 48 months to ensure sufficient recruitment for current and future events.	Late winter with top up in next two springs	88 - 88.7m AHD	~1,470	~3,000 required for top ups	~4,470
Maintain Spike-sedge Wetland (EVC 819) in floodplain areas. Promote dominance of the groundlayer in these areas by sedge and rush species.	Bed / Riparian	Between annual to four events per ten years is recommended at this site[A,B].	Between eight and ten months[A].	Spring, allowing drawdown over summer and top up following spring	88.7 – 89m AHD	~1,890 (this will also achieve channel fill)	~2,280 required for top up (this will also achieve one channel fill)	~3,030
Maintain eucalypt floodplain woodland (Black Box) in the areas higher in the wetland reserve.	Riparian	One to two events per ten years is recommended[A].	Between three and six months[A].	Spring	89m AHD	~1,890 (this will also achieve above two targets)	-	~1,890

Note: Flooding frequency and duration of flooding have been based on: [A] Roberts and Marston (2011); [B] Stakeholder opinion on the tolerances of species specifically at the site.

[1] The frequency of watering events only relates to wetland watering from dry, and does not show top-up events.

[2] Based on rating table by Chislett (2010) in Maher (2010); survey information completed by Archard's Irrigation (2000) refer to Appendix 8.

[3] As above.

[4] As above.

6.2.3. Watering regime

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

The optimal, minimum and maximum watering regimes are described below. Due to the inter-annual variability of these estimates (particularly the climatic conditions), determination of the volume needed for any given year will need to be undertaken by the environmental water manager when watering is planned.

Minimum watering regime

Provide two wetland fill events (plus maintenance of water for two seasons each) every ten years.

Fill the channels of the wetland in winter of year one. Top up to 89m AHD during spring to target inundation of floodplain environments higher in the wetland (allow wetland to drawdown for up to two weeks prior to re-topping to 89m AHD).

Allow wetland to naturally draw down to approximately 88m AHD during summer. Provide another top up during spring of year two to ~88.7m AHD, ensuring that the water remains predominantly in channel and does not re-wet Black Box communities.

Allow wetland to dry completely over the next two years, and allow wetland to remain completely dry for two seasons (years five and six) prior to re-wetting.

Optimal watering regime

Provide two wetland fill events (plus maintenance of water for three seasons each) every ten years.

Fill the channels of the wetland in winter of year one. Top up to 89m AHD during spring to target inundation of floodplain environments higher in the wetland (allow wetland to drawdown for up to two weeks prior to re-topping to 89m AHD).

Allow wetland to naturally draw down to approximately 88m AHD during summer. Provide another top up during spring of year two to ~88.7m AHD, ensuring that the water remains predominantly in channel and does not re-wet Black Box communities.

Top up wetland in spring of year three to inundate the River Red Gum zone of the floodplain and allow water to draw down over summer.

Allow wetland to dry completely over the next two years, and allow wetland to remain completely dry for one season (year six) prior to re-wetting.

Maximum watering regime

Provide two wetland fill events (plus maintenance of water for three seasons each) every ten years.

Fill the channels of the wetland in winter of year one. Top up to 89m AHD during spring to target inundation of floodplain environments higher in the wetland (allow wetland to drawdown for up to two weeks prior to re-topping to 89m AHD).

Allow wetland to naturally draw down to approximately 88m AHD during summer. Provide another top up during spring of year two to ~88.7m AHD, ensuring that the water remains predominantly in channel and does not re-wet Black Box communities.

Top up wetland in spring of year three to inundate the River Red Gum zone of the floodplain and allow water to draw down over summer.

Allow wetland to dry completely over the next two years, and allow wetland to remain completely dry for one season (year six) prior to re-wetting.

6.3. 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 (DSE 2009b) and incorporated into the Victorian Strategy for Healthy Rivers, Estuaries and Wetlands (VSHREW).

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 that can realistically be provided through environmental water management. However, these ecological objectives can be achieved in wetter periods as water resource availability increases.

Environmental water at Richardson's Lagoon can be adaptively managed in accordance with the seasonally adaptive approach. During drought for example, the environmental water reserve can be used to provide water to critical refuges across Victoria (DSE 2009b). The channel ecosystem at Richardson's Lagoon can be maintained with water to provide an important drought refuge in the northern floodplain. During average and wet scenarios the environmental water reserve should be used to provide all aspects of the flow regime and target overbank flows (DSE 2009b). In specific reference to Richardson's Lagoon, additional water can be used in these instances to provide inundation for the River Red Gum and Black Box floodplain environments of the wetland.

Table 13. The seasonally adaptive approach to river and wetland management (DSE, 2009b)

	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

7. POTENTIAL RISKS OF AND MITIGATION MEASURES FOR ENVIRONMENTAL WATERING

A risk identification process has been undertaken to investigate the risks associated with environmental water delivery and site management at Richardson's Lagoon and is presented in Table 14.

These risks are considered as potential only, and may not eventuate during environmental water delivery and management at Richardson's Lagoon. In addition, a detailed risk assessment process will be undertaken prior to delivering environmental water in any given season and provided in the site watering proposal.

Table 14. Possible risks and potential mitigation measures associated with environmental water delivery to Richardson's Lagoon

Risk	Description	Potential Impacts								Potential mitigation measures
		Environmental (Water regime does not support breeding and feeding requirements or vegetation establishment and growth)					Social		Economic	
		Fish	Birds	Amphibians	Invertebrates	Native aquatic flora	Reduced public access and use	Degradation of cultural heritage sites	Flooding of adjacent land	
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		✓	✓		✓	✓			• Undertake a water mass-balance based on seasonal conditions before placing water order • Consult with water authority throughout season. Consider purchasing delivery shares of casual use if need be. • 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 to actively adapt water management • Monitor the ecological response of the wetland to flooding

Continued

Risk	Description	Potential Impacts								Potential mitigation measures
		Environmental (Water regime does not support breeding and feeding requirements or vegetation establishment and growth)					Social		Economic	
		Fish	Birds	Amphibians	Invertebrates	Native aquatic flora	Reduced public access and use	Degradation of cultural heritage sites	Flooding of adjacent land	
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
	High acid levels in wetland water	✓	✓	✓	✓	✓	✓			• Monitor acid levels in wetland in association with ASS (water quality logger and ecological condition) • Implement wetting or drying cycle as required • Place public warning signs at the wetland if there is a public health risk
Invasive aquatic plants and animals	Introduction of invasive aquatic fauna	✓		✓	✓	✓				• Monitor the ecological response of the wetland to flooding • Implement an appropriate drying regime
	Growth and establishment of invasive aquatic plants	✓	✓	✓	✓	✓				• Monitor the abundance of invasive aquatic plants • Control invasive plants in connected waterways • Spray or mechanically remove invasive plants • Implement an appropriate drying regime

8. ENVIRONMENTAL WATER DELIVERY INFRASTRUCTURE

8.1. Constraints

Currently the only constraint to achieving ecological outcomes with environmental water is the 1km pipe that links the pontoon pump with the wetland itself. This restricts the ability for fish passage into, and out of the wetland, and may impact on the ability of Richardson's Lagoon to support large numbers of piscivorous waterbirds that rely on fish for food.

8.2. Irrigation modernisation

The Northern Victorian Renewal Project (NVIRP) is a program which aims to upgrade existing irrigation infrastructure in the Goulburn-Murray Irrigation District to achieve water savings. The wetland has not been impacted by NVIRP projects to date, and there are currently no plans to modify the delivery infrastructure to Richardson's Lagoon as it is fed directly from the Murray River.

8.3. Infrastructure recommendations

No infrastructure recommendations are made at this time.

Commented [m1]: Bree to add:
1.Leaking drop board
2.Operations – pump paid for by DEPI and operated by PV
3. Pump maintenance charges to be included in Delivery Plans

9. KNOWLEDGE GAPS AND RECOMMENDATIONS

There are currently a number of knowledge gaps in relation to environmental water management at Richardson's Lagoon. While none of these impact the ability to provide water to the wetland and generate ecological benefit, addressing these knowledge gaps would significantly improve the accuracy of environmental water bids, and provide long-term ecological understanding of the site.

Specifically, the following activities are recommended to be undertaken along with long-term investment of environmental water to Richardson's Lagoon:

- review existing wetland capacity table and survey data
- complete additional IWC assessment for wet phase / drawdown conditions
- complete a full aquatic and riparian flora survey (including mapping wetland EVCs)
- develop a long and short-term monitoring program to be used in conjunction with environmental watering proposals and delivery plans including the following:
    - identify ecological indicators for monitoring long-term ecological condition and change
    - continue monitoring to identify triggers (and mitigating actions) for determining if there is acid water generating from ASS
- fence remaining Crown Land
- support Parks Victoria in negotiating an exchange of land so that pockets of private land are not contained within the reserve boundary.

As Richardson's Lagoon contains a diversity of vegetation habitats, active monitoring should be undertaken before, during and after all watering events in order to inform decision-making. In particular, monitoring should include:

- water quality, in particular to ensure acid water does not develop from ASS
- volume of water delivered
- movement of water through the wetland reserve
- height of the water (using the two gauge boards) to inform when a wetland fill is achieved, and when top-ups are required.

As for all other wetlands and watering events, it is important to monitor ecological outcomes triggered by the event. However, regular and long-term monitoring is also required for these sites in order to understand long-term ecological condition and change (e.g. regular flora and fauna surveys).

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APPENDIX 1: CORRICK AND NORMAN CLASSIFICATION OF WETLAND CATEGORIES

Source: DSE 2007b

Category	Sub-category	Depth (m)	Duration of inundation
Flooded river flats These include many areas of agricultural land that become temporarily inundated after heavy rains or floods. Water may be retained in local depressions for just a few days or for several months.		< 2	
Freshwater meadow These include shallow (up to 0.3 m) and temporary (less than four months duration) surface water, although soils are generally waterlogged throughout winter.	1 Herb-dominated 2 Sedge-dominated 3 Red gum- dominated 4 Lignum dominated	< 0.3	< 4 months/year
Shallow freshwater marsh Wetlands that are usually dry by mid-summer and fill again with the onset of winter rains. Soils are waterlogged throughout the year and surface water up to 0.5 m deep may be present for as long as eight months.	1 Herb-dominated 2 Sedge-dominated 3 Cane grass dominated 4 Lignum dominated 5 Red gum-dominated	< 0.5	< 8 months/year
Deep freshwater marsh Wetlands that generally remain inundated to a depth of 1 – 2 m throughout the year.	1 Shrub-dominated 2 Reed-dominated 3 Sedge-dominated 4 Rush-dominated 5 Open water 6 Cane grass dominated 7 Lignum-dominated 8 Red gum-dominated	< 2	permanent
Permanent open freshwater Wetlands that are usually more than 1 m deep. They can be natural or artificial. Wetlands are described to be permanent if they retain water for longer than 12 months, however they can have periods of drying.	1 Shallow 2 Deep 3 Impoundment	<2 >2	permanent
Semi-permanent saline These wetlands may be inundated to a depth of 2 m for as long as eight months each year. Saline wetlands are those in which salinity exceeds 3,000 mg/L throughout the whole year.	1 Salt pan 2 Salt meadow 3 Salt flat 4 Sea rush-dominated 5 Hypersaline lake	< 2	< 8 months/year
Permanent saline These wetlands include coastal wetlands and part of intertidal zones. Saline wetlands are those in which salinity exceeds 3,000 mg/L throughout the whole year.	Shallow Deep Intertidal flats	< 2 > 2	permanent
Sewage oxidation basin These include artificial wetlands used for sewage treatment.	Sewage oxidation basin		
Salt evaporation basin These include artificial wetlands used salt concentration.	Salt evaporation basin		

APPENDIX 2: ENVIRONMENTAL WATER SOURCES

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:

- Bulk Entitlement (River Murray – Flora and Fauna) Conversion Order 1999 (incl. Amendments Orders and Notices 2005, 2006, 2007 and 2009); and
- Environmental Entitlement (River Murray Environmental Water Reserve) 2010.

In 1987 an annual allocation of 27,600 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 (DSE, 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.

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 3: 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);
- Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA); and
- The Convention on the Conservation of Migratory Species of Wild Animals (also known as the Bonn Convention or CMS).

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 199*9 (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 Strait 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 (DSE)

Three advisory lists are maintained by DSE 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 4: ECOLOGICAL VEGETATION CLASSES

Figure 13 shows the Ecological Vegetation Classes mapped at Richardson's Lagoon (area bounded by dotted line).

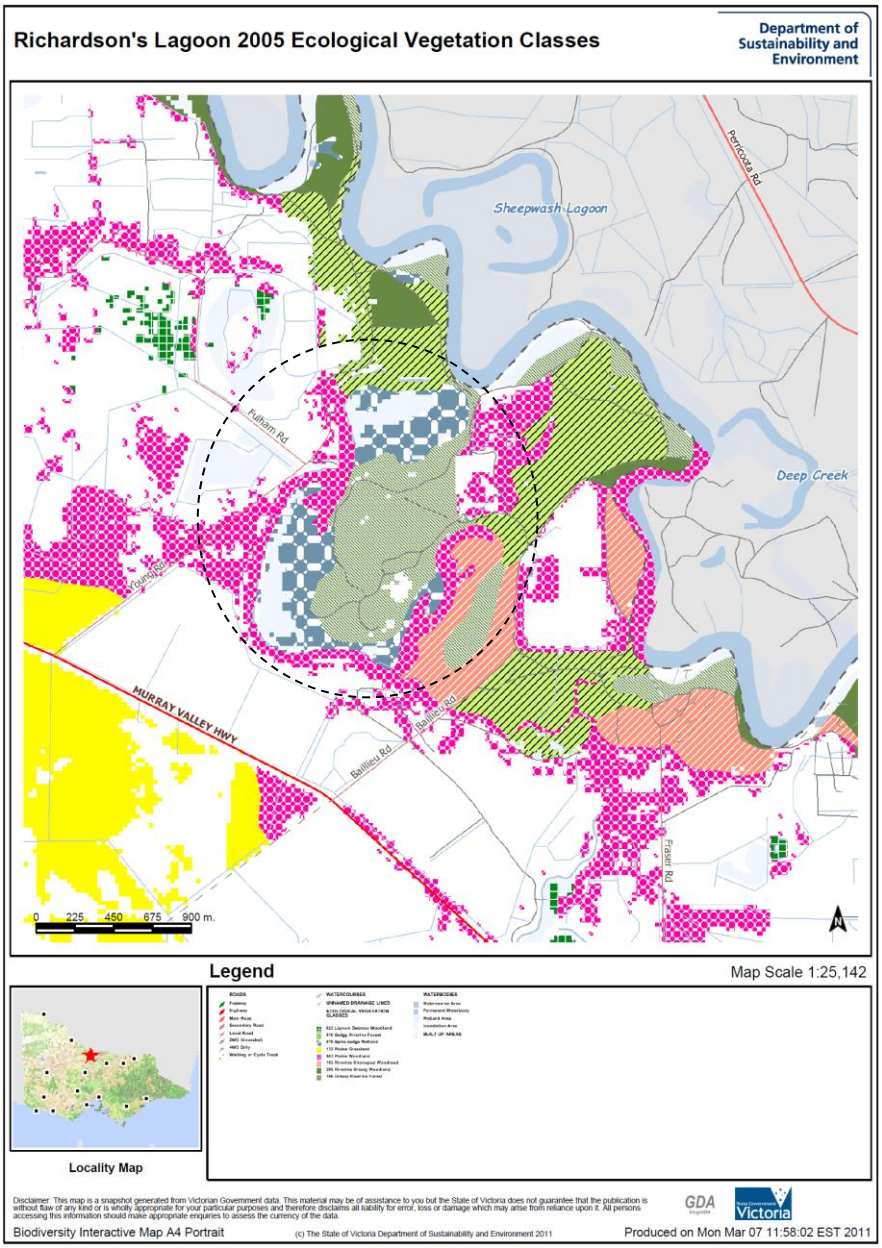

Figure 13. EVCs recorded at Richardson's Lagoon, and their location

Department of Sustainability and Environment

EVC/Bioregion Benchmark for Vegetation Quality Assessment

Murray Fans bioregion

EVC 103: Riverine Chenopod Woodland (*syn.* Black Box Chenopod Woodland)

Description:
Eucalypt woodland to 15 m tall with a diverse shrubby and grassy understorey occurring on most elevated riverine terraces. Confined to heavy clay soils on higher level terraces within or on the margins of riverine floodplains (or former floodplains), naturally subject to only extremely infrequent incidental shallow flooding from major events if at all flooded.

Large trees:

Species	DBH(cm)	#/ha
Eucalyptus largiflorens	40 cm	5/ha

Tree Canopy Cover:

%cover	Character Species	Common Name
10%	*Eucalyptus largiflorens*	Black Box
	Acacia stenophylla	River Coobah

Understorey:

Life form	#Spp	%Cover	LF code
Immature Canopy Tree		5%	IT
Medium Shrub	3	30%	MS
Small Shrub	5	25%	SS
Prostrate Shrub	1	1%	PS
Medium Herb	5	5%	MH
Small or Prostrate Herb*	5	10%	SH
Medium to Small Tufted Graminoid	2	5%	MTG
* Largely seasonal life form			
Total understorey projective foliage cover		**50%**	

LF Code	Species typical of at least part of EVC range	Common Name
MS	*Atriplex nummularia*	Old-man Saltbush
MS	*Chenopodium nitrariaceum*	Nitre Goosefoot
MS	*Eremophila divaricata* ssp. *divaricata*	Spreading Emu-bush
SS	*Sclerolaena tricuspis*	Streaked Copperburr
SS	*Enchylaena tomentosa* var. *tomentosa*	Ruby Saltbush
SS	*Atriplex lindleyi*	Flat-top Saltbush
SS	*Rhagodia spinescens*	Hedge Saltbush
PS	*Sclerochlamys brachyptera*	Short-wing Saltbush
MH	*Einadia nutans* ssp. *nutans*	Nodding Saltbush
MH	*Calocephalus sonderi*	Pale Beauty-heads
MH	*Senecio glossanthus*	Slender Groundsel
MH	*Brachyscome lineariloba*	Hard-head Daisy
SH	*Disphyma crassifolium* ssp. *clavellatum*	Rounded Noon-flower
SH	*Maireana pentagona*	Hairy Bluebush

Recruitment:
Continuous

Organic Litter:
5% cover

Logs:
5m/0.1 ha.

Victoria
The Place To Be

EVC 103: Riverine Chenopod Woodland (*syn.* Black Box Chenopod Woodland) - Murray Fans bioregion

Weediness:

LF Code	Typical Weed Species	Common Name	Invasive	Impact
T	*Olea europaea* subsp. *europaea*	Olive	low	high
MS	*Lycium ferocissimum*	Boxthorn	low	high
LH	*Sisymbrium erysimoides*	Smooth Mustard	high	high
LH	*Critesion* spp.	Barley-grass	high	low
LH	*Gazania linearis*	Gazania	high	high
LH	*Opuntia* spp.	Prickly Pear	low	high
LH	*Sisymbrium irio*	London Mustard	high	high
LH	*Psilocaulon granulicaule*	Noon-flower	high	high
MH	*Limonium sinuatum*	Notch-leaf Sea-lavender	high	high
MH	*Limonium lobatum*	Winged Sea-lavender	high	high
MH	*Trifolium arvense* var. *arvense*	Hare's-foot Clover	high	low
MH	*Mesembryanthemum nodiflora*	Ice-plant	high	high
MH	*Carrichtera annua*	Ward's Weed	high	high
MH	*Marrubium vulgare*	Horehound	high	high
MH	*Carpobrotus aequilaterus*	Angled Pigface	low	high
MH	*Silene apetala* var. *apetala*	Sand Catchfly	high	low
MH	*Medicago* spp.	Medic	high	low
MH	*Oxalis pes-caprae*	Soursob	high	high
MH	*Silene gallica*	French Catchfly	high	low
MH	*Silene nocturna*	Mediterranean Catchfly	high	low
SH	*Mesembryanthemum crystallinum*	Common Ice-plant	high	high
MTG	*Vulpia bromoides*	Squirrel-tail Fescue	high	high
MTG	*Lolium rigidum*	Wimmera Rye-grass	high	low
MTG	*Asphodelus fistulosus*	Onion Weed	high	high
MNG	*Bromus rubens*	Red Brome	high	high
MNG	*Vulpia myuros*	Rat's-tail Fescue	high	low
MNG	*Bromus* spp.	Brome	high	high
MNG	*Schismus barbatus*	Arabian Grass	high	low
SC	*Asparagus asparagoides*	Bridal Creeper	high	high

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EVC/Bioregion Benchmark for Vegetation Quality Assessment

Murray Fans bioregion

EVC 106: Grassy Riverine Forest

Description:
Occurs on the floodplain of major rivers, in a slightly elevated position where floods are infrequent, on deposited silts and sands, forming fertile alluvial soils. River Red Gum forest to 25 m tall with a groundlayer dominated by graminoids. Occasional tall shrubs present.

Large trees:

Species	DBH(cm)	#/ha
Eucalyptus spp.	90 cm	20 / ha

Tree Canopy Cover:

%cover	Character Species	Common Name
30%	*Eucalyptus camaldulensis*	River Red-gum

Understorey:

Life form	#Spp	%Cover	LF code
Immature Canopy Tree		5%	IT
Understorey Tree or Large Shrub	1	10%	T
Large Herb	2	10%	LH
Medium Herb	3	10%	MH
Medium to Small Tufted Graminoid	3	25%	MTG
Medium to Tiny Non-tufted Graminoid	3	10%	MNG
Bryophytes/Lichens	na	10%	BL
Total understorey projective foliage cover		**75%**	

LF Code	Species typical of at least part of EVC range	Common Name
T	*Acacia stenophylla*	Eumong
LH	*Wahlenbergia fluminalis*	River Bluebell
LH	*Senecio quadridentatus*	Cotton Fireweed
MH	*Goodenia fascicularis*	Silky Goodenia
MH	*Eclipta platyglossa*	Yellow Twin-heads
MTG	*Setaria jubiflora*	Warrego Summer-grass
MNG	*Eleocharis acuta*	Common Spike-sedge

Recruitment:
Continuous

Organic Litter:
40 % cover

Logs:
30 m/0.1 ha.

Weediness:

LF Code	Typical Weed Species	Common Name	Invasive	Impact
LH	*Lactuca serriola*	Prickly Lettuce	high	low
LH	*Sonchus oleraceus*	Common Sow-thistle	high	low
LH	*Centaurea melitensis*	Malta Thistle	high	low
MH	*Hypochoeris glabra*	Smooth Cat's-ear	high	low
MH	*Trifolium arvense* var. *arvense*	Hare's-foot Clover	high	low
MH	*Reichardia tingitana*	False Sow-thistle	high	low
MH	*Phyla canescens*	Fog-fruit	high	high
MTG	*Vulpia bromoides*	Squirrel-tail Fescue	high	low
MNG	*Bromus rubens*	Red Brome	high	low

EVC 106: Grassy Riverine Forest - Murray Fans bioregion

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EVC/Bioregion Benchmark for Vegetation Quality Assessment

Murray Fans bioregion

EVC 803: Plains Woodland

Description:
Grassy or sedgy woodland to 15 m tall (typically dominated by *Eucalyptus largiflorens* in the north-western part of its range) with large inter-tussock spaces potentially supporting a range of annual or geophytic herbs adapted to low summer rainfall, with low overall biomass. Mostly occurs on terrain of low relief in areas receiving <600 mm rainfall per annum. Fertile, sometimes seasonally waterlogged, mostly silty, loamy or clay topsoils, with heavy subsoils, derived largely from recent (ie Quaternary) fluvial or alluvial deposits.

Large trees:

Species	DBH(cm)	#/ha
Eucalyptus spp.	60cm	15/ha
Allocasuarina luehmannii	40cm	

Tree Canopy Cover:

%cover	Character Species	Common Name
15%	*Eucalyptus largiflorens*	Black Box
	Allocasuarina luehmannii	Buloke
	Eucalyptus microcarpa	Grey Box
	Eucalyptus porosa	Black Mallee-box

Understorey:

Life form	#Spp	%Cover	LF code
Immature Canopy Tree		5%	IT
Medium Shrub	3	10%	MS
Small shrub	1	5%	SS
Prostrate shrub	2	10%	PS
Large Herb	2	1%	LH
Medium Herb	9	10%	MH
Small or Prostrate Herb	5	10%	SH
Large tufted graminoid	1	1%	LTG
Medium to Small Tufted Graminoid	6	20%	MTG
Medium to Tiny Non-tufted Graminoid	2	1%	MNG
Scrambler or Climber	1	1%	SC
Bryophytes/Lichens	na	10%	BL
Soil Crust	na	10%	S/C
Total understorey projective foliage cover		**80%**	

LF Code	Species typical of at least part of EVC range	Common Name
MS	*Pittosporum angustifolium*	Weeping Pittosporum
MS	*Acacia pycnantha*	Golden Wattle
MS	*Acacia acinacea* s.l.	Gold-dust Wattle
SS	*Eutaxia microphylla* var. *microphylla*	Common Eutaxia
SS	*Enchylaena tomentosa* var. *tomentosa*	Ruby Saltbush
SS	*Sclerolaena diacantha*	Grey Copperburr
LH	*Senecio quadridentatus*	Cotton Fireweed
MH	*Einadia nutans ssp. nutans*	Nodding Saltbush
MH	*Calocephalus citreus*	Lemon Beauty-heads
MH	*Plantago gaudichaudii*	Narrow Plantain
MH	*Sida corrugata*	Variable Sida
SH	*Crassula sieberiana*	Sieber Crassula
SH	*Actinobole uliginosum*	Flannel Cudweed
SH	*Oxalis perennans*	Grassland Wood-sorrel
SH	*Calotis hispidula*	Hairy Burr-daisy
LTG	*Austrostipa aristiglumis*	Plump Spear-grass
MTG	*Austrodanthonia caespitosa*	Common Wallaby-grass
MTG	*Dianella revoluta* s.l.	Common Wallaby-grass

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Recruitment:
Continuous

Organic Litter:
10 % cover

Logs:
10m/0.1 ha.

Weediness:

LF Code	Typical Weed Species	Common Name	Invasive	Impact
MS	*Lycium ferocissimum*	Boxthorn	high	high
LH	*Brassica tournefortii*	Mediterranean Turnip	high	high
LH	*Sonchus oleraceus*	Common Sow-thistle	high	low
LH	*Opuntia* spp	Prickly Pear	high	high
MH	*Gazania linearis*	Gazania	high	high
MH	*Spergularia rubra* s.l.	Red Sand-spurrey	high	low
MH	*Silene apetala* var. *apetala*	Sand Catchfly	high	low
MH	*Silene longicaulis*	Portuguese Catchfly	high	low
SH	*Medicago minima*	Little Medic	high	low
MTG	*Schismus barbatus*	Arabian Grass	high	low
MTG	*Poa bulbosa*	*Bulbous Meadow-grass*	*high*	*high*
MTG	*Pentaschistis airoides* subsp. *airoides*	False Hair-grass	high	high
MTG	*Romulea rosea*	Onion Grass	high	high
MNG	*Bromus rubens*	Red Brome	high	high
MNG	*Vulpia myuros*	Rat's-tail Fescue	high	low
MNG	*Bromus* spp.	Brome	high	high
SC	*Asparagus asparagoides*	Bridal Creeper	high	high

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EVC/Bioregion Benchmark for Vegetation Quality Assessment

Murray Fans bioregion

EVC 816: Sedgy Riverine Forest

Description:
Eucalypt forest to 25 m tall with understorey dominated by larger sedges. Understorey composition indicative of at least occasional shallow flooding and a tolerance of gaps between floods of several years. Typically on heavy soils which can become wet in winter. Sedgy Riverine Forest has some floristic affinities to Red Gum Swamp. It is considered to occupy areas infrequently flooded and in which flood duration may be short, for example, higher ground surrounding the box ridges or occurring along the river levee in a position remote from the channels from which the forest first floods. These areas are therefore the last to flood and the first from which floods quickly recede. Soils are typically heavy clays. The major understorey species *Carex tereticaulis* is intolerant of total immersion (at least in turbid water).

Large trees:

Species	DBH(cm)	#/ha
Eucalyptus spp.	80 cm	20 / ha

Tree Canopy Cover:

%cover	Character Species	Common Name
30%	*Eucalyptus camaldulensis*	River Red-gum

Understorey:

Life form	#Spp	%Cover	LF code
Immature Canopy Tree		5%	IT
Medium Shrub	1	10%	T
Medium Herb	2	5%	MH
Small or Prostrate Herb	2	5%	SH
Large Tufted Graminoid	1	50%	LTG
Medium to Small Tufted Graminoid	2	10%	MTG
Medium to Tiny Non-tufted Graminoid	2	10%	MNG
Total understorey projective foliage cover		**90%**	

LF Code	Species typical of at least part of EVC range	Common Name
MS	*Exocarpos strictus*	Pale-fruit Ballart
LH	*Wahlenbergia fluminalis*	River Bluebell
LH	*Senecio quadridentatus*	Cotton Fireweed
LH	*Brachyscome basaltica var. gracilis*	Woodland Swamp-daisy
MH	*Marsilea drummondii*	Common Nardoo
SH	*Lobelia concolor*	Poison Pratia
SH	*Chamaesyce drummondii*	Flat Spurge
LTG	*Carex tereticaulis*	Rush Sedge
MTG	*Setaria jubiflora*	Warrego Summer-grass
MTG	*Lachnagrostis filiformis*	Common Blown Grass
MNG	*Eleocharis acuta*	Common Spike-sedge
MNG	*Eleocahris pusilla*	Small Spike-sedge

Recruitment:
Episodic/Flood. Desirable period between disturbances is 10 years.

Organic Litter:
10 % cover

Logs:
20 m/0.1 ha.

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Weediness:

LF Code	Typical Weed Species	Common Name	Invasive	Impact
LH	*Lactuca serriola*	Prickly Lettuce	high	low
LH	*Aster subulatus*	Aster Weed	high	low
LH	*Helminthotheca echioides*	Prickly Ox-tongue	high	low
LH	*Cirsium vulgare*	Spear Thistle	high	high

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EVC/Bioregion Benchmark for Vegetation Quality Assessment

Murray Fans bioregion

EVC 819: Spike-sedge Wetland

Description:
Low sedgy vegetation of species-poor seasonal or intermittent wetlands, dominated by spike-sedges. Typically treeless, but sometimes with thickets of saplings or scattered more mature specimens of *Eucalyptus camaldulensis*. Mostly confined to a narrow ring around the upper margins of floodway ponds. Soils are typically heavy clays (e.g. mottled yellow-grey clay, grey loamy clay), occasionally silty near the surface. In some riverine sites, annual inundation is not reliable and the rhizomic rootstocks of *Eleocharis acuta* appear capable of surviving at least occasional periods of longer dormancy.

Life Forms:

Life form	#Spp	%Cover	LF code
Large Herb	1	5%	LH
Medium Herb	6	15%	MH
Small or Prostrate Herb	4	5%	SH
Medium to Small Tufted Graminoid	2	10%	MTG
Medium to Tiny Non-tufted Graminoid	2	50%	MNG
Total understorey projective foliage cover		**75%**	

LF Code	Species typical of at least part of EVC range	Common Name
LH	*Senecio quadridentatus*	Cottony Fireweed
MH	*Myriophyllum crispatum*	Upright Milfoil
MH	*Marsilea drummondii*	Common Nardoo
MH	*Ludwigia peploides* ssp. *montevidensis*	Clove-strip
MH	*Centipeda cunninghamii*	Common Sneezeweed
SH	*Lobelia concolor*	Poison Pratia
SH	*Persicaria prostrata*	Prostrate Knotweed
SH	*Callitriche sonderi*	Matted Water-starwort
MTG	*Triglochin procerum* s.l.	Water-ribbons
MTG	*Lachnagrostis filiformis*	Common Blown Grass
MNG	*Eleocharis acuta*	Common Spike-sedge
MNG	*Eleocharis pusilla*	Small Spike-sedge

Recruitment:
Episodic/Flood – desirable period is every five years

Organic Litter:
20% Cover

Logs:
5 m/0.1 ha.(where trees are overhanging the wetland)

Weediness:

LF Code	Typical Weed Species	Common Name	Invasive	Impact
LH	*Aster subulatus*	Aster-weed	high	low
MNG	*Paspalum distichum*	Water Couch	high	high

EVC 819: Spike-sedge Wetland - Murray Fans bioregion

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APPENDIX 5: RECENT WATERING HISTORY

Wetland		1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003
Richardson's Lagoon	Status [1]	W	W	W	W	W	W	W	W-D	D	D
	Water source[2]	D	D	D	D	D	D	D	-	-	E
	Volume delivered (if available) (ML)	-	-	-	-	-	-	-	U	U	20
	Comment	Wetland holding drainage outfall, particularly during summer.							Wetland commenced drying phase.		

Wetland		2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-14
Richardson's Lagoon	Status[1]	W	W	W	W-D (?)	D	D	D-W	W	W	W	W-D
	Water source[2]	E	E	E (surplus flows)	-	-	-	E	E	-	E	-
	Volume delivered (if available) (ML)	1,201	1,200	505	-	-	-	231	2,004	-	1256	-
	Comment	Water delivered in spring using shared pump. FSL not reached due to pump demand.	Water delivered in spring using shared pump. FSL not reached due to pump demand.	Water delivered in spring in preparation for wetland fill. Pump constructed on Murray River however delays in power being connected, therefore filling could not occur.				Water delivery begun in winter 2010 using pontoon pump.	Water topped up in spring to inundate floodplain zones and allowed to drawdown during summer.			

APPENDIX 6: 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.dse.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 7: WORKSHOP OUTCOMES

Key discussion points from the local technical group workshop held on 16 June 2011 are provided below. Members of the local technical group present at the workshop were Mark Tscharke (Parks Victoria), Shelley Heron (Kellogg Brown and Root), Emer Campbell (North Central Catchment Management Authority) and Ross Stanton (Goulburn-Murray Water).

- Currently the wetland is in the best condition the group has ever seen it in, with the water stretching right through the floodplain areas as well as the deep channels.
- It is a high quality waterbird breeding wetland. This year saw the return of Magpie Geese to the site for the first time in decades.
- The wetland has a history of blue-green algae outbreaks. Therefore, it is considered important to ensure that the phosphorus in the wetland remains 'locked-up' in the soil structure – a complete and regular drying cycle is considered important to assist with this. There has been no BGA at the wetland this season, and it was felt that the previous drying cycle assisted with this.
- There are different habitats contained in the wetland and reserve area – wetland itself, then the floodplain area that can be inundated with environmental water, and the Black Box community that has some level of interaction with environmental water (although inundation is for a short period of time).
- The channels themselves are quite distinct, and then the wetland turns into more of a shallow marshland environment in amongst the River Red Gum and Black Box – this is the area that has been incredibly productive this year. At the moment there is a lot of Water Couch and sedgy species.
- The Link Channel can be managed in the same regime as the wetland itself. It is preferable for this body of water to dry completely so that any small carp that get sucked in through the pump will not go too big and enter the wetland itself.
- Under the available mapping of the wetland, the only area that shows up as being part of the wetland is the deep channels, and therefore is considered a small site. There are more important areas that should be considered as part of the wetland and it is actually much larger than any of the available mapping shows.
- Most of the wetland is under about 1m deep, however there are also holes which are up to about 2m deep (the bed has some variation).
- The edge of the wetland is mainly dominated by Giant Rush, with a little bit of Cumbungi here and there. There are also a lot of submerged aquatics showing up since the carp are no longer in the system (due to the drying of the wetland).
- There are some fish which have entered the wetland through the pump (or birds), particularly Carp Gudgeon. Fish are not the target specifically for this wetland however as this would then implicate a permanent system as there is no way of them leaving the wetland on their own accord.
- Ideal flooding regime is similar to how the wetland is being managed in this event, and is provided below:

Year	Optimal watering regime
One	Fill wetland channels in winter. Top up in spring to inundate River Red Gum and Black Box floodplain zone. Allow to draw down from floodplain zone over summer.
Two	Top up wetland channel in spring (avoiding floodplain inundation).
Three	Top up wetland and inundate River Red Gum floodplain zone (depending on climatic conditions).
Four	Allow wetland to dry.
Five	Allow wetland to dry.
Six	Allow wetland to remain dry.
Seven	Fill wetland channels in winter. Top up in spring to inundate River Red Gum and Black Box floodplain zone. Allow to draw down from floodplain zone over summer.
Eight	Top up wetland channel in spring (avoiding floodplain inundation).
Nine	Top up wetland and inundate River Red Gum floodplain zone (depending on climatic conditions).
Ten	Allow wetland to dry.

APPENDIX 8: CONTOUR PLAN AND CAPACITY TABLE

Source: Chislett (2010) in Maher (2010)

Richardson's Lagoon Capacity Report

September 2010

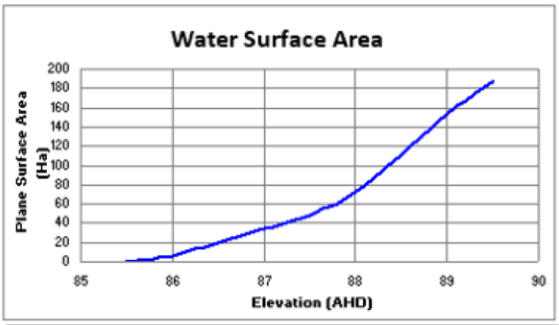
Produced by Dustin Chislett (GIS Technical Services, Jemena, Melbourne)

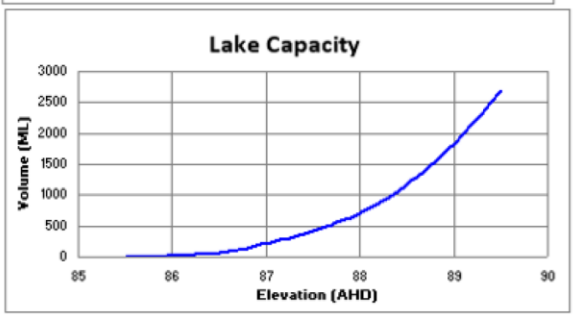
Rating Table notes:
The survey of Richardson's Lagoon was carried out using survey data (Archard's Irrigation 2000).
Software packages: AutoCAD Civil 3d 2011, Trimble Terramodel
All elevations were converted to AHD according to the published AHD elevation
For a more accurate table, additional survey points required (RTK GPS System).

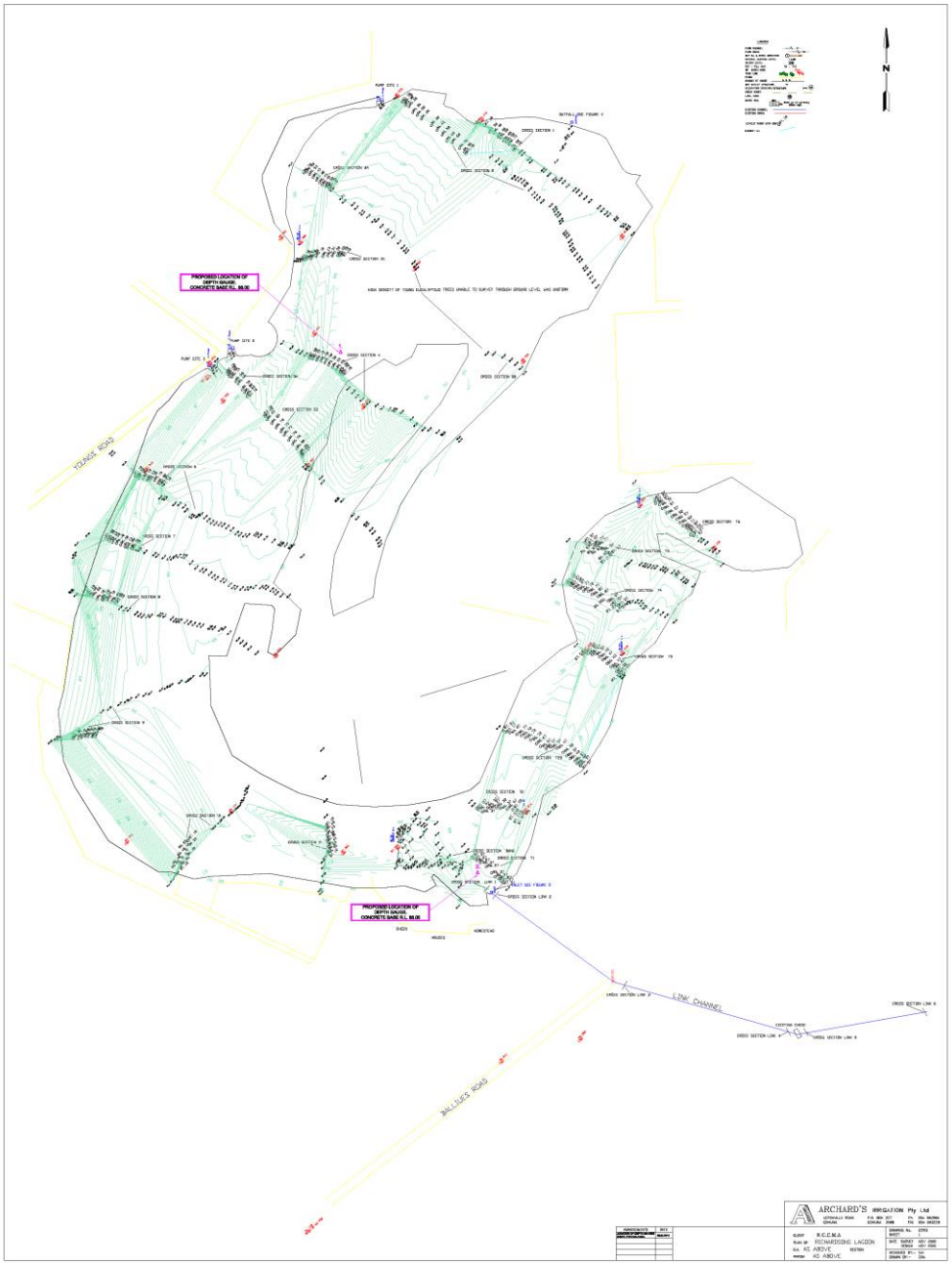
Base Level (AHD) 85.5 m
Top (AHD) 89.0 m (Estimate)

Elevation m (AHD)	Capacity ML	Surface Area Ha
85.50	0.0	0.0
85.60	0.3	0.8
85.70	1.5	1.7
85.80	3.7	2.7
85.90	7.0	4.0
86.00	11.9	5.9
86.10	19.2	8.9
86.20	29.3	11.4
86.30	42.1	14.0
86.40	57.3	16.4
86.50	75.3	19.8
86.60	96.7	23.0
86.70	121.3	26.1
86.80	148.8	28.8
86.90	179.2	32.0
87.00	212.3	34.2
87.10	247.7	36.6
87.20	285.5	39.1
87.30	326.0	41.9
87.40	369.6	45.2
87.50	416.5	48.8
87.60	467.1	52.6
87.70	521.7	56.5
87.80	580.3	60.8
87.90	643.7	66.1
88.00	712.6	72.0
88.10	788.4	79.8
88.20	872.1	87.7
88.30	963.6	95.4
88.40	1,062.8	103.1
88.50	1,170.2	111.9
88.60	1,286.5	120.5
88.70	1,411.0	128.5
88.80	1,543.8	137.1
88.90	1,685.1	145.5
89.00	**1,834.6**	**153.3**
89.10	1,991.6	160.5
89.20	2,155.5	167.3
89.30	2,326.1	174.0
89.40	2,503.4	180.7
89.50	2,687.6	187.7

*Full Supply Level






PROPOSED LOCATION OF DEPTH GAUGE CONCRETE BASE R.L. 86.00
PROPOSED LOCATION OF DEPTH GAUGE CONCRETE BASE R.L. 86.00
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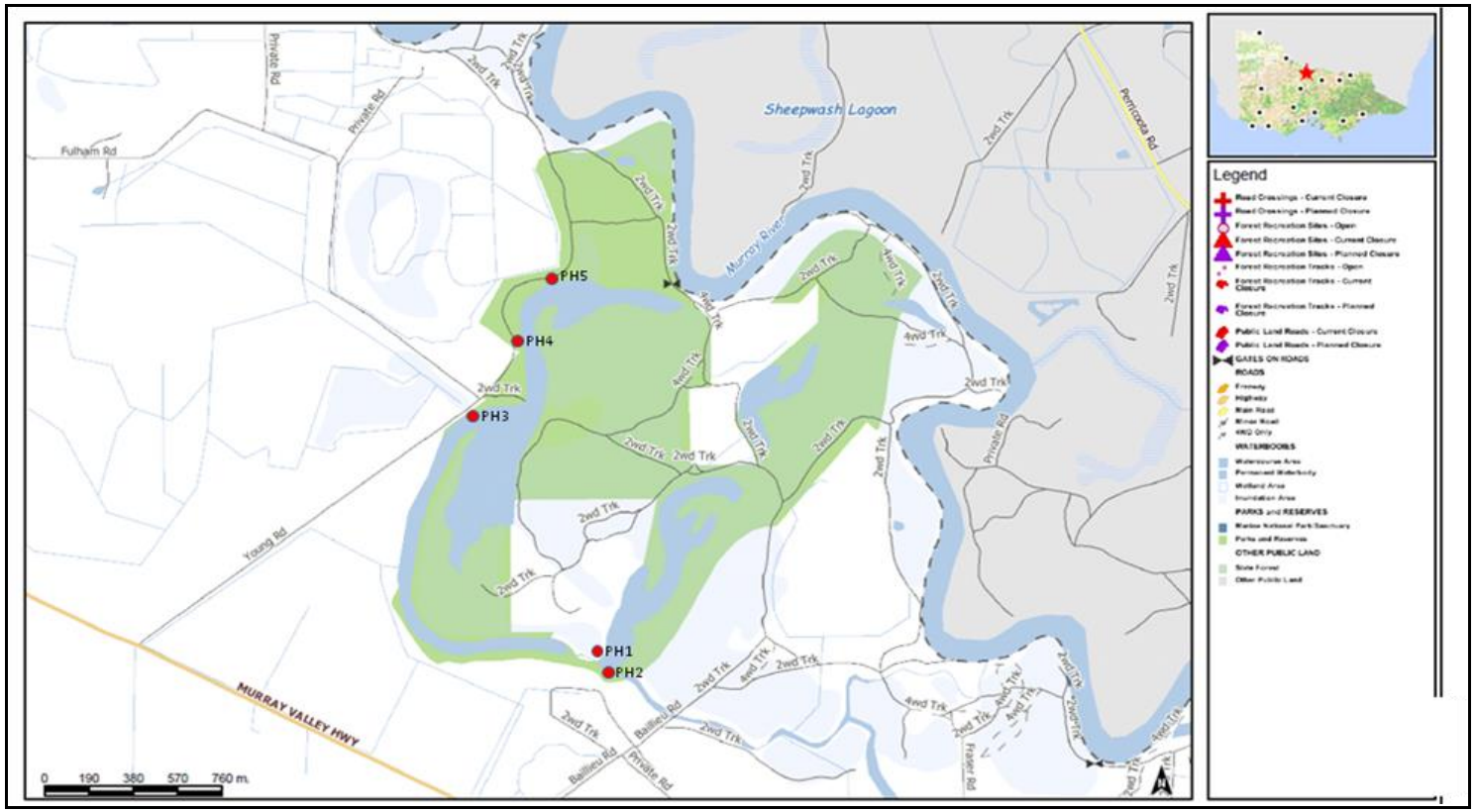
ARCHARD'S IRRIGATION Pty Ltd
R.C.C.M.A.
RETARDING LAGOON
AS ABOVE
AS ABOVE

APPENDIX 9: RICHARDSON'S LAGOON PHOTOPOINT MONITORING



Commented [m2]: Bree – need to refer to your pp in the text somewhere – to discuss

Richardson's Lagoon Photpoints

		Photopoint 1	Photopoint 2	Photopoint 3	Photopoint 4	Photopoint 5	Photopoint 6	Photopoint 7	Photopoint 8	Photopoint 9
		EASTING 280903.4 NORTHING 6008858.8 DESCRIPTION: (Standing with tree to RHS)	EASTING 280878.189 NORTHING 6008926.957 DESCRIPTION:	EASTING 281053.987 NORTHING 6010633.584 DESCRIPTION: (standing on lagoon side of Young Road across from Candie house)	EASTING 280444.3 NORTHING 6010329.0 DESCRIPTION: (standing at Road on corner next to piggery)	EASTING 280566.924 NORTHING 6010676.923 DESCRIPTION: (on top of levee system with large tree to LHS)	EASTING 281049.057 NORTHING 6010630.377 DESCRIPTION: (Standing at outlet structure with large tree to the RHS)	EASTING 281058.994 NORTHING 6010633.709 DESCRIPTION: (standing on outlet structure)	EASTING 281237.498 NORTHING 6010406.880 DESCRIPTION: (standing on island between two dirt roads with large tree to LHS)	EASTING 281259.687 NORTHING 6009818.437 DESCRIPTION: (across the road from Jan Harper's property)
13/06/12	Field visit with Australian Ecosystems	N/A	N/A				N/A	N/A	N/A	N/A
26/09/12	During field trip for Heidi's project		N/A				N/A		N/A	N/A
19/10/12	6 days prior to top-up delivery		N/A							
09/11/12	12 days after start of fill									
28/11/2012	7 days to switch off	N/A	N/A							
12/12/12	6 days after switch off	N/A	N/A							

NORTH CENTRAL
Catchment Management Authority
Connecting Rivers, Landscapes, People

APPENDIX 10: TARGETED COMMUNITY CONSULTATION – SUMMARY REPORT

Method

Community Consultation for the Richardson's Lagoon Environmental Water Management Plan (EWMP) has been undertaken via telephone interviews during the week of the 11th March 2013. To finalise the EWMP local knowledge and input was required. The interviews were focussed on collecting information from the community in relation to the wetland, its values and the draft environmental watering regime recommendations. The information collected has been summarised below and will be used to update, revise and complete the plan. The community consultation component of developing the plan is essential in ensuring that the plan is meaningful and robust into the future.

Community representatives interviewed

Stan Archard, Tuesday Browell, Dianne Bowles, Keith Stockwell and Ken Colvin

1. Wetland information (general)

- When I first visited this wetland approximately 20 years ago, the wetland was spectacular. Wetland would receive water from channel (from the plains), therefore due to farming influence the phosphates and cow manure was an additional input into the wetland. Blue Green Algae became a regular even at the wetland.
- A bore exists at one of the private property's, approximately 30-35ft.
- There use to be approximately five diversion licences off the wetland.
- First drying of the wetland was in 2006/07, installing the pump off the Murray River was the option selected to mange water into the wetland rather than using the irrigation system.
- Richardson's just missed out on being classified as a Ramsar wetland.
- Need to sort out the private land ownership of the wetland (Torrumbarry Estate own part of the wetland).
- Rubbish is an issue at the wetland due to campers, duck shooting, 4WD e.t.c. The Shire Council or Parks Victoria need to put bins and cart away.
- Still a lot of rubbish on the Public Land
- One landholder traps wild cats – has caught 10-20 in one year.
- Duck shooting is an environmental and public safety issue. Many shooters are shooting over people's houses.
- Other private land in the wetland (two homes) – there are currently no markings to distinguish private property from public land. This has caused issues during the hunting season, where hunters have entered private property.
- Magpie Geese identified at the wetland in 2011, there was a voluntary ban put in to try and stop duck shooters. However at the end of the season they were gone.
- Richardson's Lagoon is hidden from the road and the community are not as aware of this wetland as they are of others. It would be a good idea to put some signage up (just near the highway).
- Environmental water notices are a good way of notifying the community of watering events. Need to ensure that they are being put in all the relevant papers and it would be useful to add a photo of the project officer talking to the community at the wetland to attract the reader's attention.
- The fish population is also very important and it is recommended that fish surveys are included as part of the management of the wetland (if funding allows).

2. Wetland values

Environmental

- Lots of wildlife at the moment (March 2013) including Sea Eagles, Red-bellied Black Snakes, Platypus.
- Broad Shelled, Murray River and Long Neck turtles frequently visit this wetland. Hundreds of Broad Shelled Turtles have been observed laying eggs. However foxes are a real threat, 20 turtles were found dead last year.

- A good contact for turtles is Graham Stockfeld from the Australian Freshwater Turtle Conservation and Research Association has monitored turtle activity at Richardson's Lagoon.
- Sea Eagles nest here. Grey Crowned Babblers, Brolga and Royal Spoonbills are also frequent visitors.
- Frogs including Barking Marsh Frog and Bull Frogs have been recorded at Richardson's.
- White-Bellied Sea Eagles nest at times, Brolga's have been sited and Magpie Geese have nested at the lagoon.
- The bushland surrounding the wetland is very good for bush birds, e.g. Diamond Firetail and Grey-crowned Babbler.
- The Sandalwoods *Santalum Lanceolatum* (depleted in Victoria after gold rush). Estimated to be only 80 left in Victoria. Richardson's Lagoon has approximately 18 with one about 900 years old and another about 500 years old. Rabbits are a real threat to these trees, especially during the drying cycle.
- Ibis use to visit this wetland in the 1000s.
- Overall, water quality was quite good when it was permanent, it was the dry years when Blue Green Algae events would occur.

Cultural Heritage

- Many pre-contact trees exist at Richardson's Lagoon.
- A quick cultural heritage survey at Richardson's revealed 150 Scar trees.
- Cultural Heritage – the sand hills have human remains in them, burials occurred during the floods. An elder who is 85 years old remembers when he was 10 years old burials occurring at Richardson's Lagoon. Three burial sites have been found and registered with AAV.

Recreation

- Canoeing in lagoon is a great attraction at the wetland.
- Great wetland for bird watching, tours often stop at this wetland.
- Camping, 4WD and duck hunting activities.

3. Draft environmental watering regime

- Richardson's was full all of the time, previously a permanent wetland. It was dried out and had pumps put in to get control over wetting/drying. Mark Tscharke (Park Victoria) has done a great job in getting the licences off the wetland and improving the water quality and overall health of Richardson's.
- The last two watering events were marvellous.
- The water has receded significantly in the last couple of weeks, very hot weather.
- It is vital that we maintain these lagoons off the Murray River, they provide important refuges and habitat for many animals.
- Drying out Richardson's Lagoon was really important in the early stages, snorkelling with a mask down the bottom of the wetland you can now see organic matter and vegetation growth.
- Value of continuously drying out the wetland, not sure if this is what should happen. What will happen to the fish and turtles?
- Last year (2012) there were twice as many breeding events, for example, two rounds of Cygnets were successfully bred last year.
- Watering the wetland should coincide/build on with rainfall and rejection flows. Autumn to mid Winter is the dry/drawdown period.
- From field monitoring it has been found that Egrets are the last to nest and fledge their young, this is a good indicator that the wetland level can be allowed to start to drawdown (over Summer).
- It doesn't hurt to leave the wetland dry for a period of time.
- When the wetland was drained it killed the Cumbungi, platypus and fish