Lake Yando

Environmental Water Management Plan

Final

NORTH CENTRAL
Catchment Management Authority
Connecting Rivers, Landscapes, People

DOCUMENT CONTROL

Document History and Status

Version	Date Issued	Prepared By	Reviewed By	Date Approved
1	19/5/2016	Phil Slessar	Andrew Sharpe	23/5/2016
2	30/5/2016	Phil Slessar	Marcus Cooling	16/6/2016
3	29/7/2016	Phil Slessar	Jamie Bell	
4				

Distribution

Version	Date	Quantity	Issued To
1	19/5/2016	1	Andrew Sharpe
2	30/5/2016	1	Marcus Cooling
3	29/7/2016	1	Jamie Bell
4			

Document Management

Printed:	29 July 2016
Last saved:	29 July 2016 09:09 AM
File name:	Lake Yando EWMP Draft 4.docx
Authors:	Phil Slessar
Name of organisation:	North Central CMA
Name of document:	Lake Yando Environmental Water Management Plan
Document version:	Final
SharePoint link:	\\sharepoint\DavWWWRoot\nrmops\Operations\MD Basin Plan - EWMP - 2013-16\Lake Yando EWMP Final.docx

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

North Central Catchment Management Authority
PO Box 18
Huntly Vic 3551
T: 03 5448 7124 F: 03 5448 7148
E: info@nccma.vic.gov.au
www.nccma.vic.gov.au

Cover photos:

Top Left – White-necked heron utilising Lake Yando, Nov 2014;
Top right – Open water during partial fill, Nov 2014;
Bottom - Lake Yando in flood, December 2010

This is a working document, compiled from the best available information. It will be subject to revision in the future as new information becomes available.

Please cite this document as: North Central CMA, 2016. *Lake Yando Environmental Water Management Plan*. North Central Catchment Management Authority, Huntly, Victoria.

EXECUTIVE SUMMARY

The Lake Yando Environmental Water Management Plan (EWMP) sets out the long-term objectives for the priority environmental values of Lake Yando, in the Venables Creek sub-catchment of the Loddon River Basin. The EWMP is an important part of the Victorian Environmental Water Planning Framework. It provides the five to ten year management intentions, based on scientific information and stakeholder consultation, which can be used by the respective agencies; North Central Catchment Management Authority (CMA), Department of Environment, Land, Water and Planning (DELWP) and the Victorian Environmental Water Holder (VEWH); for both short and longer-term environmental water planning.

This EWMP is not a holistic management plan for the wetland, but is focused on environmental water management so that Lake Yando can continue to provide environmental, social, cultural and economic values for all users. Actions such as infrastructure upgrades and pest plant and animal works are documented as complementary to environmental water management in this EWMP.

The following components are the main sections featured in the Lake Yando EWMP. A summary of the main conclusions to facilitate appropriate environmental water management into the future are summarised below.

Hydrology and system operations

A key threat to the long-term health of Lake Yando is the changed watering regime since European Settlement. Historically Lake Yando experienced wetting and drying phases in response to high flow in the Loddon River and Venables Creek.

Modifications to the catchment through land use changes have significantly altered its watering regime. Channel outfalls from the irrigation system, rainfall rejection flows and irrigation drainage flows from adjacent land combined to keep the wetland full most of the time.

Due to increased efficiencies in irrigation infrastructure and practices and declining regional rainfall, the volume of channel outfalls decreased throughout the 1990s and early 2000s. As a result, the wetland's hydrology shifted from almost permanent inundation to an annual wetting/drying regime. The wetland dried out completely between 1997 and 2009 as a result of the Millennium Drought. In response to the decreased availability of water, environmental water has been delivered intermittently to the wetland from 2009 onwards.

Water dependent values

Lake Yando is a wetland of regional significance, largely due to its habitat values that include the unique gilgai formation, and the vegetation that provides food, habitat and shelter for a range of waterbirds and frogs. In particular, large numbers of waterbirds use the wetland for feeding and breeding including herons, stilts, egrets, ibis and ducks. The wetland also supports important plants and vegetation communities including young river red gums (*Eucalyptus camaldulensis*), patches of lignum, and emergent and aquatic plants.

Ecological condition and threats

Although land use change has impacted on the duration, timing and frequency of inundation, the wetland is currently considered to be in good health. Waterbirds opportunistically use the wetland during environmental watering events and localized rainfall events. Although the structure and composition of native vegetation has changed from its pre-European state, the current vegetation is considered to be in good health. The management objectives for Lake Yando focus on providing conditions that facilitate river red gum growth and recruitment, and maintaining appropriate extents of various wetland habitats.

Management objectives

A long-term management goal has been defined for Lake Yando:

Management goal:
To provide a water regime that maintains existing mature river red gums (*Eucalyptus camaldulensis*), supports the recruitment of new river red gums and promotes the growth of a diverse range of aquatic and amphibious plant species that offer habitat for waterbirds, reptiles and amphibians.

The ecological objectives and hydrological objectives that sit under the long-term management goal were informed by the Lake Yando Environmental Watering Plan (NCCMA 2010) and other technical investigations and were refined during the development of this EWMP.

Managing risks to achieving objectives

The threats to achieving the ecological objectives that are external to environmental water are identified by this EWMP. In particular if large numbers of European carp enter the wetland during filling events, they may prevent the environmental water delivery from meeting specific objectives for aquatic and semi-aquatic fauna and aquatic flora.

Environmental water delivery infrastructure

Water enters Lake Yando via a delivery channel that comes off the Pyramid Boort Channel 5/2. The existing infrastructure is adequate to provide the recommended flow regime.

Demonstrating outcomes

Monitoring is required to allow adaptive management of annual environmental watering (intervention monitoring). It is also required to enable the CMA and VEWH to demonstrate the long-term outcomes of implementing the Lake Yando EWMP. The Lake Yando EWMP recommends a suite of intervention and long-term monitoring activities that will assess the effect of environmental water deliveries and inform adaptive management of the wetland.

Consultation

Key stakeholders, including DELWP, Parks Victoria and Goulburn Murray Water (GMW) were engaged during the development of this EWMP. Local community members, private landholders, recreational and environmental groups were also consulted and provided advice that has been incorporated into the management actions recommended in this document.

Knowledge gaps

The recommended management actions for Lake Yando are based on the best available information. A number of knowledge gaps have been identified during the development of the EWMP. These include the watering requirements of the winged water starwort, the relationship between Lake Yando filling and the regional groundwater table, and determining the populations of turtle species at Lake Yando. This information will contribute to a greater understanding of the values of the system and inform the watering regime.

ACKNOWLEDGEMENTS

The information contained in the Lake Yando EWMP has been sourced from a variety of reports and field inspections and from individual knowledge and expertise. The North Central CMA acknowledges the assistance of the following people in preparing this EWMP and/or the EWP that preceded it:

- Rob O'Brien (Department of Primary Industries)
- Cherie Campbell, Caitlin Johns, Christine Reid, and Dr Todd Wallace (Murray-Darling Freshwater Research Centre)
- Geoff Sainty (Sainty Associates)
- Shelley Heron (Kellogg Brown and Root)
- Mark Reid (DPI Primary Industries Research Victoria)
- Andrea Joyce (Department of Sustainability and Environment)
- Mark Tscharke (Parks Victoria)
- Ross Stanton and Lawrence Cameron (G-MW)
- Pat Feehan (Feehan Consulting)
- Ross Plunkett, Chris Solum and Mark Paganini (NVIRP)
- NVIRP Technical Advisory Committee
- Wetland workshop attendees
- Marg Piccoli (landholder), Rod Stringer (landholder)
- Paul Haw, Barry Barnes (community members)
- Graham Hall, Bridie Velik-Lord, Rebecca Horsburgh, Peter McRostie, Lyndall Rowley, Andrew Sharpe, Phil Dyson (North Central CMA).

ACKNOWLEDGEMENT OF COUNTRY

The North Central Catchment Management Authority acknowledges Aboriginal Traditional Owners within the region, their rich culture and spiritual connection to Country. We also recognise and acknowledge the contribution and interest of Aboriginal people and organisations in land and natural resource management.

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1. Introduction

1.1. Management of environmental water in Victoria

Management of environmental water is planned and implemented through the Victorian Environmental Water Management Framework (see Figure 1). The North Central Catchment Management Authority (CMA) has recently developed the *North Central Waterway Strategy 2014-2022* (NCWS) which is an integrated strategy for managing and improving the North Central CMA's rivers, streams and wetlands. The NCWS is guided by the *Victorian Waterway Management Strategy 2013* (VWMS) and the *North Central Regional Catchment Strategy 2012* (RCS). The NCWS sets priorities and outlines a regional works program to guide investment over the next eight years (North Central CMA 2014).

Lake Yando is identified as a priority wetland in the NCWS, with the aim to influence long-term resource condition. The objectives for Lake Yando and other Boort district wetlands are to:

- Maintain and improve the condition of the Mid-Loddon wetlands by 2050 as measured by the Index of Wetland Condition.
- Increase the species richness of wetland-dependent bird species across the Boort Wetlands to 30 by 2020 and the number of individuals to an average of 1000 - as measured by monthly counts during a wet phase.

These targets are reflected in the overall management goals and objectives described by this EWMP (Section 6). Specific management activities are recommended to achieve these targets, including pest plant and animal control, appropriate delivery of environmental water, and ecological monitoring and assessments to improve knowledge of the wetland. These activities will be delivered by working with the CMA's partners, including Parks Victoria (PV), Goulburn Murray Water (GMW), the Victorian Environmental Water Holder (VEWH), the Department of Environment, Land, Water and Planning (DELWP) and local landholders.

The North Central CMA has received funding through the Department of Environment, Land, Water and Planning (DELWP) 'Victorian Basin Plan Environmental Water Management Plan Program' to prepare an EWMP for Lake Yando. This EWMP aims to establish the long-term environmental water management goals for Lake Yando to guide future management. 00.

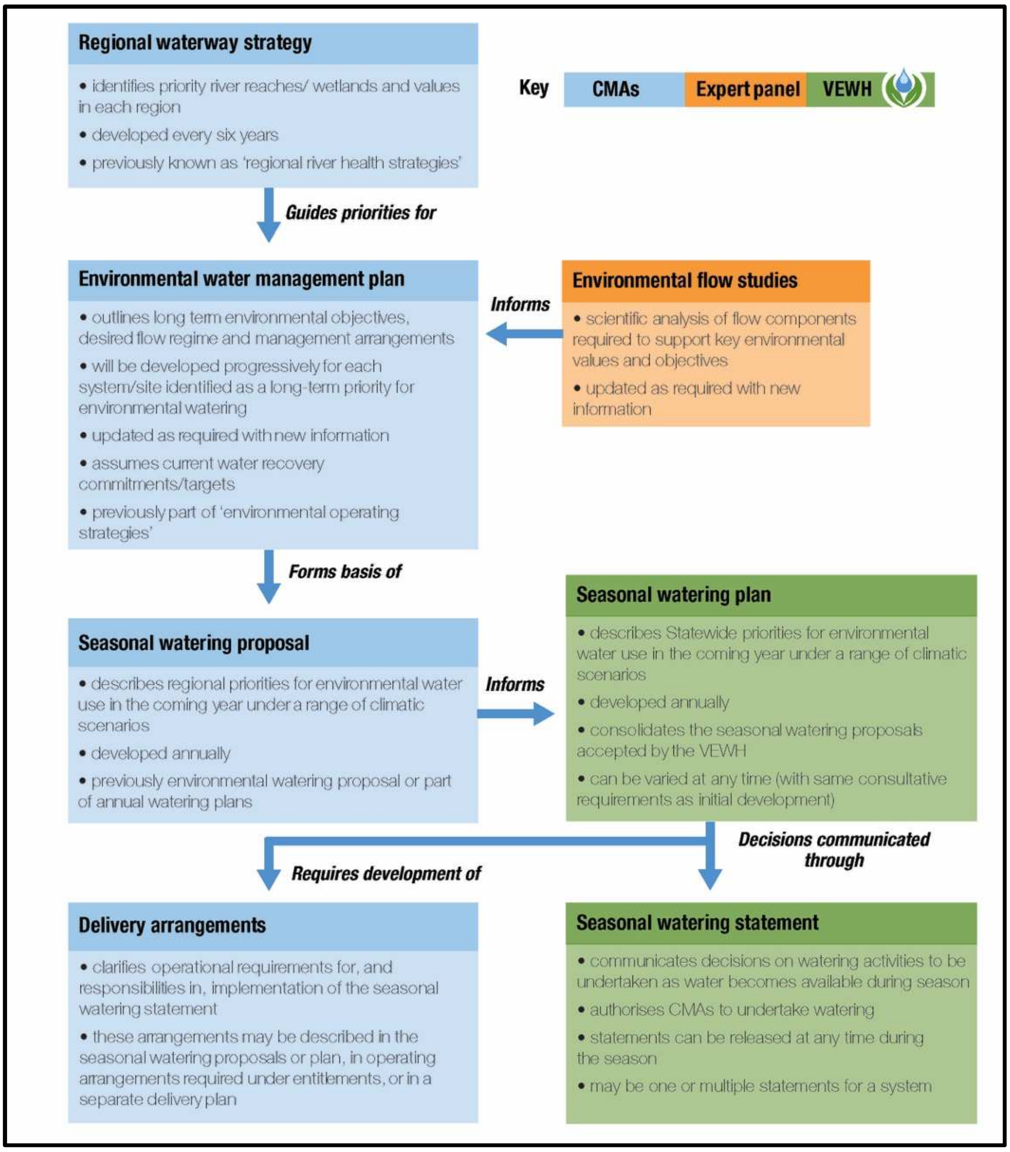

Figure 1. Planning framework for environmental water management in Victoria (Source: VEWH 2016).

1.2. Purpose and scope

The Lake Yando EWMP is a ten year management plan that describes the ecological values present, the long-term goal for the wetland, priority ecological objectives and the watering regime required to achieve these objectives. It is based on scientific information and stakeholder consultation, and will be used by the North Central CMA when making annual environmental watering decisions, as well as by the Department of Environment, Land, Water, and Planning (DELWP) and the Victorian Environmental Water Holder (VEWH) for both short and longer-term environmental water planning (Department of Environment and Primary Industries [DEPI] 2014a).

The key purposes of the EWMP are to:

- identify the long-term objectives and water requirements for Lake Yando;
- provide a vehicle for community consultation, including for the long-term objectives and water requirements of Lake Yando;
- inform the development of future Seasonal Watering Proposals (Seasonal Watering Proposals) and Seasonal Watering Proposals; and

- inform Long-term Watering Plans that will be developed by the State under the Murray-Darling Basin Plan Chapter 8 (DEPI 2014a).

1.3. Development Process

North Central CMA developed an Environmental Watering Plan (EWP) for Lake Yando in 2010 for the Goulburn Murray Water Connections Project (formerly the Northern Victoria Irrigation Renewal Project) (NCCMA, 2010). The purpose of the EWP was to establish a volume of mitigation water that Goulburn Murray Water Connections Project needed to set aside to address environmental impacts associated with reduced channel outfalls to Lake Yando. The development process for the EWP established ecological objectives and a watering regime for Lake Yando. The Lake Yando EWMP is based on work undertaken for, and presented in, the *Lake Yando Environmental Watering Plan 2010*.

The conversion of the Lake Yando EWP to the Lake Yando EWMP has been undertaken in collaboration with key stakeholders including DELWP, Parks Victoria, VEWH, GMW and local landholders. Where available, technical information used in the Lake Yando EWP has been updated with newer information including monitoring data, water delivery information and results of ecological investigations.

Information from the Lake Yando EWP provides justification and evidence for the following sections of the EWMP:

- **Water dependent values:** environmental values were derived from baseline flora and fauna surveys, historical reports, DELWP databases and community and stakeholder accounts. Terrestrial species that, due to large-scale clearing of woodland habitat throughout the catchment, are dependent on the vegetation surrounding the wetland are also documented. Social, cultural, recreational and economic values are further described.
- **Ecological condition, condition trajectory and threats:** Available information was used to describe the current condition and water related threats to Lake Yando. A "do-nothing" scenario is further considered to understand the condition trajectory if no action is undertaken.
- **Management objectives:** The water management goal and the ecological objectives for Lake Yando are based on the water dependent values recorded for the wetland, the current condition of those values and the condition trajectory. The objectives are also aligned with the broader environmental outcomes proposed in the *Basin Plan draft Environmental Watering Strategy 2014*.
- **Managing risks:** the risks to achieving the ecological objectives for Lake Yando are based on the best-available scientific and local knowledge. Management actions to mitigate each risk have been recommended and residual risk (assuming full adoption of the proposed management action) is identified.
- **Environmental water delivery infrastructure:** Current constraints on the delivery of environmental water are identified and recommendations are made to improve environmental water delivery in the future.
- **Demonstrating outcomes:** monitoring to adaptively manage the delivery of environmental water and to demonstrate the outcomes against the ecological objectives are recommended and justified.
- **Knowledge gaps and recommendations:** a number of knowledge gaps were identified during the process of developing the ecological objectives, management actions and risk analysis sections. A series of recommended activities to address each knowledge gap are described and ranked.

2. Site overview

2.1. Site location

Lake Yando is a shallow swamp located on the Loddon River floodplain approximately 9 km north of Boort and 3.8 km west of the Loddon River (Figure 2). It is located in the mid-Loddon floodplain of the Loddon River basin and is significant because it continues to support river red gums and a high diversity of fauna species (NLWRA, cited in NCCMA 2005).

The lake occupies 78 ha of an 86 ha Wildlife Reserve (NCCMA 2010). It is oval in shape with a lunette on the north eastern margin, and an irregular floor characteristic of a gilgai surface (Figure 3). The wetland is deeper on the eastern side, with its lowest elevation at 86.4 m AHD. At full supply level (FSL) (87.59 m AHD) the wetland has a storage capacity of 478 ML and a maximum depth of 1.2 m (Price Merrett Consulting 2006). The bathymetry and rating table for Lake Yando can be found in Appendix 1.

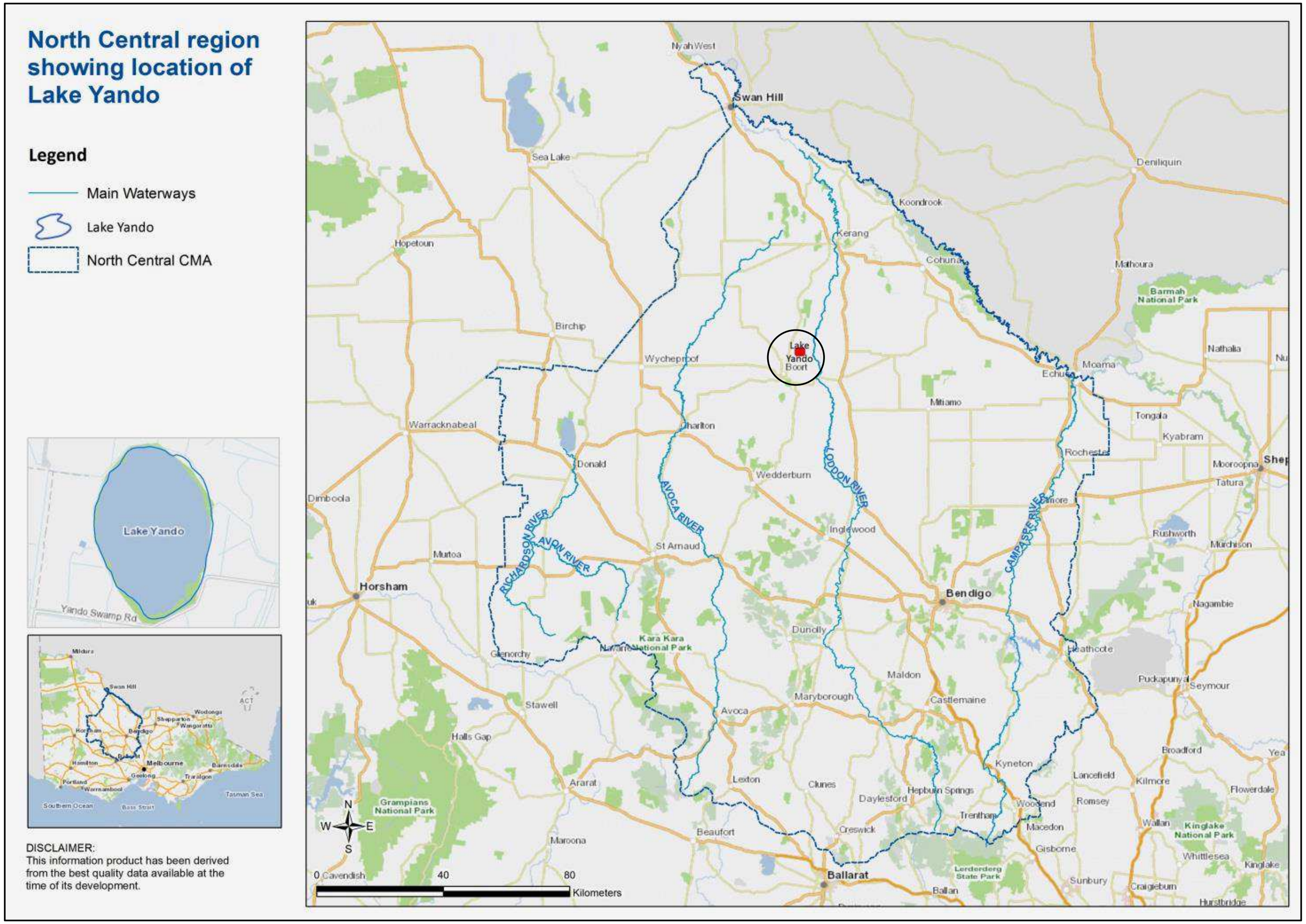

Figure 2. Location of Lake Yando within the North Central region

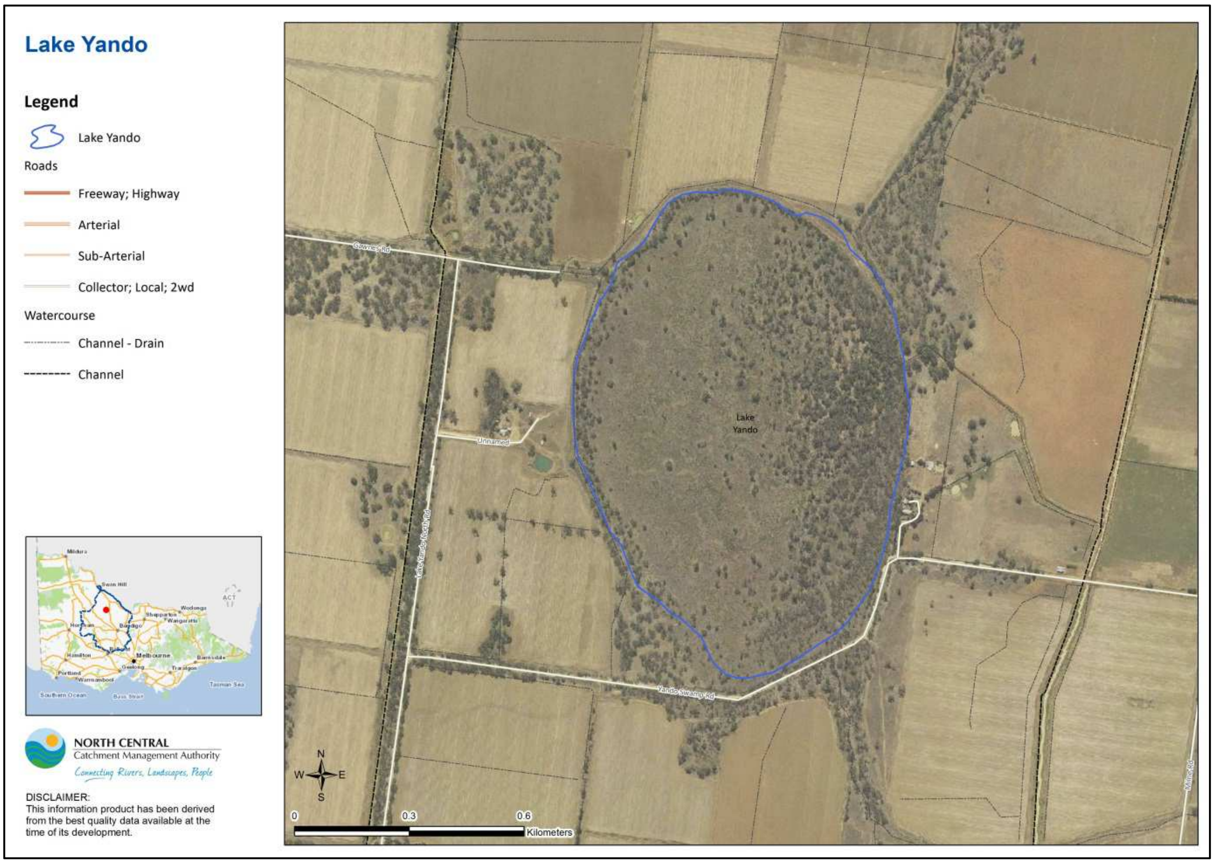

Figure 3. Lake Yando

2.2. Catchment setting

Climate

The closest Bureau of Meteorology (BOM) monitoring station to Lake Yando is at Boort (Station No: 080002). Rainfall in the Boort region averages 394 mm/year, with May to October being significantly wetter than November to April (Macumber 2002). Maximum average daily temperatures range from 13.9 °C in July to 31.3 °C in January; minimum temperatures rarely fall below zero (BOM 2016). Evaporation rates from the 'Kerang Model Farm' shows pan evaporation (Class A Pan) rates of approximately 1,384.1 mm per year between 1991 and 2013, with monthly evaporation rates ranging from 32.8 mm in June to up to 233.3 mm in January (data supplied by R & E Jones, 2013).

2.3. Land status and management

Land use

Lake Yando is a wildlife reserve under the "state game reserve" classification. Wildlife reserves are managed to conserve and protect species, communities or habitats of indigenous animals and plants while permitting recreational activities (including hunting in season as specified by the land manager) and educational use (VEAC 2008 and DSE 2009).

Land and water management

Table 1 describes the key stakeholders that are involved in the management (including environmental water management) of Lake Yando.

Table 1. Roles and responsibilities for environmental water in Lake Yando

Agency/group	Responsibilities/involvement
Department of Environment, Land, Water and Planning (DELWP)	- Manage the water allocation and entitlements framework - Develop state policy on water resource management and waterway management for approval by the Minister for Environment, Climate Change and Water - Develop state policy for the management of environmental water in regulated and unregulated systems - Act on behalf of the Minister for Environment, Climate Change and Water to maintain oversight of the VEWH and waterway managers (in their role as environmental water managers) - Legislative responsibilities for the management of flora and fauna - Provides approval of EWMPs and endorsement of Seasonal Watering Proposals.
Victorian Environmental Water Holder(VEWH)	- Make decisions about the most effective use of the Water Holdings, including use, trade and carryover - Authorise waterway managers to implement watering decisions - Liaise with other water holders to ensure coordinated use of all sources of environmental water - Publicly communicate environmental watering decisions and outcomes - Write the State-wide Seasonal Watering Plan - Provide final endorsement of Seasonal Watering Proposals - Approves delivery of environmental water (Seasonal Watering Statement) and funds environmental water related monitoring.
Commonwealth Environmental Water Holder (CEWH)	- Make decisions about the use of Commonwealth water holdings, including providing water to the VEWH for use in Victoria. - Liaise with the VEWH to ensure coordinated use of environmental water in Victoria - Report on management of Commonwealth water holdings.
Murray-Darling Basin Authority (MDBA)	- Implement the Murray-Darling Basin Plan - the Basin Plan sets legal limits on the amount of surface water and groundwater that can be taken from the Basin from 1 July 2019 onwards - Coordinate and integrate water resource management across the Murray-Darling Basin
North Central Catchment Authority (North Central CMA)	- Waterway Manager - Identify regional priorities for environmental water management in regional waterway strategies - In consultation with the community assess environmental water requirements of priority rivers and wetlands to meet agreed objectives and implement environmental works to use environmental water efficiently - Propose annual environmental watering actions to the VEWH and implement the VEWH environmental watering decisions - Provide critical input to manage other types of environmental water (passing flows management, above cap water) and report on environmental water management activities.
Goulburn Murray Water (GMW)	- Water Corporation – Storage Manager and Resource Manager - Work with the VEWH and Waterway Managers to plan the delivery of environmental water to maximise environmental outcomes - Operate water supply infrastructure such as dams and irrigation distribution systems to deliver environmental water - Provide passing flows and manage diversion limits in unregulated and groundwater systems - Endorse Seasonal Watering Proposal and facilitate on-ground delivery.

Agency/group	Responsibilities/involvement
Parks Victoria	- Land Manager - Implement the relevant components of EWMPs. - Operate, maintain and replace, as agreed, the infrastructure required to deliver environmental water, where the infrastructure is not part of the GMW irrigation delivery system. - Where agreed, participate in the periodic review of relevant EWMPs and endorse Seasonal Watering Proposals - Manage and report on other relevant catchment management and risk management actions required due to the implementation of environmental water.
Input, advice and interest in environmental watering	
Loddon System Environmental Water Advisory Group (EWAG)	- Stakeholder and community groups provide advice on the best use of environmental water in the Loddon River system (including Boort district wetlands) - Members represent GMW, DELWP, Parks Victoria, VEWH, North Central CMA, Field and Game Australia, and local community.

2.4. Wetland characteristics

Victoria's wetland classification and inventory was updated in 2013 and replaces the system developed by Corrick and Norman in the early 1980s. The updated classification is based on the Australian National Aquatic Ecosystem (ANAE) Classification Framework and converts data on wetlands and their classification attributes into spatial Geographic Information System (GIS) layers.

The ANAE framework produces 37 wetland types based on a hierarchical classification. The first classification level distinguishes between naturally occurring and human-made wetlands. The second classification level distinguishes between aquatic ecosystem habitats: palustrine, lacustrine and estuarine wetlands. The third classification level distinguishes wetlands based on the following attributes: water regime, salinity, landscape context, soils and wetland vegetation (DELWP 2016a).

Under Corrick and Norman, the pre-European classification (1750 Classification) for Lake Yando was a deep freshwater marsh. It has retained this classification over time (1994 classification) despite existing in a heavily modified environment. Based on the ANAE classification, Lake Yando is described as a naturally occurring temporary freshwater marsh (DEPI 2016a). An overview of the wetland characteristics is provided in Table 2.

Table 2. Wetland characteristics of Lake Yando

Characteristics	Description	
Name	Lake Yando	
Mapping ID (Corrick)	7625 507077	
Area (ha)	Reserve	86 hectares
	Wetland (Lake Yando)	78 hectares
Bioregion	Victorian Riverina	
Conservation status	Bioregionally significant wetland (NLWRA, cited in NCCMA 2005)	
Land status	Wildlife Reserve (hunting) (86 ha), under the *Wildlife Act 1975*	
Land manager	Parks Victoria	
Surrounding land use	Irrigated agriculture	
Water supply	• Historical: Unnamed distributary of Venables Creek • Current: Pyramid-Boort Irrigation System: Channel outfall (5/2) and environmental allocations • Automated regulator capacity: 60 ML/day • 400-600 EC • Delivery capacity of inflow channel: 35 ML/day • Average delivery rate 35 ML/day (approx. 14 days to FSL)	
1788 wetland category (Corrick and Norman)	Deep freshwater marsh	

Characteristics	Description
1994 wetland category (Corrick and Norman)	Category: Deep freshwater marsh Sub-category: Reed, Red Gum and Open Water
2013 Victorian wetland classification (DEPI 2014b) (ANAE)	*Wetland ID: 42643* *Aquatic System:* Palustrine *Salinity Regime:* Fresh *Water regime:* Periodically inundated- seasonal or episodic *Water Source – Tidal:* Non-tidal *Water Source – River:* High *Water Source – Groundwater:* Low *Source – Artificial:* Artificial *Wetland Origin:* Naturally occurring *Wetland Type:* Temporary freshwater marsh
Wetland capacity	478 ML at FSL 87.59m *AHD* (Price Merrett Consulting 2006)
Wetland depth at capacity	1.2m maximum depth
Source: DELWP (2016a); NCCMA 2010;	

2.5. Environmental water sources

The environmental water available for use at Lake Yando is derived from a number of sources, described below and in Table 3. Water shares are classed by their reliability and there are two types in Victoria:

- High-reliability water shares (HRWS), which are a legally recognised, secure entitlement to a defined share of water.
- Low reliability water shares (LRWS) which are water shares with a relatively low reliability of supply. Allocations are made to high-reliability water shares before low-reliability shares

Water availability can vary from season to season according to climatic conditions, volumes held in storages and carryover entitlements.

Bulk Entitlement (Loddon River – Environmental Reserve) Order 2005

The Loddon River Environmental Reserve Bulk Entitlement provides 2,000 ML HRWS in the Loddon System. It is held by the VEWH for the purpose of maintaining environmental values and condition. It has been used for the Boort Wetlands, including Lake Boort, Lake Meran, and Lake Yando. It can also be traded on the water market on an annual basis. The use of this water in Lake Yando is not guaranteed and is at the discretion of the Victorian Environmental Water Holder (VEWH).

An additional 7,490 ML is available in the Goulburn system from Wimmera-Mallee pipeline savings. This water is available when allocations are >1% on April 1st of the previous water year, and can be used in the Loddon River or the Boort District Wetlands.

Commonwealth Water Holdings

Commonwealth water holdings are the direct result of government purchases of entitlements and a substantial investment in more efficient water infrastructure in the Murray-Darling Basin. The volume of Commonwealth water available varies from year to year, but can be up to 3,356 ML HRWS and 527 ML LRWS in the Loddon system. The use of this water for wetlands in the North Central CMA region is not guaranteed and is at the discretion of the Commonwealth Environmental Water Office (CEWO).

Unregulated flows

Unregulated flows result from reservoir spill, emergency releases, local catchment runoff or river operations. In Lake Yando, unregulated flows are limited, and are most likely to occur when the Loddon River floods.

Table 3. Environmental water sources for Lake Yando

Water entitlement	Volume	Flexibility of management	Conditions on availability and use	Responsible agency
Bulk Entitlement (Loddon River – Environmental Reserve) 2005	2,000 ML (high reliability)	Available primarily for wetlands but can be used for Loddon River flows	Pro rata according to high-reliability water allocations in the Loddon River System. Management according to priorities in Seasonal Watering Proposal	VEWH
	Up to 2,024 ML (low reliability)	Available in Loddon system	Only available with low-reliability allocations.	
	7,490 ML	Can be used in waterways and in wetlands. Available from Goulburn system	Available when allocations are <1% on 1 April of previous water year	
Commonwealth Water Holdings	Up to 3,356 ML (High reliability), Up to 527 ML (Low reliability) (Determined by CEWH)	Agreement is required with the CEWH Available in the Loddon system	Can be used across multiple systems, within relevant trade protocols Pro rata according to water allocations in the Loddon River system	CEWH (facilitated through VEWH)
Unregulated flow	Variable	Determined by rainfall and GMW irrigation demand/usage	Excess water from the Pyramid-Boort Irrigation District; Excess supply in channel system	GMW

2.6. Related agreements, legislation, policy, plans and activities

There is a range of international treaties, conventions and initiatives, as well as National and Victorian State Acts, policies and strategies that direct the management of wetlands within Victoria. Those that may have particular relevance to the management of the environmental and cultural values at Lake Yando are listed below. The function and major elements of each can be sourced from 0.

International treaties, conventions and initiatives:

- Japan Australia Migratory Birds Agreement (JAMBA) 1974 – Two species listed under this agreement have been recorded at Lake Yando.
- China Australia Migratory Birds Agreement (CAMBA) 1986 - Three species listed under this agreement have been recorded at Lake Yando.
- Republic of Korea Australia Migratory Birds Agreement (ROKAMBA) 2002 – One species listed under this agreement has been recorded at Lake Yando.
- Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention) 1979 – One species listed under this convention have been recorded at Lake Yando.

Commonwealth legislation and policy:

- Aboriginal and Torres Strait Islander Heritage Protection Act 1984 (Part IIA) – Lake Yando is an area of cultural sensitivity.
- Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) – One faunal species and one floral species listed under this Act have been recorded at Lake Yando.

- Water Act 2007 – to provide for the protection of ecological values at Lake Yando through appropriate management of Murray-Darling Basin water resources.

Victorian legislation:

- Aboriginal Heritage Act 2006 – Lake Yando is an area of cultural sensitivity.
- Catchment and Land Protection Act 1994 - governs the management of land surrounding Lake Yando e.g. pest plant and animal control.
- National Parks Act 1975 – Wildlife Reserves
- Water Act 1989 - provides a formal means for integrated water management in Victoria
- Wildlife Act 1975 - Parks Victoria manages Lake Yando in accordance with this Act.
- Flora and Fauna Guarantee Act 1988 (FFG Act) - 10 faunal species and 0 flora species listed under this Act have been recorded at Lake Yando.

National policies and strategies:

- The National Cultural Flows Research Project – this project is investigating indigenous water values and uses to form the basis for cultural flow water entitlements. These would be legally and beneficially owned by the Indigenous Nations and are of a sufficient and adequate quantity and quality to improve the spiritual, cultural, environmental, social and economic conditions of those Indigenous Nations. The cultural flows framework is under development but may influence Lake Yando as it is an area of cultural sensitivity.

Victorian policy and strategies:

- Victorian threatened flora and fauna species (DELWP advisory lists) – 9 fauna species and 12 flora species on the DELWP advisory lists have been recorded at Lake Yando.
- Victorian Waterway Management Strategy (VWMS) – this strategy outlines the direction for the Victorian Government's investment over an eight year period (beginning in 2012-13). The overall management objective is to maintain or improve the environmental condition of waterways to support environmental, social, cultural and economic values (DEPI 2013a).

Regional strategies and plans:

- North Central Regional Catchment Strategy (RCS) (North Central CMA 2012) – this strategy sets regional priorities for the management of natural assets and overall direction for investment and coordination of effort by landholders, partner organisations and the wider community. The Boort Wetlands Complex is identified as a priority wetland asset in the RCS that supports highly depleted wetland types and significant threatened species.
- North Central Waterway Strategy (NCWS) (North Central CMA 2014) – this regional strategy is an action out of the VWMS and provides the framework for managing rivers and wetlands with the community over the next eight years. It delivers key elements of the VWMS including developing work programs to maintain or improve the environmental condition of waterways in the North Central region. Lake Yando is a priority wetland for this eight year planning period.

3. Hydrology and system operations

Hydrology is the most important determinant of wetland types and ecological processes in wetlands. It affects the chemical and physical aspects of the wetland, which in turn affects the types of flora and fauna that the wetland supports. A wetland's hydrology is determined by surface and groundwater inflows and outflows in addition to precipitation and evapotranspiration (Mitsch & Gosselink 2000). Duration, frequency and seasonality (timing) are the main components of the hydrological regime for wetlands and rivers.

3.1. Wetland hydrology, water management and delivery

3.1.1. Pre-regulation

Lake Yando is a natural depression within a complex interconnecting creek system, with the lake floor displaying gilgai microtopography (Figure 4 and Plate 1). Prior to river regulation Lake Yando filled and flushed in winter/spring when Loddon River floodwater fanned out across the floodplain (NCCMA 2010) (Figure 5). It would naturally have received floodwaters from an unnamed distributary of Venables Creek that enters the wetland at its southern edge (Figure 4 and Figure 5). During large floods, Lake Yando would have also received water from Kinypanial Creek via Lake Boort and Lake Lyndger (Lugg *et al.* 1993) (Figure 5). Lake Yando was well connected to a creek and floodplain system where wide corridors of native vegetation provided opportunities for native fauna to move throughout the floodplain.

Naturally, floodwaters overflowed out of the wetland in a northerly direction at different locations and widths depending on flood levels, with flood water flowing into Lake Leaghur via a floodway (Figure 5). Because Lake Yando is relatively shallow, it only holds water for a few months after a flood event and under natural conditions would have dried out frequently (NCCMA, 2010).

Figure 4. Google Earth image of Lake Yando showing gilgai formation and natural inflow

Plate 1. Gilgai channels filling during environmental watering in 2009 (Photo: Paul Haw)

3.1.2. Post-regulation

During the mid to late 1800s, and early 1900s many channels were cut across the Loddon Floodplain to divert natural river flows into wetlands and depressions to increase water security for settlers. Levees were also constructed to prevent sheet flooding on private land (NCCMA 2006). These changes, along with the development of the irrigation system around the 1920s/1930s, meant that Lake Yando was inundated more frequently than natural and held water for prolonged periods. Between the 1950s and 1970s, Lake Yando was nearly permanently inundated (O'Brien and Joyce 2002). Unnaturally long inundation and intrusion of saline groundwater contributed to the death of river red gum trees across a large area of the wetland (NCCMA 2010).

Anecdotal evidence suggests that in the 1960s/1970s Lake Yando received significant volumes[1] of excess channel water, channel drainage and irrigation drainage water from the local catchment to the south (pers comm, P. Haw (local community member) 2010) which entered the wetland from the natural channel outfall (Figure 5). The irrigation supply system also delivered excess channel water to the delivery channel outfall east of the wetland (Figure 5) which contributed to the health of river red gums and emergent aquatic vegetation in this area, particularly during low rainfall periods. Local catchment drainage was delivered by the breakaway that enters the wetland to the south. Records of inflows and the watering regime during the period before 1996 were not available, but it was suggested that an average outfall to Lake Yando was around 80 ML/year (pers comm Lawrence Cameron (Customer Service Coordinator, GMW), April 2010).

In 1996 as part of the *Boort West of Loddon Land and Water Management Plan* (NCCMA 2006), the sill of the overflow creek was lowered to slightly reduce its depth and improve the water regime and condition of the wetland (NCCMA 2010).

Table 4 shows the watering history of Lake Yando since 1996/97.

[1] Relative to the storage capacity of the wetland

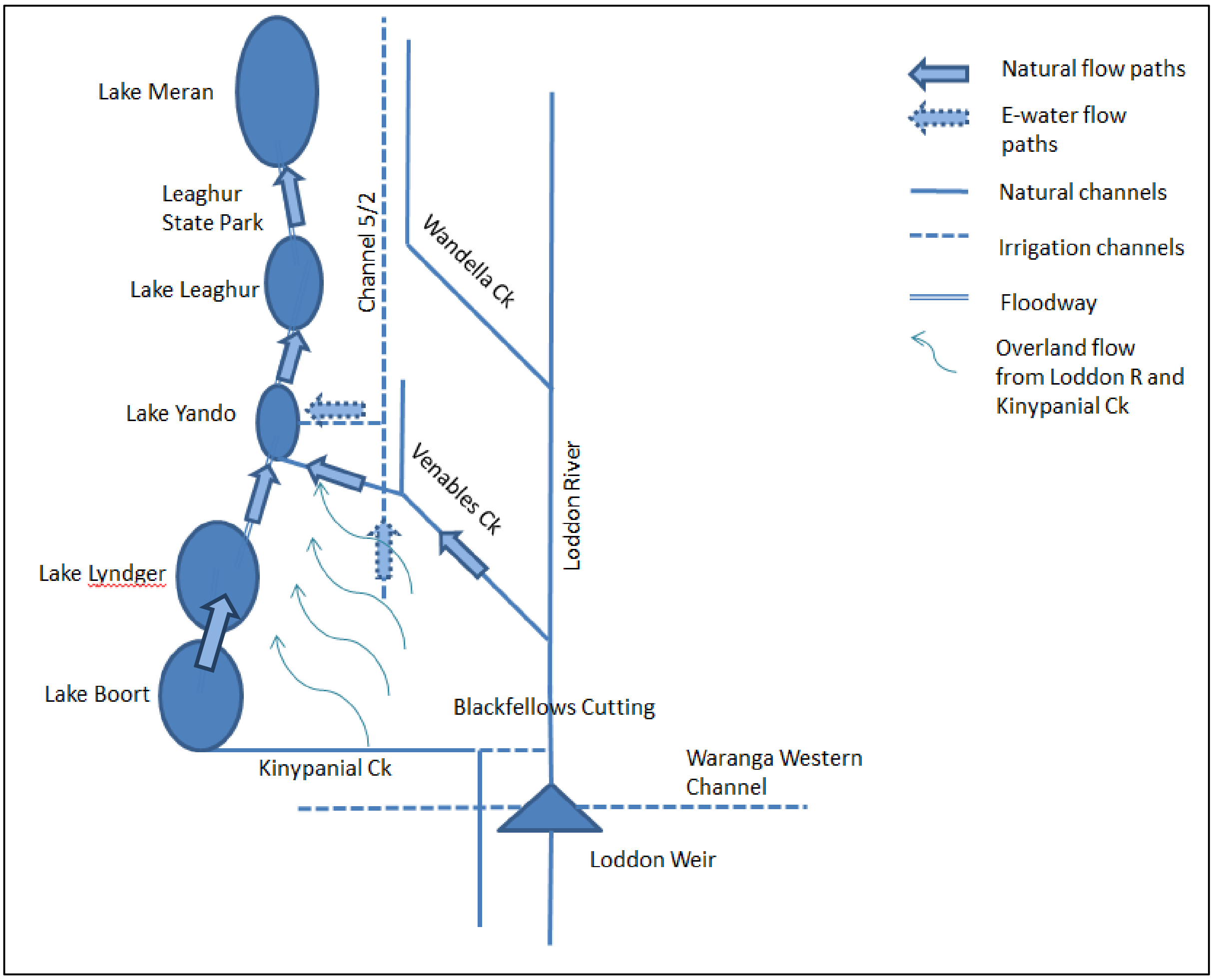

Figure 5. Schematic diagram of flow paths on the Loddon floodplain downstream of Loddon Weir showing historic and current Lake Yando inflow-outflow paths

Table 4. Lake Yando wetting/drying calendar (Source: North Central CMA 2010)

Recommended watering regime	Watering History	Season									
		1996 - 1997	1997 - 1998	1998 - 1999	1999 - 2000	2000 – 2001	2001 - 2002	2002 - 2003	2003 - 2004	2004 - 2005	2005 - 2006
One event every year (i.e. wet and dry cycle every year) (duration of ~8mths)	Status[1]	W	D	D	D	D	D	D	D	D	D
	Water source[2]	U									
		2006 - 2007	2007 - 2008	2008 - 2009	2009 - 2010	2010 - 2011	2011 - 2012	2012 - 2013	2013 - 2014	2014 - 2015	2015-2016
	Status[1]	D	D	D	W-D	W-D	D	D	W-D	W-D	D
	Water source[2]				E	I			E	E	

[1] Water present / Dry wetland
[2]Environmental water allocation / Flood mitigation / Unknown / Channel outfall / Surplus flows / Flood Inundation/Irrigation Tailwater

Lake Yando is connected to the Pyramid-Boort Irrigation System and receives inflows from Channel 5/2 (Figure 5). Works completed in 2008 gave the delivery channel to Lake Yando and a portion of channel 5/2 a capacity of 35 ML/day. The fully automated outfall structure has a reported capacity of 60 ML/day (NCCMA, 2010).

Lake Yando also provides an amount of 120 ML/year in opportunistic licences to users on the lake in years when the lake contains water, but is rarely used.

3.1.3. Groundwater/surface water interactions

Information in this section is derived from a report produced by Bartley Consulting (2010) that reviewed groundwater data and hydrogeological information. That document indicates that, while there may have been some rise in groundwater levels following the floods, groundwater does not commonly intersect the wetland.

Lake Yando is situated approximately 3.8 km west of the Loddon River on the western edge of lower floodplain alluvial sediments. Shepparton Formation sediments outcrop on the western and northeast sides of Lake Yando and Parilla Sand sediments outcrop 4 km to the northwest, near the Leaghur Fault. The wetland sits on a 40 m thick layer of alluvial/Shepparton Formation sediments comprising sandy clay and clay. Parilla Sand and Renmark Group sediments lie beneath the alluvial layer.

Groundwater beneath the floodplain west of the Loddon River moves from the south and southeast toward the north and northwest. Regional groundwater levels declined during the late 1990s and 2000s due to a combination of below average rainfall, more efficient irrigation practices and lower irrigation allocations. The 2010/11 floods caused a rapid rise in regional groundwater levels, but levels have declined again since then. Figure 6 illustrates groundwater behaviour from a number of bores close to or in the bed of Lake Yando from 1983 to 2012[2]. Details about each bore can be found in Table 5.

Surface water levels at Lake Yando have been similar to the groundwater level in adjacent monitoring bores throughout much of the period that records have been kept (Bartley Consulting, 2010). When full, Lake Yando could have been a local source of groundwater recharge. However, once the surface water level declined, groundwater could have discharged to the wetland. Local residents have advised that saline areas were appearing within Lake Yando, particularly on the south-eastern side, during the wet period 1950s to 1990s, due to the effects of shallow groundwater (Bartley Consulting, 2010). At this time, and through to the mid to late 1990s, groundwater was generally measured at within 2 meters of the surface. Levels declined during the latter part of the 90s and the 2000s as a result of a lack of recharge during the millennium drought (Figure 6).

The current groundwater level at bore 36221 (located in the north-western corner of the Lake bed) is at least 3 m below the lake floor level and ground water discharge to the lake floor is unlikely to occur. The water table could be as deep as 5m below the bed in some places (DELWP, 2016).

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[2] 2012 is the most recent data available from most bores in the area

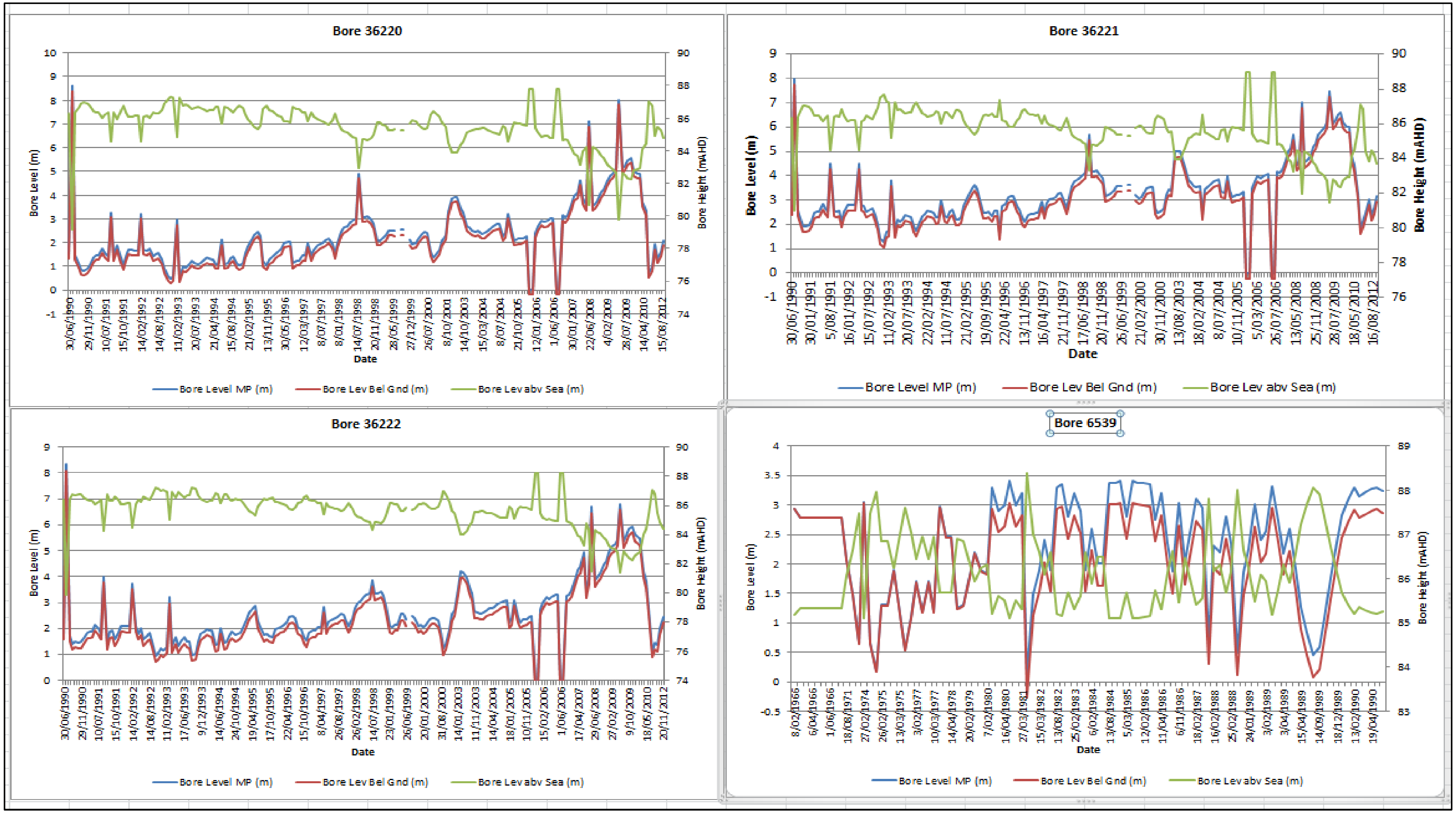

Figure 6. Groundwater levels from bores in the north west (Bores 36220-36222) and south (Bore 6539) of Lake Yando (Source: DEWLP (2016))

Groundwater levels within close proximity to Lake Yando have fluctuated over time (Figure 6). The figure shows fluctuations typical of a relatively shallow water table. The levels peaked in January 1993, declined to early 1995, and then peaked again in late 1995 and late 1996. The decline in groundwater levels observed since late 1996 are at a similar rate to the regional decline. In more recent times the water table in most bores has shallowed as a result of more normal rainfall in most years since the drought.

Data from bores within the vicinity of Lake Yando also show fluctuating EC levels (Table 5). Overall, groundwater EC is considered high (>15,000 uS/cm) throughout the area, with slightly lower levels in bores to the east of Lake Yando (6558, 36223, 36224 and 36225) close to the Loddon River. Analysis of the monitoring record shows extremely high EC levels (maximum >30,000 uS/cm) in bores close to Lake Yando (36220, 36221, 36222 and 6539, 26072).

Table 5. Analysis results of monitoring bores within the vicinity of Lake Yando (Source: Bartley Consulting 2010)

Bore	Location	Drilled depth	Screen top (m)	Screen bottom (m)	Electrical Conductivity (uS/cm)			
					Min	Max	Mean	Readings
6539	500m west of southern edge	3.05			2310	52833	28775	14
26072		11.78	9.56	11.56	31000	42612	38866	12
36220	Northwest edge	10.00	7.74	9.74	2131	30000	12469	13
36221		10.00	7.97	9.97	20980	34036	29177	13
36222		10.09	8.09	10.09	26200	33528	30684	13
6538	3.2km northwest (adj. channel)	3.05						
6594		9.00			2700	25149	13545	10
26066		11.62	9.42	11.42	18400	27200	20757	13
6536	1.3km northwest	3.05			8550	23333	12403	19
6535	3.4km northwest	3.05			1683	34333	17246	19
50983		112.50	84.00	90.00	1400	1400	1400	1
50984		76.00	66.00	72.00	20000	20000	20000	1
6540	2.1km east	3.05			1666	23333	17472	24
36296		5.50	3.47	5.47	17001	27600	22454	11
36297		7.00	4.98	6.98	4867	31500	22996	11
36298		7.78	5.50	7.50	6988	26000	17561	11
6558	3.8km east	11.00			1675	32130	15954	11
36223		9.00	6.51	8.51	13800	26703	17095	11
36224		8.49	6.49	8.49	5973	29000	22351	11
36225		7.26	5.08	7.08	934	35000	12062	11
6541	4.4km southwest	3.05			13000	25960	18360	26
6542	2.5km south	3.05			12900	43333	25031	24
6543	2.5km southeast	3.05			3333	21500	16363	25
50971	2.6km east	162.76	42.67	51.81	22143	26000	23509	5
50972	3km southeast	88.39	0.00	88.39	13000	25929	15726	5
50973	3km east	78.33	73.15	78.33	23095	23095	23095	1

Lake Yando has received negligible channel outfalls since 1997, and has been dry for much of the time since. Prior to this surface water EC levels have fluctuated over time from 680 uS/cm to 6800 uS/cm, with a median of 2360 uS/cm (53 readings). Although the monitoring record is incomplete with many gaps, the lower EC appears to correspond with periods when the water level is high, and higher EC with low water level, indicating concentration of salt by evaporation.

Based on the analysis in Bartley Consulting (2010):

- A shallow water table poses a risk of salinisation to Lake Yando and the neighbouring land.
- The greatest risk of water table rise to within the capillary fringe in surrounding areas is when there is high water level in the lake combined with high regional groundwater levels.
- Intermittently inundating Lake Yando is likely to result in the local water table rising temporarily.
- Putting water into Lake Yando when groundwater levels are low increases the opportunity to flush salts from the soil profile and into the groundwater.
- There is a close hydraulic link between lake water and the water table aquifer. If Lake Yando were maintained as a permanent wetland, it would be a continual source of recharge to the groundwater. Consequently, the water table mound would grow, with an increased risk of salinisation and possibly waterlogging around the lake including low lying areas on neighbouring land.

3.1.4. Water Quality

Some water quality data was collected for Lake Yando during the vegetation survey in 2013 and 2014 (Rakali Ecological Consulting, 2015) (Appendix 4). In general water quality is good, with pH between 6.3 and 8.8, the latter being something of an outlier

Salinity in this survey ranged from around 300 us/cm to over 900 us/cm, but generally fell within the range 400 – 700 us/cm.

Turbidity readings were generally between 20 and 40 NTU, with a very high reading of 400 NTU was noted on the same sample date as the high pH reading. The turbidity was related to high algae and zooplankton numbers in the sample (Rakali Ecological Consulting, 2015).

3.1.5. Environmental watering

Environmental water has been delivered to Lake Yando three times over the last decade, as well as filling from floodwaters during 2010-11. The first fill occurred in 2009-10, during the latter part of the Millennium Drought, to provide a local refuge for birds during the extremely dry conditions.

The 2010-11 floods saw the lake fill and spill (Plate 2), and the wetland retained water for approximately one year.

The second and third deliveries of environmental water happened in 2013 and 2014. These were partial fills that aimed to wet the gilgai channels, water existing river red gums and encourage the recruitment of new river red gums. In 2013 only 150 ML was delivered to the wetland, and the response was disappointing, with water drying up before the end of summer and little response from wetland plants and water birds.

The environmental water event in 2014 used approximately 600 ML, with most of the water delivered in spring and a smaller top up delivered in summer. Monitoring associated with that event recorded 60 species of native birds using Lake Yando and the presence of several rare, short lived wetland plants (Rakali Ecological Consulting, 2015).

Plate 2. Lake Yando in flood looking south, with north-flowing overflow in the foreground, December 2010.

Plate 3: Venables Creek carrying floodwater, December 2010.

4. Values

4.1. Environmental values

4.1.1. Listings

Lake Yando supports a wide diversity of waterbirds, aquatic, semi aquatic and terrestrial vegetation, and a number of reptile species (See Appendix 5).

Some of the birds, reptiles and flora species identified at Lake Yando are listed or protected under various state, federal and international legislation and treaties. Table 6 lists the various conventions, agreements and legislation relevant to the management of Lake Yando.

Table 6. List of state, federal and international environment legislation and agreements that relate to flora and fauna at Lake Yando.

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	✓
Republic of 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	✓
Victorian advisory lists	State	✓

4.1.2. Water-dependent fauna

A total of 14 bird species and four reptile species of high conservation significance have been recorded at Lake Yando since 1997 (see Table 7). Thirteen of these species are listed under one or more of the agreements and conventions described in Table 6.

Table 7. Significant fauna species recorded at Lake Yando since 1997

Common name	Scientific name	International status	EPBC status	FFG status	Victorian status
Baillon's Crake	*Porzana pusilla palustris*			L	vu
Blue-billed Duck	*Oxyura australis*			L	
Common Greenshank	*Tringa nebularia*	B/C/J/R			
Eastern Great Egret	*Ardea modesta*			L	vu
Freckled Duck	*Stictonetta naevosa*			L	
Glossy Ibis	*Plegadis falcinellus*	B/C			
Grey-crowned Babbler	*Pomatostomus temporalis*			L	en
Hardhead	*Aythya australis*				vu
Little Egret	*Egretta garzetta*			L	
Nankeen Night-Heron	*Nycticorax caledonicus*				nt

Rainbow Bee-eater	*Merops ornatus*	J			
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	C		L	vu
Common Long-necked Turtle	*Chelodina longicollis*				dd

Key:
International status: B – Bonn Convention; C – CAMBA; J – JAMBA; R – ROKAMBA
EPBC status: EN – endangered; VU - vulnerable
FFG status: L – Listed as threatened
Victorian status: vu – vulnerable; nt – near threatened; en – endangered; dd – data deficient

4.1.3. Terrestrial fauna

Terrestrial fauna at Lake Yando include several species of reptiles, including the endangered striped legless lizard (*Delma impar*) and lace monitors. Black wallabies (*Wallabia bicolor*) and grey kangaroos (*Macropus giganteus*) are also frequently seen at the wetland. Pest species such as foxes and rabbits are commonly observed at Lake Yando. A range of terrestrial birds have also been identified.

4.1.4. Vegetation communities and flora

As a result of anthropogenic changes to the hydrology of the wetland, and associated changes in salinity, native vegetation at Lake Yando has been significantly altered from its pre-European state. Surveys in 2014 identified four distinct wetland Ecological Vegetation Classes (EVCs) and another three EVCs that form complexes with Intermittent Swampy Woodland (Rakali Ecological Consulting 2015). Three of the EVCs recorded at Lake Yando are depleted or endangered in Victoria (see Table 8).

Ecological Vegetation Classes (EVC) recorded at Lake Yando were ground-truthed and found to be significantly different to those mapped on the Biodiversity Interactive Map (DELWP 2014a). The Biodiversity Map shows the majority of Lake Yando supporting Lignum Swamp, with a fringe of Lignum Swampy Woodland. The recent ground surveys confirmed that Lake Yando supports the following EVCs:

- Riverine Chenopod Woodland (EVC 103), which fringes the lake above its normal high water level, at approximately 87.8 mAHD
- Lignum Swampy Woodland (EVC 823), which forms a narrow band around the normal high water level (87.6 mAHD), and
- Intermittent Swampy Woodland (EVC 813), which occurs across the floor of the wetland. In deeper sections of the lake. Intermittent Swampy Woodland forms a complex with Aquatic Herbland (EVC 653) and/or Dwarf Floating Aquatic Herbland (EVC 949) when the lake is inundated and Lake Bed Herbland (EVC 107) when the lake is dry. The lake bed is at 86.4 mAHD.
- Tall Marsh (EVC 821), dominated by Broad and Narrow-leaved Cumbungi (*Typha orientalis* and *Typha domingensis* respectively), has invaded areas of Intermittent Swampy Woodland within the wetland as a consequence of prolonged artificial inundation.

Red Gum Swamp (EVC 292) was described as 'degraded' in Johns *et al*. 2010, but was not referred to in later vegetation assessments. It was determined that the EVC was not present at Lake Yando and was mis-identified in the earlier survey (pers. comm. Damian Cook [Rakali Ecological Consulting], April 2016).

Table 8. Conservation status of EVCs at Lake Yando

EVC no.	EVC name	Bioregional Conservation Status
EVC 103	Riverine Chenopod Woodland	Endangered
EVC 813	Intermittent Swampy Woodland	Depleted
EVC 821	Tall Marsh	Least concern
EVC 823	Lignum Swampy Woodland	Vulnerable
EVC 107*	Lake Bed Herbland	Vulnerable
EVC 653*	Aquatic Herbland	Depleted
EVC 949*	Dwarf Floating Aquatic Herbland	N/A
Source: DEPI (2014d); Rakali Ecological Consulting (2015) *These EVCs form complexes with intermittent swampy woodland EVC.		

Native and threatened flora

Table 9 lists the flora of high conservation significance found at Lake Yando during a survey undertaken by Rakali Ecological Consulting (2015). Some of these species were not previously recorded at Lake Yando, and/or showed an extension to their range by being present at Lake Yando. These are marked with an asterisk in Table 9.

Table 9. Significant water dependent flora recorded at Lake Yando

Common name	Scientific name	Last Record	EPBC status	FFG status	Victorian status
Jerry-jerry*	*Ammannia multiflora*	2015			v
Graceful Swamp Wallaby-grass	*Amphibromus fluitans*	2015	V		
Bladder Saltbush	*Atriplex vesicaria* subsp. *macrocystidia*	2015			k
Winged Water-starwort	*Callitriche umbonata*	2015			r
Spiny Lignum	*Duma horrida* subsp. *horrida*	2015			r
Pale Spike-sedge	*Eleocharis pallens*	2015			k
Bristly Love-grass	*Eragrostis setifolia*	2015			v
Water Nymph*	*Najas tenuifolia*	2015			r
Woolly Knotweed	*Persicaria lapathifolia* (floccose form)	2015			k
Swamp Buttercup	*Ranunculus undosus*	2015			v
Dark Roly-poly	*Sclerolaena muricata* var. *semiglabra*	2015			k
Sweet Fenugreek	*Trigonella suavissima*	2015			r
New Holland Daisy	*Vittadinia* sp.	2010			r
Key: EPBC status – V = Vulnerable; Victorian status: v = vulnerable; k = poorly known; r = rare					

4.1.5. Wetland depletion and rarity

Both the Corrick and Norman and the updated ANAE classifications have been included in Table 10, which demonstrates the extent to which wetlands have been altered since European settlement. The table indicates that the extent of Deep Freshwater Marsh has been significantly reduced since European settlement, and despite representing a relatively small proportion of the remaining total Temporary Freshwater Marsh, Lake Yando is important in the regional context in terms of representing a depleted wetland type.

Table 10. Area, depletion and rarity of wetland classifications in the region

Region	Corrick and Norman classification deep freshwater marsh				Current classification (ANAE) Temporary Freshwater Marsh	
	Pre-European area (ha)	Current area (ha)	Reduction (%)	Lake Yando contribution to current area (%)	Current area (ha)	Lake Yando contribution to current area (%)
Victoria	125,942	54,537	57	0.3	224,456	0.03
North Central catchment	11,774	4,811	41	3.4	153,024	0.05
Loddon catchment	8,576	2,880	34	5.7	114,083	0.07
Murray Fans bioregion	3,141	1,074	34	15.2	42,589	0.18

4.1.6. Ecosystem function

The term 'Ecosystem function' is used to describe the biological, geochemical and physical processes and components that take place or occur within an ecosystem. These functions relate to the structural components of an ecosystem (e.g. vegetation, water, soil, atmosphere and biota) and how they interact with each other, both at a local (i.e. site specific) and regional (i.e. complex) scale. Specific examples include processes that are essential for maintaining life such as storage, transport and nutrient cycling as well as the provision of resources that support biodiversity such as habitat, food and shelter.

From a landscape context, Lake Yando is considered of high value as it represents a highly depleted wetland type and supports threatened flora and fauna species and communities that are important for maintaining biological diversity in the biogeographic region. These values contribute not only to the wider Boort District Wetlands complex but the North Central CMA region as a whole.

Ecosystem functions provided by Lake Yando at a local and regional level are described in Table 11.

Table 11. Ecosystem function of Lake Yando on a local and regional scale

Local ecosystem functions	Regional ecosystem functions
• **Convert matter to energy for uptake by biota** - this includes substrate surfaces (i.e woody debris) for biofilms and plant matter and interactions between primary producers and consumers such as the breakdown of carbon and nutrients by zooplankton and macroinvertebrates for higher order consumers. • **Provide shade and shelter for biota** - this includes amelioration of extremes in temperature, sunlight exposure and wind as well as protection from predators. The interrelationship of tree, shrub, forb and grass species with compatible geology, soil type, slope aspect, elevation, moisture availability and temperature range characteristics are the main ecosystem components supporting this function. • **Provision of water for consumption** - retention and storage of water for use by biota to enhance growth and development and to ensure survival and reproduction. • **Reproduction** - recruitment of new individuals requires sufficient shelter from predators, food for growth, resources for nest building and cues for breeding (i.e. water level changes, temperature, rainfall etc.). Adequate resources to support newly fledged	• **Movement/ dispersal** - movement of individuals is linked to food web functions (see local ecosystem functions) and is a requirement for the life cycle of some species (i.e. migration). It is also assists with maintaining genetic diversity within the landscape and reduces the risk of local species extinction. The movement of mobile species through the landscape further supports the dispersal of seeds/progapules in the landscape providing a source for colonisation. • **Cycle nutrients and store carbon** - important for essential ecological processes. • **Population persistance** - a number of species require specific habitat conditions to breed. With a dramatic reduction in the area of temporary freshwater marsh in the landscape, the populations of species such as Brolga are aging, which results in reduced fecundity and recruitment. • **Biological diversity** - the provision of a sufficient number and range of habitat types in the landscape supports a high diversity of native species. This in turn helps build resilience to local catastrophic events (i.e. loss of habitat through fire and clearing) due to there being sufficient alternative habitats available. This helps maintain genetic

individuals are also required, including shelter, food and provision of water for consumption. Plants also require specific germination and growth conditions (including flood cues, follow up flooding, drying etc.) to ensure successful recruitment.	and species diversity in the region.
Note: The above ecosystem services are particularly important for species with low or restricted mobility.	

4.2. Social values

4.2.1. Cultural heritage

Cultural heritage values are abundant on productive wetlands throughout the district, including Lake Yando. There are no known cultural heritage sites at Lake Yando currently registered with Aboriginal Affairs Victoria (AAV); however anecdotal evidence suggests that the Boort wetland system overall was an extremely productive system that provided food and other resources to Aboriginal people (Haw & Munro, 2010).

4.2.2. Recreation

Unlike other wetlands in the Boort District (such as Lake Leaghur), Lake Yando still contains a significant population of river red gums of various ages. Because of this, and because it is quite shallow when full, it is not used for some recreational activities such as water skiing and powered boating. It does support other recreational activities including bird watching, unpowered boating (eg. row-boats and kayaks), hunting and camping.

4.3. Economic

The economic significance of Lake Yando is related to its recreational activity and educational value. The Boort district receives an influx of visitors during duck hunting season and over summer, and this creates a significant economic benefit for the region. Wetlands in the Boort district collectively contribute to the economic activity of the region.

4.4. Conceptualisation of the site

Figure 7 shows conceptuals model of the processes and components of Lake Yando when it is wet (7a) and dry (7b). The text below Figure 7 describes specific components of the wetland and ecological processes that are denoted by numbers in the diagrams.

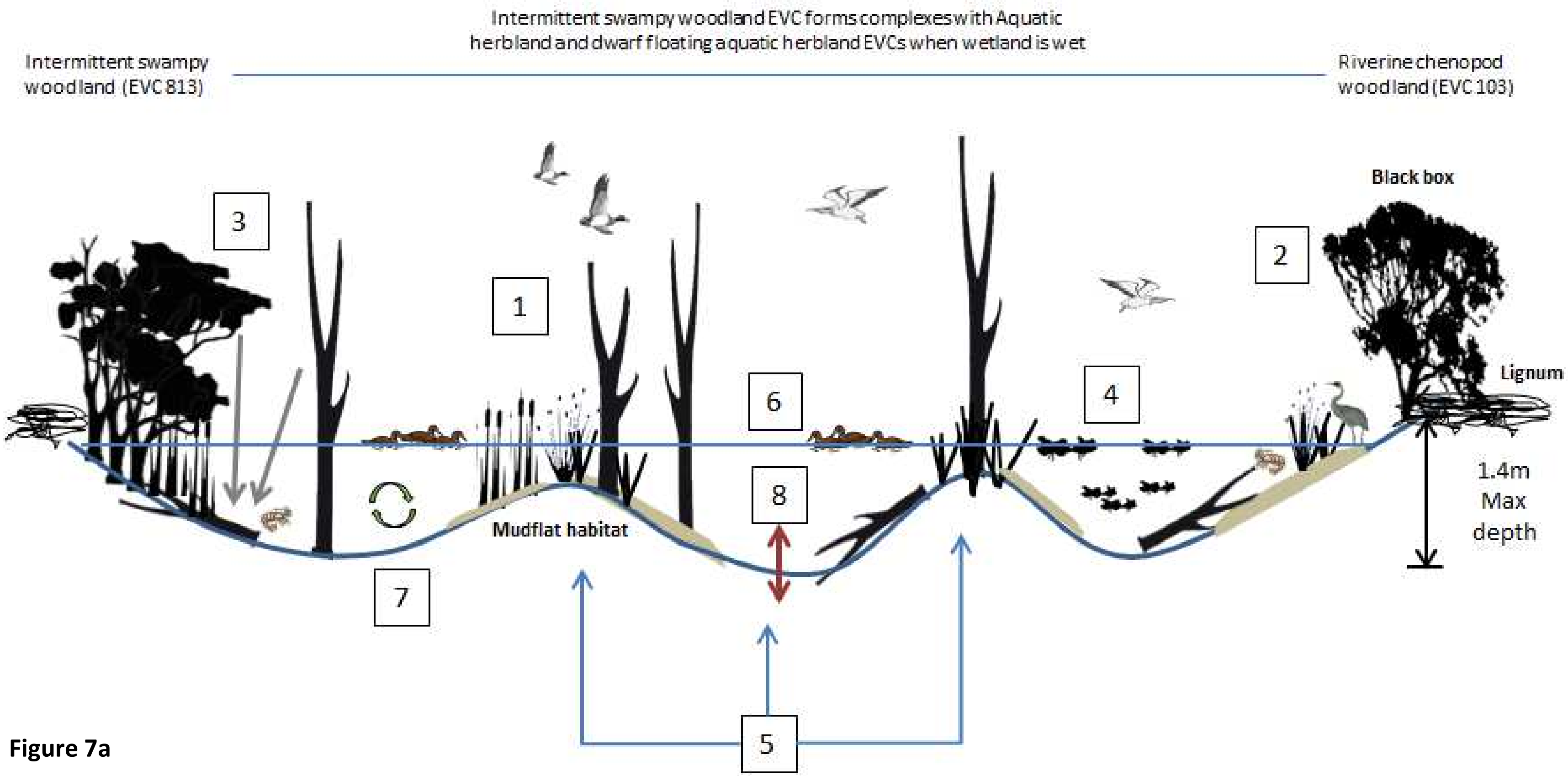
Intermittent swampy woodland EVC forms complexes with Aquatic herbland and dwarf floating aquatic herbland EVCs when wetland is wet
Intermittent swampy woodland (EVC 813)
Riverine chenopod woodland (EVC 103)
Black box
Lignum
3
1
2
6
4
8
7
5
Mudflat habitat
1.4m Max depth

Figure 7a

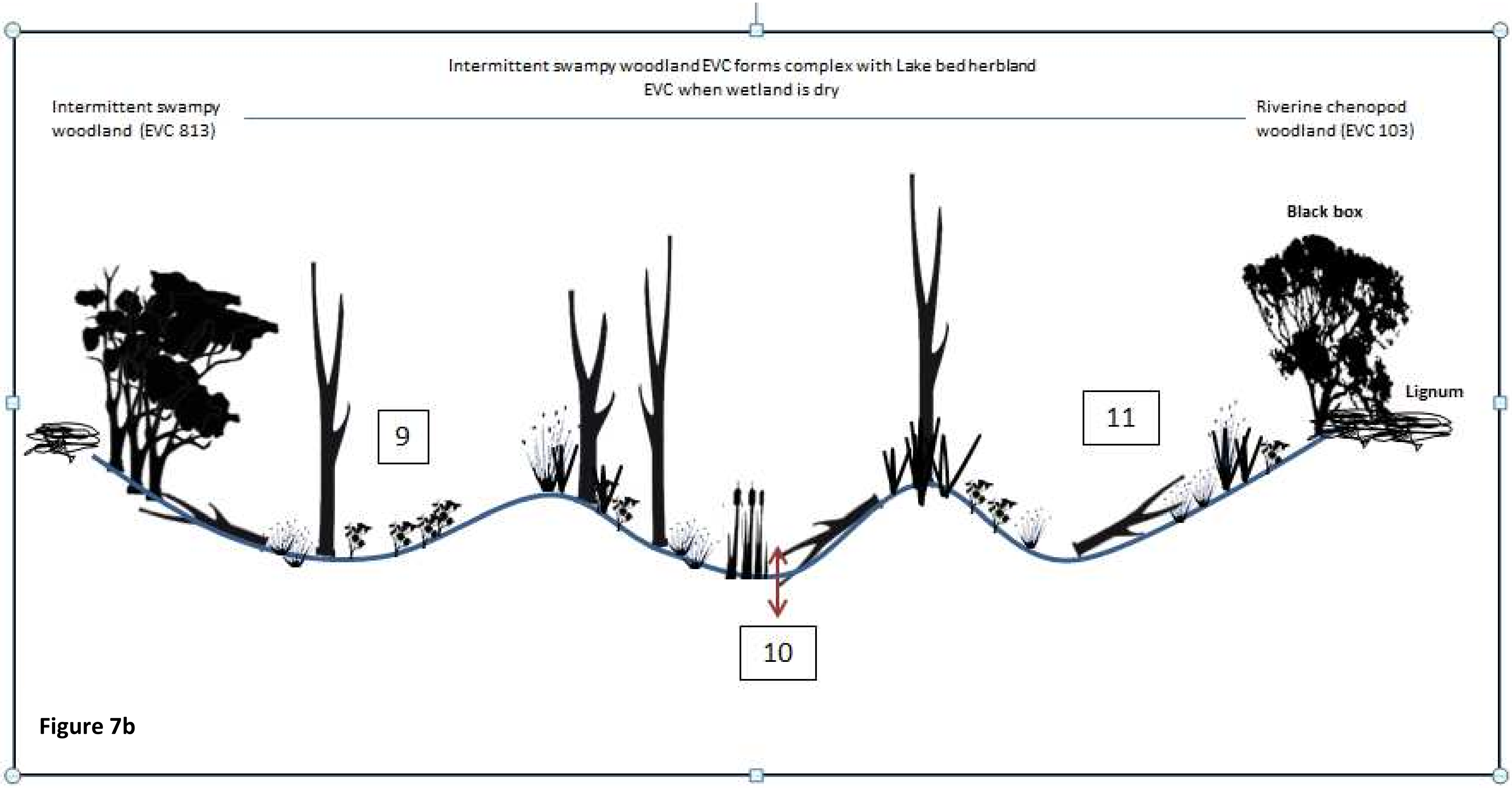

Figure 7. Schematic representation of different wetland habitats at Lake Yando during wet (Figure 7a) and dry (Figure 7b) phases, and the ecological processes that each habitat and environmental water will support (not to scale)

Figure 8a (When inundated)

1. Lake Yando supports a range of habitats including open water and mudflats, marshland, reed bed and herbland vegetation, and fringing river red gums and black box
2. Lake Yando contains a number of vulnerable or depleted EVCs, including Riverine Chenopod Woodland (EVC 103), Intermittent swampy woodland (EVC 813), Lignum Swampy Woodland (EVC 823) Aquatic Herbland (EVC 653) when wet
3. Woody debris from both live trees and dead standing timber provides a substrate for biofilms and macroinvertebrate habitat. Both live and dead river red gums and black box provide roosting, nesting and vantage points for birds, bats, reptiles and mammals
4. Floating and submerged aquatic vegetation provides habitat and a food source for macroinvertebrates, supporting the food chain. Phytoplankton also provide a food source for zooplankton
5. The gilgai microtopography, which is characterised by an irregular wetland surface with a series of interconnected channels and pools (see Figure 4 and Plate 1) provides a range of habitats for birds, frogs and macroinvertebrates.
6. Open water provides drought refuge when other sites in the landscape are dry, and supports open water feeders such as dabbling ducks
7. Wetting and drying cycles, and filling to different levels facilitate nutrient and carbon cycling, and provide habitat and food for different biota at different times
8. During periods of high water tables, groundwater discharge and intrusion can occur in the deepest parts of the wetland

Figure 8b (When dry)

9. Red gums germinated as a result of the wetting phase can grow and establish
10. Waterlogged or flooded soils can promote the growth of cumbungi (T*ypha sp*)
11. Intermittent Swampy Woodland EVC dominates, and forms a complex with Lake Bed Herbland (EVC 107) during the dry phase

4.5. Significance

Lake Yando represents a depleted wetland type and is considered a regionally significant wetland because it is one of the few wetlands in the region that retains a mixed age class of live river red gums (NCCMA 2010). It also displays gilgai microtopography that provides a range of habitat types of varying depth and complexity when it is inundated (See Plate 4).

Lake Yando has good biodiversity compared to other wetlands in the Boort district, supporting fauna and flora of national and state conservation significance, and migratory waterbirds protected under international agreements.

Plate 4: Habitat elements of Lake Yando include gilgai formation, dead standing and fallen timber and mature, mixed age river red gums.

5. Ecological condition and threats

5.1. Context

Prior to European settlement, Lake Yando was a deep freshwater marsh[3] dominated by river red gums (*Eucalyptus camaldulensis*) (DELWP, 2016a). Anecdotal evidence suggests that trees were widely spaced across the wetland floor (NCCMA, 2010).

European settlement, the establishment of the Pyramid-Boort Irrigation System in the 1920s/1930s, and construction of levees across the floodplain resulted in significant changes to the hydrology of the wetland. Lake Yando received significant volumes of drainage and outfall water from the irrigation channel system and as a result was nearly permanently inundated (further detail provided in Section 4). Farm development and the construction of roads, channels, levees etc. have significantly impacted the natural catchment and altered water flows into Lake Yando (pers. comm. Rod Stringer [landholder] and Lawrence Cameron [G-MW] 25 March 2010). This has meant the lake contained water for much longer periods than would naturally have occurred, drowning mature red gums and changing the nature of the Intermittent Swampy Woodland and Aquatic Herbland EVCs.

Environmental water was added to Lake Yando in 2009-10 to provide refuge, with the wetland having been dry since 1997-98 due to the Millennium Drought. Campbell *et al.* (2009) conducted a vegetation survey of Lake Yando on 22 October 2009 to assess the response to the environmental water. That survey reported the following results:

- River red gum trees across the wetland displaying various levels of health. To the west of the wetland they are predominately dead, but to the east they have regenerated and are in moderate to good condition.
- River red gum trees are of mixed age, with some thick patches of younger trees, suggesting some level of recruitment.
- Understorey vegetation dominated by exotic annual grasses.
- A small patch of tangled lignum (*Muehlenbeckia florulenta*) towards the southeast corner of the wetland.
- Small patches of both Narrow-leaf and Broadleaf Cumbungi (*Typha domingensis* and *T. orientalis*) in the north-east.
- Small patches of herbs supported by damper ground, such as the rare winged water-starwort (*Callitriche umbonata*).

The region experienced severe floods in 2010-11, which filled all the wetlands in the Boort District. Those floods and the two environmental watering events since the floods have helped to improve the condition of existing river red gums in Lake Yando, and triggered significant recruitment of new river red gums.

Unlike other wetlands within the district, Lake Yando continues to support living river red gums, dead standing and fallen timber, scattered reeds and, when inundated, open water and associated mudflats. These habitat components in turn attract a high diversity of waterbirds, reptiles and amphibians (Section 3).

[3] Deep freshwater marshes are generally less than 2 m deep and are inundated for longer than eight months of the year (DCFL 1989)

5.2. Current condition

Displacement of wetland vegetation communities

Many of the wetland EVCs that are likely to have occurred at Lake Yando prior to European settlement have been displaced as a result of the altered hydrological regime. Areas that once supported Intermittent Swampy Woodland EVC now support EVCs that are more typical of permanently inundated habitats, although frequent drying during and since the Millennium Drought has also depleted species that favour wet conditions.

Weeds are a significant problem at Lake Yando, with 46% of species recorded during vegetation surveys exotic (Appendix 5).

5.3. Condition trajectory – do nothing

Since European settlement, changes to the natural hydrological regime have resulted in a decline in wetland health, including habitat loss. More frequent inundation and shallow saline groundwater has contributed to the death of river red gums in the lake, and an influx of pest plant and animal species have contributed to a loss of diversity of native species.

As a complementary action to the Regional Catchment Strategy, the North Central CMA is developing the *North Central Climate Change Adaptation and Mitigation Plan* (NCCMA, 2015), which predicts the long term impacts of climate change under a range of scenarios. Although the scale of impacts (e.g. severity, timeframe) differs accordingly for each scenario, the following impacts are expected to occur across all scenarios:

- Increased average temperatures in all seasons
- More hot days and less very cold days
- Decrease in winter rainfall
- Possible increase in summer rainfall
- Increase intensity of extreme rainfall
- Continued rainfall variability
- Increased frequency and severity of bushfire and flood events.

Under these predictions, Lake Yando is likely to experience less natural rainfall over the winter period, coupled with higher spring and summer temperatures and increased evaporation during summer. Longer dry periods may render the endemic seedbank unviable, which will limit future recruitment of native wetland plants and allow weed infestation and native terrestrial plants to become established. It may also cause the health of river red gum and Lignum to decline.

Lake Yando supports a high diversity of water birds (including mostly mud-flat feeding migratory species listed under JAMBA, CAMBA and ROKAMBA). Without a variable water regime with regular wetting and drying sequences the diversity of waterbird feeding guilds will be reduced.

6. Management objectives

6.1. Management goal

The long term management goal takes into account the values the wetland supports, the current wetland condition and potential risks that need to be managed. The management goal that was developed for the *Lake Yando Environmental Watering Plan 2010* is considered to still be relevant.

Long-term Management Goal

To provide a water regime that maintains existing mature river red gums (*Eucalyptus camaldulensis*), supports the recruitment of new river red gums and promotes the growth of a diverse range of aquatic and amphibious plant species that offer habitat for waterbirds, reptiles and amphibians.

6.2. Ecological objectives

Ecological objectives describe the intended outcomes of environmental water delivery. They contribute towards achieving the long term management goal. The ecological objectives for Lake Yando are based on the key water-dependent values of the wetland. Where appropriate, these are expressed as the target condition or functionality for each key value, using one of the following trajectories:

- restore – recover a value that has been damaged, degraded or destroyed and return it to its original condition.
- rehabilitate – repair a value that has been damaged, degraded or destroyed but not to the extent of its original condition.
- maintain – maintain the current condition of a value.

Ecological objectives are presented as primary objectives and as secondary objectives. Primary objectives are related to the key values of Lake Yando. Secondary objectives either support the primary objectives (e.g. macroinvertebrates are a food source for fish) or are objectives for values for which little baseline information is known (e.g. frogs). If the monitoring budget in future years is restricted it is anticipated that the North Central CMA will prioritise monitoring of primary objectives.

The ecological objectives for Lake Yando and the justification for each are shown in Table 12.

Table 12. Ecological objectives and their justifications for Lake Yando

Objective	Justification
1. Primary objectives - vegetation	
1.1 Maintain the health and restore the distribution of river red gum and understorey species (such as tangled lignum) associated with Intermittent swampy woodland EVC	• Lake Yando was originally a Red Gum swamp, and is one of the few wetlands in the region that retains a healthy stand of mixed age class river red gums. The distribution of river red gums can be increased in the western side of the lake by facilitating recruitment. • Understorey vegetation such as sedges and grasses provide habitat for a range of frog and waterbird species • Historically lignum was common across the Loddon floodplain. Lake Yando still contains healthy lignum populations and therefore represents an opportunity to expand the distribution of this community.
1.2 Rehabilitate EVCs 107 (Lake bed herbland), 653 (Aquatic herbland) and 949 (Dwarf floating aquatic herbland) to benchmark condition • Provide a water regime that supports these EVCs and allows species to complete their lifecycles (i.e. set seed) • Maintain a viable seed bank for these EVCs	• Lake Yando contains a number of rare plant species including winged water starwort, jerry-jerry and water nymph. Inundating mudflat areas and providing open water allows these EVCs to flourish • Lake bed herbland EVC requires at least 2 dry years to complete life cycles and set seed • The target EVCs provide habitat and feeding opportunities for frogs, waterbirds and reptiles
1.3 Maintain the health and increase the distribution of vegetation associated with Riverine chenopod woodland (EVC 103) • Maintain health of existing black box trees • Provide opportunities for recruitment of black box and understorey species	• Riverine chenopod woodland EVC is considered to be endangered in the Victorian Riverina bioregion.
2. Primary objectives - fauna	
2.1 Maintain and where necessary rehabilitate the abundance and diversity of waterbirds using the wetland when it is full and as it draws down.	• A range of waterbird feeding guilds (mudflat, herbivore, lake edge fringing/emergent) makes use of Lake Yando when it is inundated and drying. • The watering regime may provide opportunities for some waterbird species to breed, but this is not a primary objective.
3. Primary objectives - process	
3.1 Rehabilitate macroinvertebrate and zooplankton production to levels expected in healthy freshwater swamps.	• Macroinvertebrates and zooplankton are critical components of wetland food webs. Productive macroinvertebrate and zooplankton communities will provide food to support large numbers of frogs and waterbirds • Multiple functional groups use different habitats and serve different ecological processes. At Lake Yando particular habitats include open water, shallow littoral, mudflats and submerged wood • Wetting and drying regimes are important for nutrient and carbon cycling to support high macroinvertebrate and zooplankton biomass

6.3. Hydrological requirements

A series of hydrological requirements based on the ecological objectives detailed in Section 6.2 have been developed for Lake Yando. The information provided in Table 13 is a summary of this information.

Table 13. Hydrological requirements for Lake Yando

Ecological Objectives	Water management area	Elevation	Hydrological Objectives										
			Recommended number of events in 10 years			Tolerable interval between events once wetland is dry (months)			Duration of ponding (months)			Preferred timing of inflows	Depth (m)*
			Min	Opt	Max	Min	Opt	Max	Min	Opt	Max		
1. Primary objectives - vegetation													
1.1 Maintain the health and restore the distribution of river red gum and understorey species associated with Intermittent swampy woodland EVC	Bed/fringe	87.6	1	2	3	24	36	60	1-3	3-6	6	Not critical, but more growth and regeneration achieved if flooded during spring-summer	Not critical for mature trees, but juveniles not to be fully inundated
1.2 Maintain and rehabilitate EVCs 107 (Lake bed herbland), 653 (Aquatic herbland), 949 (Dwarf floating aquatic herbland) • Provide a water regime that supports these EVCs and allows species to complete their lifecycles (ie set seed) • Ensure a viable seed bank is maintained	Bed/fringe	87.0	2	3	5	12	24	60	1	6	12	Late winter/ spring	0.4-1m
1.3 Maintain the health and increase the distribution of	Bed and riparian zone	87.8	1	2	3	36	60	120	2	3-7	12	Spring	

Ecological Objectives	Water management area	Elevation	Hydrological Objectives										
			Recommended number of events in 10 years			Tolerable interval between events once wetland is dry (months)			Duration of ponding (months)			Preferred timing of inflows	Depth (m)*
			Min	Opt	Max	Min	Opt	Max	Min	Opt	Max		
Riverine chenopod woodland (EVC 103) • Maintain health of existing trees • Provide opportunities for recruitment													
2. Primary objectives - fauna													
2.1 Maintain and where necessary rehabilitate the abundance and diversity of waterbirds using the wetland when it is full and as it draws down	Bed/fringe	Up to 87.8	3	5-10	10	4	4-6	-	4	6	12	Winter to summer	Variable
			Source: DEPI 2012, Fitzsimons et al. 2011, Roberts and Marston 2011, Rogers and Ralph 2011										

6.4. Watering regime

The watering regime for Lake Yando is based on watering requirements outlined in Table 13. Lake Yando should be filled to inundate the Riverine Chenopod Woodland EVC by surcharging to 87.8 m AHD approximately once per decade, which has the potential to flood private land. Further work is required to determine the extent of inundation at 87.8 m and it is likely landholder agreements will be required (M. Maher [Project Manager, NCCMA] pers comm May 2016). More frequent partial fills to 87.6 m AHD will water river red gums and serve other environmental objectives.

The draw-down period for spring watering events at Lake Yando is approximately 5 months, through evaporation and seepage (NCCMA, 2010).

Minimum watering regime

- Fill wetland to 87.8 m AHD between autumn and early spring (variable timing recommended) in year 1 to inundate areas of riverine chenopod woodland on higher ground. Provide top-ups if required to allow short lived aquatic/semi aquatic plants to complete their lifecycles and set seed and to support waterbird breeding. Wetland should naturally draw down over 5 months
- Allow to dry out in years 2-4 to allow Lake bed herbland EVC species to develop and complete their life cycles, and to control *Typha* and *Phragmites*, then inundate to 87.6 m AHD in spring of year 5
- Allow to dry out in years 6-8, then inundate to 87.6 m AHD in spring of year 9

Optimum watering regime

- Fill wetland to 87.8 m AHD between autumn and early spring (variable timing recommended) in year 1 to inundate areas of riverine chenopod woodland on higher ground. Provide top-ups if required to allow short lived aquatic/semi aquatic plants to complete their lifecycles and set seed and to support waterbird breeding.
- Keep dry in years 2-3 then fill to 87.6 m AHD in year 4 to water mature river red gums and promote germination of seeds
- Partial fill to inundate the gilgai formation[4] over spring/summer of year 5. This will promote the growth of short lived aquatic and semi aquatic plants, as well as providing a follow up watering for river red gum seedlings that are likely to have germinated in year 4. Elevation is not defined, but a level of 87.0 mAHD is the likely target level
- Dry in years 6 and 7, to allow Lake bed herbland EVC species to develop and complete their life cycles and to control *Typha* and *Phragmites*
- Partial fill in September-October of year 9 and allow to draw down in year 10

[4] Due to the bathymetry being too course and a lack of gauges in the gilgais, system watering is currently done by sight. Bathymetry and gauges are identified in the knowledge gaps

<u>Maximum watering regime</u>

- Fill wetland to 87.8 m AHD between autumn and early spring (variable timing recommended) in year 1 to inundate areas of riverine chenopod woodland on higher ground. Provide top-ups if required to allow short lived aquatic/semi aquatic plants to complete their life cycle and to support waterbird breeding.
- Allow to dry in year 2 then fill to 87.6 m AHD to inundate mature river red gums and promote germination of new river red gums in year 3.
- Year 4 partial fill to inundate the gilgai channels over spring/summer as follow up watering for river red gum juveniles that germinated in year 3. Also facilitates growth and seed setting for short lived aquatic and semi aquatic vegetation species and feeding opportunities for waterbirds (particularly mudflat specialists)
- Dry year 5 and 6 to allow Lake Bed herbland species to complete their lifecycles, and to control *Typha* and *Phragmites,* then fill to 87.6 m AHD in year 7 to inundate mature river red gums and promote germination across the floor of the wetland. Will also help aquatic and mudflat species during drawdown
- Dry in year 9, then fill to 87.8 to inundate Riverine chenopod woodland EVC again in year 10

Figure 8 is a visual representation of the flow regime as outlined above.

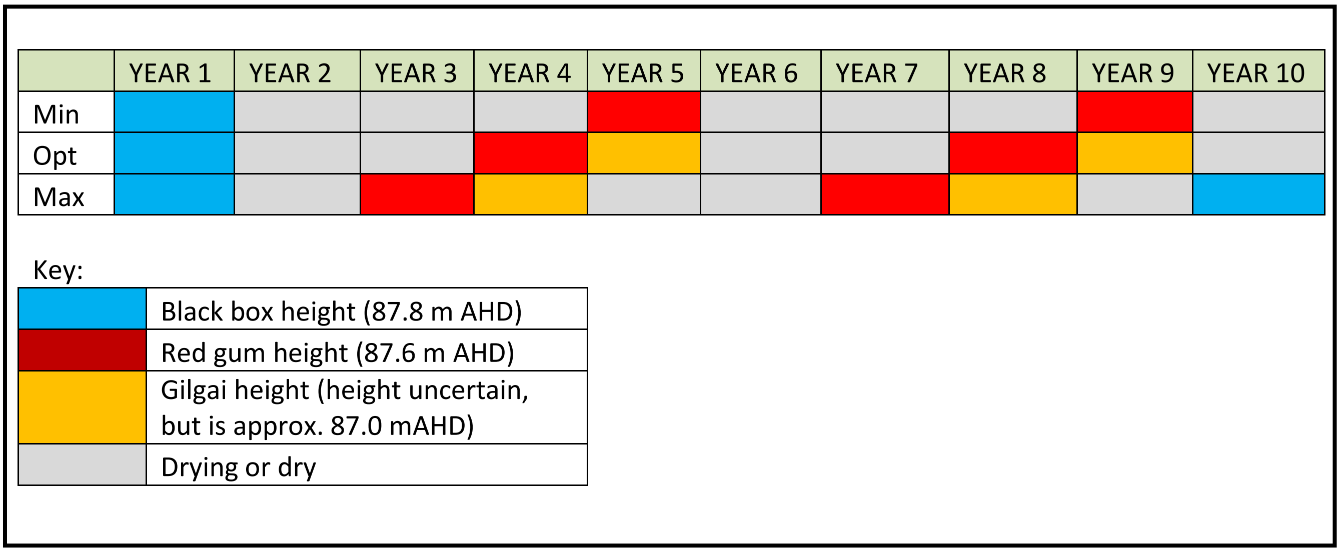

Figure 8: Visual representation of watering regimes for Lake Yando

7. Risk Assessment

A qualitative risk assessment has been undertaken for Lake Yando to assign the level of long-term risk associated with:

- delivering environmental water; and
- achieving set ecological objectives (i.e. factors outside delivery of environmental water that may limit those objectives)

As shown in Table 14, the relationship between likelihood (probability of occurrence) and the severity (severity of the impact) provide the basis for evaluating the level of risk.

Table 14. Risk Matrix

		Severity		
		Major	Moderate	Minor
Likelihood	Probable	High	High	Moderate
	Possible	High	Moderate	Low
	Improbable	Moderate	Low	Low

The risk assessment has been adapted from the Lake Yando EWP and the results are presented in Table 15. Management measures to mitigate moderate to high level risks are recommended and the residual risk, after applying those measures, is then recalculated using the same risk matrix. Short-term operational risks (e.g. environmental releases cause flooding of private land) are assessed as part of the development of the Loddon System Seasonal Watering Proposal (which includes Lake Yando), and therefore are not discussed here.

Table 15. Possible risks associated with environmental water delivery to Lake Yando and recommended mitigation measures to address those risks.

Risk No.	Threat	Outcome	Relevant objective	Likelihood	Severity	Risk rating	Management Measure	Residual Risk rating
1	**Threats from environmental water**							
1.1	Poor water quality (i.e. temperature fluctuations, blackwater events, high turbidity, salinity and nutrient levels)	• Reduced primary production (turbid water), limiting food resources for aquatic invertebrates and waterbirds. • Excessive algal growth • Potential fish kills • Saline groundwater discharge to low lying parts of the lake bed	3.1	Possible	Moderate	Moderate	• Monitoring of groundwater levels, salinity and nutrient inputs in conjunction with a regular water quality monitoring program. • Adaptively manage water regime and delivery.	Moderate
1.2	Groundwater intrusion or discharge to low-lying parts of the wetland resulting from elevated groundwater levels[5]	• Poor vegetation health • Limited regeneration and dominance of salt tolerant species • Unsuitable habitat for waterbirds and food sources	1.1, 1.2, 2.1, 3.1	Unlikely	Major	Moderate	• Monitoring of groundwater levels and salinity within wetland and surrounding area to evaluate the threat. • Adaptive management of water regime to minimise impacts on groundwater levels.	Low
1.3	Shallow water remains in the wetland for a prolonged period during summer.	• Encroachment of *Typha* and *Phragmites* across the bed of the wetland, excluding other plants and reducing habitat diversity.	1.1, 1.2, 2.1,	Probable	Moderate	High	• Water earlier in winter or fill to lower level to ensure wetland is dry during main growing season • Allow wetland to remain dry for > 2 years between environmental watering events to allow Typha and Phragmites to die off	Low
2	**Threats to achieving ecological objectives**							

[5] Under current conditions of low groundwater levels, this is unlikely. However, if regional groundwater levels rise due to wetter climatic conditions or other human induced factors there could be a risk of saline groundwater intrusion into the wetland or discharge onto low-lying adjacent land (Bartley Consulting 2010).

Risk No.	Threat	Outcome	Relevant objective	Likelihood	Severity	Risk rating	Management Measure	Residual Risk rating
2.1	Introduced species – fish	• European Carp and Gambusia are possibly present during inundation events, as they are likely to be present in the irrigation system. A high abundance of these species may limit the establishment of aquatic plants, predate on frogs (food sources for waterbirds) and reduce water quality. However they may also provide a source of food for piscivorous waterbirds.	1.2, 2.1, 2.2, 3.1	Possible	Moderate	Moderate	• Annual drying (as per recommended regime) will manage population. • Install carp screen during wetland filling. • A broad scale method for carp control is identified as a knowledge gap across the entire Murray-Darling Basin.	Low
2.2	Depleted seedbank	• Species representative of target EVC communities may not respond to watering • Emergence of unexpected native or exotic species • Restricted regeneration • Lower species diversity	1.1, 1.2, 1.3, 1.4,	Possible	Moderate	Moderate	• Active planting of depleted species • Alter watering regime if riparian plants are not completing their life cycles • Fluctuation of water levels will be required to support river red gum germination.	Low
2.3	Opportunistic diversion licences	• Artificial lowering of water level threatening achievement of identified objectives and goal. • Licence holders can potentially take up to 120 ML from Lake Yando, but currently use very little of the entitlement when the lake holds water	All	Improbable	Moderate	Low		Low

8. Environmental water delivery infrastructure

At present, Lake Yando is supplied via a fully automated regulator and delivery channel with capacities of 60 ML/day and 35 ML/day, respectively. The maximum amount required to fill the lake is 878 ML (NCCMA, 2010) so at a rate of 35 ML/day, Lake Yando is able to be filled to 87.6 mAHD in 25 days (assuming no losses and adequate capacity is available in channel 5/2).

The current delivery infrastructure is considered adequate to deliver the desired water regime and no infrastructure upgrades are recommended.

9. Complementary actions

Implementing the recommended watering regime for Lake Yando will benefit the wetland. Some objectives require complementary actions in order to be realised. These complementary actions are described in Table 16, and directly target the risks described in Section 7 of this EWMP.

Table 16. Complementary actions to enhance the benefits of environmental watering

Activity	Rationale
Revegetation program	Revegetate areas of Riverine chenopod woodland in areas around Lake Yando that are depleted in this EVC. There is also a potential to re-seed Lake Yando with desirable wetland plants if the seedbank is found to be lacking.
Exotic flora control	46% of species recorded at Lake Yando in 2014-15 were exotic. These plant species have the potential to disturb the function of native vegetation through displacement and competition. Weed control such as manual removal and chemical application should target high threat terrestrial and amphibious weeds. This activity is also a complementary activity to revegetation programs.
Carp screen	During the most recent watering events (2013 and 2014), a screen was placed in the delivery channel to Lake Yando in order to keep out carp. This was found to be quite successful. By keeping the carp out of the wetland, submerged and emergent aquatic plants have a greater chance of survival. Ongoing maintenance and cleaning of the carp screen is required to maintain its effectiveness.
Fox and rabbit control	Foxes and rabbits are abundant in the area surrounding Lake Yando. They can impact on fauna (foxes) and flora (rabbits) in the fringing zones, reducing the effectiveness of watering at higher levels. Lake Yando is also a ‘refuge’ from agricultural land, and controlling exotic pests at Lake Yando will contribute to controlling numbers in the surrounding areas.

10. Demonstrating outcomes

Effective monitoring is needed to determine whether the environmental water program is achieving its intended objectives. The results of such monitoring help managers in two ways. First they inform adaptive management whereby the water regime and/or complementary actions can be modified to better meet the environmental water objectives. Second, they provide evidence that can be used to demonstrate that the environmental water actions have been effective.

Two types of monitoring are recommended to assess the effectiveness of the proposed water regime on objectives and to facilitate adaptive management:

- Intervention monitoring
- Long-term condition monitoring

It is essential that analysis of monitoring results is regularly undertaken in order to develop an understanding of changes occurring at the wetland so that water managers can adapt accordingly.

10.1. Intervention monitoring

Intervention monitoring will assess the responses of key environmental values to the changes in the water regime (intervention) and inform the achievement of ecological objectives. Intervention monitoring may include monitoring of water quality, vegetation and biota during filling events.

Monitoring the response to a watering event will be important to provide feedback on how the system is responding and whether any amendments need to be made to the operational managements or determine if any risk management actions are needed.

Current intervention monitoring

The North Central CMA conducts an ongoing environmental flow water resource planning program for Lake Yando, which is undertaken as part of the implementation of the Seasonal Watering Proposal. Each year environmental flows are released based on an assessment of the monitoring data as well as the water availability.

The internal CMA monitoring program currently includes waterbird monitoring, in-situ physico-chemical water quality monitoring and photopoints. The existing monitoring program does not adequately cover the suite of ecological objectives described in this EWMP.

Required intervention monitoring

Further intervention monitoring is required so that the CMA is able to adaptively manage Lake Yando over the next ten years to ensure that the delivery of environmental water is achieving the ecological objectives. The proposed intervention monitoring program and the objective that is being monitored is shown in Table 17.

Table 17. Required intervention monitoring for the implementation of the Lake Yando EWMP

Ecological objective		Monitoring question	When	Method
1.1	Maintain the health and restore the distribution of river red gum and understorey species associated with Intermittent swampy woodland EVC	Has RRG health improved as a result of watering?	Before watering and approximately one year after	• Photo points • Vegetation distribution mapping (e.g. using drones, aerial photography or transect surveys) • Transect surveys to record recruitment • Tree health assessments via either (1) fisheye photography to quantify canopy density or using remote sensing imagery to measure canopy health (see Cunningham et al 2009) if part of a broader landscape scale assessment of tree condition.
		Are juvenile RRGs recruiting across the bed of the lake?	Surveys in late spring/early summer	
1.2	Maintain and rehabilitate EVCs 107 (Lake bed herbland), 653 (Aquatic herbland), 949 (Dwarf floating aquatic herbland) • Provide a water regime that supports these EVCs and allows species to complete their lifecycles (ie set seed) • Ensure a viable seed bank is maintained	Have the specific EVCs increased in extent and diversity from watering compared with previous events?	Amphibious and aquatic plant surveys in late spring/summer when lake is inundated, and again after the lake has been dry for a year.	• Photo points • Vegetation surveys (e.g. fixed location transects) to record distribution, recruitment and provide species lists that can be compared against EVC benchmarks; • Distribution mapping (e.g. from drones).
1.3	Maintain the health and increase the distribution of Riverine chenopod woodland (EVC 103) • Maintain health of existing trees • Provide opportunities for recruitment	Has watering increased the extent and diversity of the Riverine chenopod woodland EVC	Survey during and after filling	• Vegetation surveys (e.g. fixed location transects) to record distribution, recruitment and provide species lists that can be compared against EVC benchmarks; • Distribution mapping (e.g. from drones).
2.1	Maintain and where necessary rehabilitate the abundance and diversity of waterbirds using the wetland when it is full and as it draws down	Is the abundance and diversity of waterbirds increasing as a result of watering?	Monthly during inundation	• Comprehensive bird surveys
3.1	Rehabilitate relative biomass of macroinvertebrates and zooplankton to levels expected	Has an adequate biomass of macroinvertebrates and zooplankton developed from	Once approx. one month after watering commences and once during drawdown	• Quantitative macroinvertebrate sampling (e.g. composite

	in healthy freshwater swamps.	the watering event?	phase	Hess samples or samples from artificial substrates) and zooplankton trawls.
Risk		**Monitoring question**	**When**	**Method**
1.1	Poor water quality	When the wetland is full, is the water quality adequate to support aquatic biota and is intervention required?	Monthly	Multi-meter for EC, pH, DO, temperature and turbidity.
1.2	Groundwater intrusion or discharge to low-lying surrounding area resulting from elevated groundwater levels	Is the watering regime causing elevated groundwater levels?	Annually	Monitoring of groundwater levels and salinity within wetland and surrounding area[2]

[1]Subject to availability of regularly updated imagery.
[2]See Bartley 2009 for further detail of recommended groundwater monitoring.

10.2. Long term monitoring

Long-term condition monitoring will provide information on whether the watering regime (and other factors) is causing a change in, or maintaining, the overall condition of the wetland (trend over time). As there is currently no formal long-term condition monitoring program in place, Table 18 details monitoring required to demonstrate change in condition over time specifically focusing on the long-term outcomes of the Lake Yando EWMP.

It should be noted that condition monitoring is recommended to be conducted in conjunction with intervention monitoring to comprehensively evaluate any changes to Lake Yando.

Recommendations have been made below for variables to be monitored in order to assess the response to the provision of the desired water regime and inform its adaptive management.

Table 18. Required long-term condition monitoring for Lake Yando

Ecological Objective	Objective No.[1]	Method	When
Specifically relating to ecological objectives			
Maintain the health and restore the distribution of river red gum and understorey species associated with Intermittent swampy woodland EVC	1.1	Comprehensive vegetation surveys incorporating regular transects and quadrats, aerial photos and possibly drones. including tree health, IWC, EVC condition, species presence and abundance and weediness	Ideally annually with no more than two years between surveys
Rehabilitate EVCs 107 (Lake bed herbland), 653 (Aquatic herbland) and 949 (Dwarf floating aquatic herbland) to benchmark condition	1.2		
Maintain the health and increase the distribution of vegetation associated with Riverine chenopod woodland (EVC 103)	1.3		
Maintain the health and restore the distribution of tangled lignum across a greater range of elevations within woodland EVCs	1.4		
Maintain and where necessary rehabilitate the abundance and diversity of waterbirds using the wetland when it is full and as it	2.1	Comprehensive waterbird monitoring including indication of age distribution, movement, abundance, diversity and breeding in the wider population.	Ideally annually with no more than two years between surveys

draws down			
Risks	**Risk No.**	**Method**	**When**
Groundwater intrusion or discharge to low-lying surrounding area resulting from elevated groundwater levels.	1.3	Review groundwater-related aspects of the site, including environmental risks and impact of adopted watering regime. Subject to data availability, this should include an appraisal of the movement of the wetting front and salt, impacts on surrounding groundwater levels and neighbouring land, and a water budget that includes estimates of accessions to groundwater.	At least every 7 years or sooner if regional groundwater levels rise.

11. Knowledge gaps and recommendations

A number of knowledge gaps have been identified for Lake Yando. In particular, the turtle population at the wetland is not known, even though common long-necked turtles have been recorded at the site (eg Rakali Ecological Consulting 2015). Given the pressures on turtle populations in the region, investigating the population of turtles at Lake Yando may give further insight into the values at Lake Yando and potentially result in modifications to objectives in this EWMP.

Table 19. Knowledge gaps and recommendations for Lake Yando

Knowledge Gap	Recommendation	Who	Priority
Objectives			
Bathymetry and height measurement	Re-survey bathymetry at a finer scale and ensure gauges are accurately placed	Consultant, GMW	High
Winged water starwort	What are the watering requirements for this species?	Research body on behalf of NCCMA	Moderate
Investigate options to deliver water to 87.8 m AHD	Investigate the practicalities of modifying infrastructure to allow the wetland to be filled to 87.8 m AHD	CMA and consultant	Moderate`
Vegetation responses to varying water levels	Investigate whether there are significant differences in the species and abundance of aquatic and semi-aquatic plants when the lake is filled compared to partially filled	CMA and consultant	Moderate
Current status of freshwater turtle populations at Lake Yando	Investigate whether there is a turtle population at Lake Yando and whether it is sustainable	CMA or research body on behalf of CMA	Low
Risks			
Groundwater behaviour	Long term monitoring of groundwater levels and salinity for bores within the Lake Yando area and the regional aquifer. Install additional bores as required.	CMA and consultant	Moderate
Seedbank viability of species not currently present	Comparison of species present during watering compared to EVC benchmarks; Comparison of dry-phase vegetation against EVC benchmarks.	CMA and consultant	Moderate

12. References

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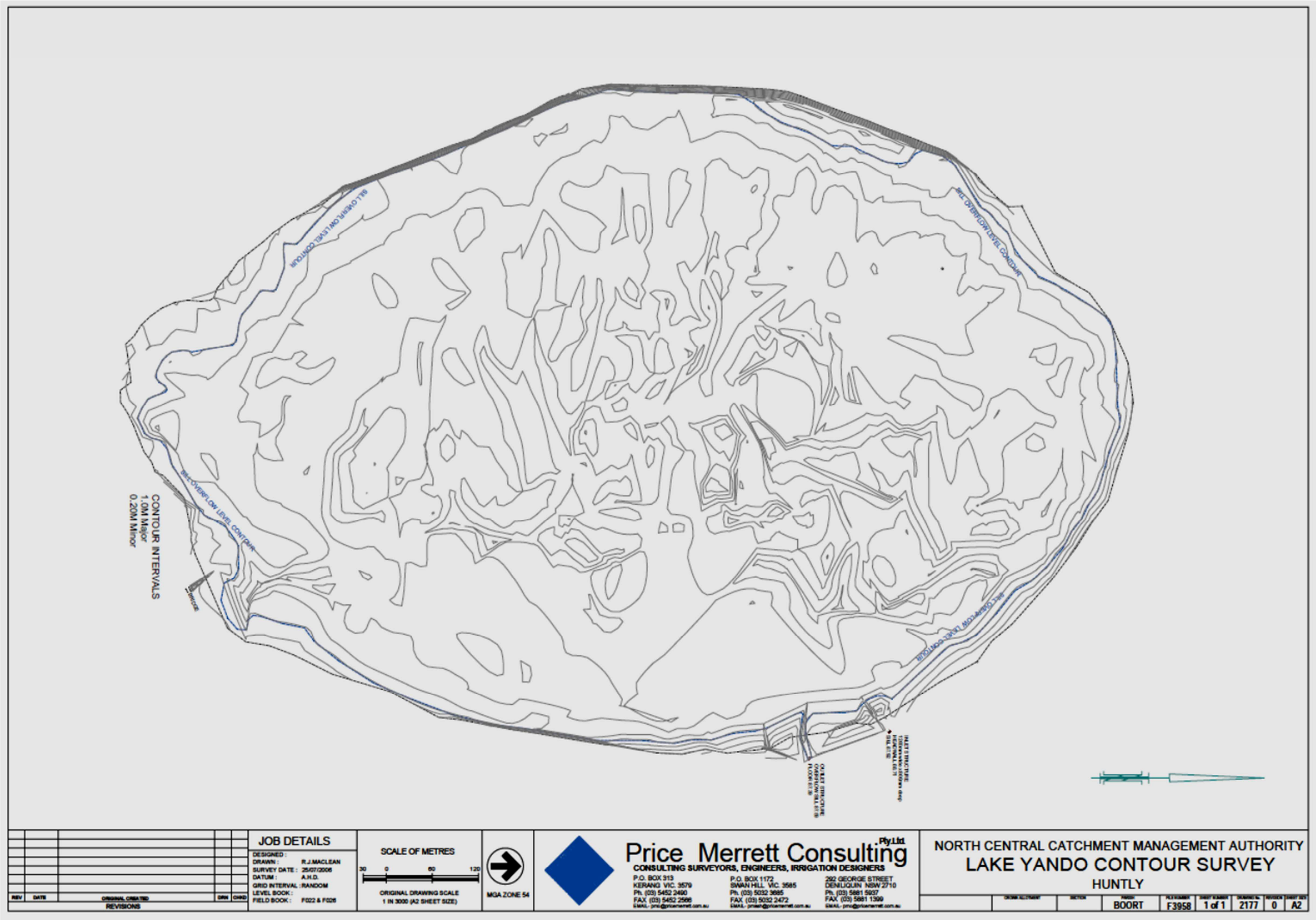
13. Abbreviations and acronyms

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
CMA	Catchment Management Authority
DELWP	Victorian Department of Environment, Land, Water and Planning
DEPI	Victorian Department of Environment and Primary Industries
DPI	Victorian Department of Primary Industries
DSE	Victorian Department of Sustainability and Environment (Now DELWP)
EPBC	Environment Protection and Biodiversity Conservation Act 1999 (Cth)
EVC	Ecological Vegetation Class
EWMP	Environmental Water Management Plan
FFG	Flora and Fauna Guarantee Act 1988 (Vic)
FSL	Full supply level
GIS	Geographical Information System
GL	Gigalitre (1,000 Megalitres)
GMW	Goulburn Murray Water
GMWCP	Goulburn Murray Water Connections Project
HRWS	High Reliability Water Share
JAMBA	Japan-Australia Migratory Bird Agreement
LRWS	Low Reliability Water Share
MEWAG	Central Murray Wetlands Environmental Water Advisory Group
MDBA	Murray-Darling Basin Authority (formerly Murray-Darling Basin Commission, MDBC)
ML	Megalitre (one million litres)
ML/d	Megalitres per day
NCWS	North Central Waterway Strategy
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement
RCS	Regional Catchment Strategy
VEWH	Victorian Environmental Water Holder
VWMS	Victorian Waterway Management Strategy

Appendix 1. Contour Map and Capacity Table



LAKE YANDO

RATING CURVE TABLE

ELEVATION AHD	SURFACE AREA (Ha)	VOLUME STORED (MEGALITRES)	
86.40	0.420	0.24	
86.50	1.072	0.96	
86.60	2.208	2.54	
86.70	4.353	5.69	
86.80	8.442	11.93	
86.90	17.271	24.18	HIGH WATER MARK ON GUAGE
87.00	32.163	48.45	
87.10	51.590	90.44	
87.20	62.501	148.39	
87.30	67.995	213.63	
87.40	72.880	284.20	
87.50	75.755	358.60	
87.59	77.595	427.65	OUTFALL SILL ELEVATION
87.60	77.725	435.41	

Note - volumes are cumulative volumes

Appendix 2. Legislative Framework

International agreements and conventions

Ramsar Convention on Wetlands (Ramsar)

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

World Heritage Sites

Heritage includes places, values, traditions, events and experiences that capture where we've come from, where we are now and gives context to where we are headed as a community. The World Heritage Convention aims to promote cooperation among nations to protect heritage from around the world that is of such outstanding universal value that its conservation is important for current and future generations. It is intended that, unlike the seven wonders of the ancient world, properties on the World Heritage List will be conserved for all time (DEWHA ~2008a).

East Asian-Australasian Flyway Sites

Australia provides critical non-breeding habitat for millions of migratory waterbirds each year. Migratory waterbirds include species such as plovers, sandpipers, stints and curlews. The corridor through which these waterbirds migrate is known as the East Asian-Australasian Flyway.

To ensure their conservation, the Australian Government has fostered international cooperation through the recently launched East Asian-Australasian Flyway Partnership. Under the Flyway Partnership, the site network for shorebirds has been combined into a single network, referred to as the East Asian–Australasian Flyway Site Network.

Bilateral migratory bird agreements

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

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

These agreements require that the parties protect migratory birds by:

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

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

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

Commonwealth legislation

Environment Protection and Biodiversity Conservation Act 1999 (EPBC)

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

Water Act 2007 (Commonwealth Water Act)

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

Aboriginal and Torres 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.

Nationally Important Wetlands

Victoria has a number of waterways of National importance as described in A Directory of Important Wetlands in Australia (Environment Australia, 2001).

There are 159 wetlands in Victoria listed in the Directory.

Living Murray Icon Sites

The Living Murray was established in 2002 in response to evidence that the health of the River Murray system is in decline. The Living Murray's first stage focuses on improving the environment at six 'icon sites' along the River:

- Barmah-Millewa Forest;
- Gunbower-Koondrook-Perricoota Forest;
- Hattah Lakes;
- Chowilla Floodplain and Lindsay-Wallpolla Islands;
- Lower Lakes, Coorong and Murray Mouth; and
- River Murray Channel.

The sites were chosen for their high ecological value—most are listed as internationally significant wetlands under the Ramsar convention—and also their cultural significance to Indigenous people and the broader community (MDBC, 2006).

HEVAE

Through National Water Initiative (NWI) commitments, a toolkit for identifying high ecological value aquatic ecosystems (HEVAE) has been developed so that national consistency may be applied. Five core criteria are used to develop HEVAE sites across a range of scales and ecosystems:

- Diversity
- Distinctiveness
- Vital habitat
- Naturalness
- Representativeness.

The HEVAE toolkit is saved at http://www.environment.gov.au/resource/aquatic-ecosystems-toolkit-module-3-guidelines-identifying-high-ecological-value-aquatic

National Heritage Sites

The National Heritage List has been established to list places of outstanding heritage significance to Australia. It includes natural, historic and Indigenous places that are of outstanding national heritage value to the Australian nation (DEWHA ~2008).

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 3. Community Interaction/Engagement

Community Engagement purpose

An important component of the EWPs involves identifying the goal, underlying environmental objectives and wetland type for each of the wetlands being assessed for the NVIRP. This requires an understanding of physical attributes, the history and the main biological processes associated with each of the wetlands.

In many cases, adjoining landholders have had a long association with a wetland and have developed a good understanding that is useful to include in the development of the EWPs. This is particularly important if only limited monitoring records exist.

Method

A targeted community/agency engagement process was developed for the first round of EWPs developed in early 2009. A list of people with a good technical understanding of each wetland was developed by the technical working group (DPI, DSE and North Central CMA representatives).

This list included key adjoining landholders that have had a long association with the wetland and proven interest in maintaining its environmental value. A minimum of 2 landholders were invited to provide input for each wetland.

Other community and agency people that can provide useful technical and historic information include G-MW water bailiffs, duck hunters (Field & Game Association), bird observers and field naturalists. These people often possess valuable information across several of the wetlands currently being studied.

The method of obtaining information was informal and occurred at the wetland (e.g. oral histories, interviews). The information has been captured in brief dot point form and only technical information and observations are to be noted that will add value to the development of the EWP.

A list of participants has been recorded however all the comments have been combined for each of the wetlands so individual comments are not referenced back to individuals.

List of community and agency participants (Lake Yando)

Marg Piccoli (landholder)

Rod Stringer (landholder)

Lawrence Cameron (G-MW and former landholder)

Paul Haw (community member)

Note: the results below document the comments received from the community members approached as part of the community engagement process. However, if new information comes to light this can be amended and redistributed accordingly.

Information provided to the community

It is important that the people approached for this information have a brief, straight summary of the purpose of the EWPs and type of information that will be useful to include in the planning process. Refer to summary below (adapted from Rob O’Brien, DPI 2009):

We are currently completing a study for NVIRP Northern Victoria Irrigation Renewal Project. It involves completing plans for Lake Leaghur, McDonalds Swamp, Little Lake Meran, Lake Meran, Little Lake Boort, Round Lake and Lake Yando.
As part of this it would be valuable to gather information that is broadly described below with a focus on the water regime and associated wetland values. It's recognised that these wetlands have been altered significantly since European settlement and the expansion of irrigated agriculture.
Providing information on these changes and how these influenced and altered the wetlands is important. It is particularly important to collate information or observations over more recent times, such as the last 30 - 50 years.
What was the original (pre-European settlement) condition of the wetland, including any details of the water regime and values (environmental, cultural)?
What broad changes to the wetlands have occurred, particularly changed water regimes, as agricultural development influenced the floodplains and wetland?
What connection does the wetland have to the floodplain to provide floodwater, or local catchment runoff?
To what extent does the current irrigation supply channel have on the water regime over time?
During more recent times (last 50yrs?) how did the productivity of the wetland vary with the altered water regimes?
Describe the health of the wetland and notable plants and animals (both aquatic/terrestrial) associated with its water management.
Comment on pest plants (boxthorn, willows, cumbungi etc)
What influence has grazing domestic stock had on the reserve, both positive and negative effects?
Given the history and current condition what type of water regime would be needed to achieve the best environmental results for the wetland?
What other management practices could be adopted to improve the environmental value of the wetland?

Comments and feedback from participants for original Lake Yando community and stakeholder engagement for the EWP.

Pre European Settlement Condition

- Seasonal, intermittent Red Gum Swamp.
- Filled and flushed when Loddon River floodwater fanned out across the floodplain.
- The Loddon River floodplain and its wetlands experienced highly variable rainfall and flooding conditions.
- Lake Yando functioned as a deeper section within a complex interconnecting creek system.
- Floodwater overflowed out of the wetland in a northerly direction at different locations and widths, at different flood levels.
- The wetland was not deep and there is no formed lunette on the eastern side.
- The Swamp only held water for several months after a flood event always drying out regularly.
- Lake Yando was well connected to a creek and floodplain system where wide corridors of native vegetation linked provided opportunity for native fauna to move throughout the floodplain area.
- The wetland supported large widely spaced Red Gums across the lake floor.

- The archeological sites present at Lake Yando confirm it was an environmentally productive system that provided food and other resources to Aboriginal People.
- The wetland would have contained a greater diversity of native plants, insects and animals than what is present today

Changed Management

- Lake Yando and the broader floodplain area were impacted dramatically as part of European Settlement.
- Grazing of hard hoofed domestic livestock put significant pressure on the native plants, altered the soil conditions and displaced native fauna.
- The Loddon River Floods were manipulated to suit European settlers and this changed water regime altering the districts waterways and wetlands.
- Heavy grazing of livestock diminished native plant cover and extinction of the more palatable species was likely in the mid 1800's.
- Some of the large Red Gums may have initially died from excessive flooding in the 1860's and onwards. The influence of "Black Fellows Cutting" at Fernihurst was significant in pushing additional floodwater through the Boort wetlands.
- Levees constructed on the floodplain channel the water through the creek lines and waterways and prevented the natural spread or sheet flooding of the area.
- William Haw operated a Saw Mill in the bed of Lake Yando.
- The development of the irrigation supply system resulted in Lake Yando receiving significant channel outfall quantities.
- In the 1960's some people wanted to keep Lake Yando full to maintain the high Ibis numbers while other wanted it to dry out to reduce the salinity impact.
- Lake Yando has remained in good condition, despite excessive flooding due to it being a shallow wetland and still periodically drying out.
- The healthy Red Gums on the eastern side of the wetland have been encouraged by a long history of GMW channel outfalls.
- Channel outfalls have significantly been reduced, particularly over the past 10 to 15 years and are currently insignificant.
- Irrigation tail water flowing off surrounding irrigated farmland and entered the wetland throughout the irrigation system.
- Irrigation tail water runoff into the wetland has completely ceased as irrigation and efficiency have improved.
- GMW has occasionally outfall reasonable quantities of water, to the eastern side of the reserve, as part of draining down the irrigation supply system.
- Saline areas were appearing, particularly on the southeastern side during the wet period (1950's to 1990's).
- Over the past 10 years the water tables beneath Lake Yando have dropped significantly and are currently more than 5 m below the surface.
- Groundwater levels dropped about 3m from 2002 to 2010.
- Stock from the surrounding farmland frequently grazed and damaged the reserve, but minimal grazing occurs now.
- An annual pumping license of 120 ML was issued a long time ago (perhaps1950's?) but rarely ever used.
- In 1996 the sill of the overflow creek was lowered as part of the Boort West of Loddon Salinity Management Plan to slightly reduce its depth and improve the water regime and condition of the wetland.

Environmental Values

- The diversity and environmental values of Lake Yando were much higher before European settlement
- The wetter period after the 1950's resulted in more frequent flooding of the swamp and resulted in increased waterbird usage.
- The environmental condition of the creek lines and wetlands was still very good in the 1950's.
- During the wetter periods of the 1970's and 1980's Ibis roosted in large numbers at the swamp.
- Ibis breed at Lake Yando during the wetter periods when the swamp received more frequent and prolonged flooding.
- The deeper channeled sections along the eastern side of the wetland create variable water depths and increase the diversity of plants and animals that use the area.
- Ducks were the most prolific waterbirds that utilized the wetland.
- Heaps of waterbirds were present across all of the districts wetlands during the flood years of the 1950's.
- Lake Yando water levels were maintained mostly permanent in the 1970's and good numbers of Red Fin were present.
- Carp kills occurred when the wetland dried out after successive flooding.
- Less bird life now, compared to when it received more water.
- Commercial quantities of firewood have been removed from Lake Yando over the past 5 years, reducing its environmental value.
- Increased community interest in environmental protection.
- Another nearby private wetland "Loddon Park Swamp" also supported a good ibis rookery during wetter periods.
- Long extended dry periods will reduce understory species and associated insect activity and diminish the food change.
- Avoid leaving the wetland dry for more than 5 years.

Suggested Future Management

- The land managers Parks rarely visit the reserve.
- The management of Lake Yando needs to be in context of the other environmental features within the area.
- Lake Yando will deteriorate if denied water for long periods.
- The wetland should not be left dry for over 10years.
- Ideal water regime should be around 1 in 3 years although floods may dictate this.
- It is important that the wetland be allowed to dry out frequently.
- Flooding frequency needs to maintain the aquatic plants such as Cumbungi and Phragmites as they are important components of the vegetation.
- Motorbikes currently enter and damage the reserve and these needs to be controlled.
- Firewood removal should be prevented as it threatens the environmental and cultural values of the reserve.

Key Points

- Lake Yando was an intermittent and shallow wetland that received water during a Loddon River flood event.

- In its natural condition it supported large widely spaced Red Gums across the lake bed and a range of aquatics that were adapted to variable climatic conditions.
- The aboriginal cultural sites present at the wetland are evidence that this wetland and connecting waterways were very productive.
- European settlement lead to the overgrazing of domestic livestock and changed water regimes.
- Lake Yando has developed new environmental values over the past 150 years and is still considered significant.
- Channel outfalls have contributed to the water regime and the more recently developed environmental values.
- The wetland is naturally shallow and regularly dries out even during successive floods.
- Extended dry periods of 5 to 10 years, without flooding, will result in loss of environmental values.
- The ideal water regime is 1 in 3 years flooding however this needs to be considered in the wider floodplain context and natural flooding will influence this also.
- There is a need to deter motorbikes, 4WD's and firewood collection to protect the environmental and cultural values of the reserve.

Additional comments, feedback and information from the 2016 EWMP community consultation

- Lake Yando generally speaking is the most valuable natural environment in the region because it is very diverse in both wet and dry phases
- In really dry times filling to the level of the gilgai depressions will help red gums through soil moisture. In general agreement with watering regime
- Has a significant layer of silt that doesn't get flushed because floodwaters generally just flow over it without stirring up the wetland itself
- Weeds are there but not a great concern. Boxthorn is not there and that is one of the common weeds in the area
- Considered to be 'stable' – that is, 'during my lifetime it hasn't changed much'
- 2014 partial fill was a great success
- It has always carried a lot of waterbirds and on occasions large numbers of ibis bred there

Appendix 4. Water quality results (Rakali Ecological Consulting, 2015)

Site	Date	Time	Depth at SW corner (mm)*	pH	Temp (^{0}C)	Ec (µS/cm^3)	Turbidity (NTU)	Comments
LY Q1	09-Dec-14	10.30	DRY					
	02-Mar-15	14.00	DRY					
LY Q2	09-Dec-14	11.15	dry in nw corner, 100mm in SE	6.3	21.7	311	30	Coloured water from decomposing leaf litter
	02-Mar-15		DRY					
	50th Percentile			6.3	21.7	311	30	
LY Q3	09-Dec-14	11.42	10mm in NW and 140mm at SE corner	6.4	21	314	20	
	02-Mar-15		DRY					
	50th Percentile			6.4	21	314	20	
LY Q4	09-Dec-14	17.45	470	7.1	32.1	391	17	
	02-Mar-15		70	8	27.7	584	<10	Water surface and upper water column dominated by a carpet of filamentous algae
	50th Percentile			7.55	29.9	487.5	17	
LY Q5	09-Dec-14	16.40	70	7	31.2	516	12	
	02-Mar-15		DRY					
	50th Percentile			7	31.2	516	12	
LY Q6	10-Dec-14	13.00	760	6.8	25.2	384	17	
	03-Mar-15	1300.00	360	8.8	27	960	400	Lots of algae/zooplankton in water column which increases the turbidity reading.
	50th Percentile			7.8	26.1	672	208.5	
LY Q7	10-Dec-14	12.16	50	7.6	27.3	456	35	Lots of algae/zooplankton in water column which increases the turbidity reading.
	03-Mar-15		dry					
	50th Percentile			7.6	27.3	456	35	

LY Q8	10-Dec-14	13.30	230	7.7	26.8	481	25	Lots of algae/zooplankton in water column which increases the turbidity reading.
	03-Mar-15		DRY					
	50th Percentile			7.7	26.8	481	25	

Appendix 5. Species lists

Species listed in Rakali Ecological Consulting (2015)

Vascular Plants

EPBC	FFG	DSE	Wetland Dependence	Origin	*Scientific Name*	Common Name	ISW	LSW*
							9/12/14	9/12/14
			MF	*	*Abutilon theophrasti*	Chingma Lantern	x	
			D/GD		*Acacia salicina*	Willow Wattle	x	
			MF		*Alternanthera denticulata s.l.*	Lesser Joyweed	x	x
		v	MF		*Ammannia multiflora*	Jerry-jerry	x	
V	X		AM		*Amphibromus fluitans*	Graceful Swamp Wallaby-grass	x	
			AM		*Amphibromus nervosus*	Common Swamp Wallaby-grass	x	
			T		*Anthosachne scabra (glabrous form)*	Common Wheat-grass	x	
			MF	*	*Aster subulatus*	Aster-weed	x	
			T		*Atriplex eardleyae*	Small Saltbush		x
			T		*Atriplex lindleyi subsp. inflata*	Corky Saltbush		x
			MF	*	*Atriplex prostrata*	Hastate Orache	x	
			T		*Atriplex semibaccata*	Berry Saltbush	x	x
			MF		*Atriplex suberecta*	Sprawling Saltbush	x	x
		k	T		*Atriplex vesicaria subsp. macrocystidia*	Bladder Saltbush		x
			T		*Austrostipa scabra subsp. falcata*	Spear Grass		x
			T	*	*Avena barbata*	Bearded Oat	x	x
			T		*Boerhavia dominii*	Tah-vine		x
			T	*	*Bromus diandrus*	Great Brome	x	x
			T	*	*Bromus hordeaceus subsp. hordeaceus*	Soft Brome	x	x
			AM	*	*Callitriche stagnalis*	Common Water-starwort	x	
	X	r	MF		*Callitriche umbonata*	Winged Water-starwort	x	
			AM		*Carex inversa*	Knob Sedge	x	

EPBC	FFG	DSE	Wetland Dependence	Origin	*Scientific Name*	Common Name	ISW	LSW*
			MF		*Centipeda cunninghamii*	Common Sneezeweed	x	
			MF		*Centipeda minima subsp. minima s.s.*	Spreading Sneezeweed	x	
			MF		*Chenopodium glaucum*	Glaucous Goosefoot	x	
			T	*	*Chenopodium murale*	Sowbane	x	x
			AM		*Chenopodium nitrariaceum*	Nitre Goosefoot		x
			T		*Chloris ventricosa*	Plump Windmill-grass	x	
			T	*	*Chondrilla juncea*	Skeleton Weed	x	x
			T	*	*Cirsium vulgare*	Spear Thistle	x	
			T	*	*Conyza bonariensis*	Flaxleaf Fleabane	x	x
			T	*	*Cynodon dactylon var. dactylon*	Couch	x	
			MF/AM		*Cyperus difformis*	Variable Flat-sedge	x	
			AM	*	*Cyperus eragrostis*	Drain Flat-sedge	x	
			AM		*Cyperus gymnocaulos*	Spiny Flat-sedge	x	x
			AM		*Damasonium minus*	Star Fruit	x	
			AM		*Duma florulenta*	Tangled Lignum		x
		r	AM		*Duma horrida subsp. horrida*	Spiny Lignum		x
			MF		*Dysphania pumilio*	Clammy Goosefoot	x	
			MF	*	*Echinochloa crus-galli*	Barnyard Grass	x	
			AM		*Eclipta platyglossa*	Yellow Twin-heads	x	
			T		*Einadia nutans subsp. nutans*	Nodding Saltbush		x
			AM		*Elatine gratioloides*	Waterwort	x	
			AM		*Eleocharis acuta*	Common Spike-sedge	x	
		k	AM		*Eleocharis pallens*	Pale Spike-sedge	x	
			T		*Enchylaena tomentosa var. tomentosa*	Ruby Saltbush		x
			T		*Enteropogon acicularis*	Spider Grass		x
			D		*Epilobium billardierianum subsp. cinereum*	Grey Willow-herb	x	
			AM		*Eragrostis infecunda*	Southern Cane-grass	x	x

EPBC	FFG	DSE	Wetland Dependence	Origin	***Scientific Name***	**Common Name**	**ISW**	**LSW***
		v	AM		*Eragrostis setifolia*	Bristly Love-grass		x
			AM		*Eucalyptus camaldulensis*	River Red-gum	x	
			AM		*Eucalyptus largiflorens*	Black Box	x	x
			MF/D		*Euchiton sphaericus*	Annual Cudweed	x	x
			T		*Euphorbia drummondii*	Flat Spurge	x	
			MF		*Glinus oppositifolius*	Slender Carpet-weed	x	
			MF		*Glycyrrhiza acanthocarpa*	Southern Liquorice	x	
			AM		*Goodenia heteromera*	Spreading Goodenia	x	
			T		*Helichrysum luteoalbum*	Jersey Cudweed	x	x
			MF		*Heliotropium curassavicum*	Smooth Heliotrope	x	
			T	*	*Heliotropium europaeum*	Common Heliotrope		x
			MF	*	*Heliotropium supinum*	Creeping Heliotrope	x	
			MF	*	*Heliotropium supinum*	Creeping Heliotrope		x
			T	*	*Helminthotheca echioides*	Ox-tongue	x	
			T	*	*Hordeum murinum s.l.*	Barley-grass	x	x
			AM	*	*Juncus acutus subsp. acutus*	Spiny Rush		x
			AM		*Juncus aridicola*	Tussock Rush	x	
			AM	*	*Juncus articulatus*	Jointed Rush	x	
			AM		*Juncus flavidus*	Gold Rush	x	
			MF/AM		*Lachnagrostis filiformis s.s*	Common Blown-grass	x	
			T	*	*Lactuca saligna*	Willow-leaf Lettuce	x	
			T	*	*Lactuca serriola*	Prickly Lettuce	x	
			OA		*Landoltia punctata*	Thin Duckweed	x	
			T/AM		*Leiocarpa websteri*	Stalked Plover-daisy	x	
			OA		*Lemna disperma*	Common Duckweed	x	
			D	*	*Leontodon taraxacoides subsp. taraxacoides*	Hairy Hawkbit	x	
			T	*	*Lepidium africanum*	Common Peppercress	x	x

EPBC	FFG	DSE	Wetland Dependence	Origin	*Scientific Name*	Common Name	ISW	LSW*
			MF		*Limosella australis*	Austral Mudwort	x	
			T	*	*Lolium rigidum*	Wimmera Rye-grass	x	
			AM		*Ludwigia peploides subsp. montevidensis*	Clove-strip	x	
			T	*	*Lycium ferocissimum*	African Box-thorn		x
			MF/D		*Lythrum hyssopifolia*	Small Loosestrife	x	
			T		*Maireana brevifolia*	Short-leaf Bluebush		x
			T		*Maireana decalvans*	Black Cotton-bush		x
			MF		*Malva aff. preissiana (pink-flowered inland form)*	Australian Hollyhock	x	
			T	*	*Marrubium vulgare*	Horehound		x
			AM		*Marsilea costulifera*	Narrow-leaf Nardoo	x	
			AM		*Marsilea drummondii*	Common Nardoo	x	x
			AM		*Marsilea hirsuta*	Short-fruit Nardoo	X	
			T	*	*Medicago minima*	Little Medic	x	x
			T	*	*Medicago polymorpha*	Burr Medic	x	
			T	*	*Medicago truncatula*	Barrel Medic	x	x
			T	*	*Melilotus indicus*	Sweet Melilot	x	
			AM/MF		*Mimulus repens*	Creeping Monkey-flower	x	
			AM		*Myriophyllum caput-medusae*	Coarse Water-milfoil	x	
			AM		*Myriophyllum papillosum*	Robust Water-milfoil	x	
			AM		*Myriophyllum verrucosum*	Red Water-milfoil	x	
		r	OA		*Najas tenuifolia*	Water Nymph	x	
			T/D		*Oxalis perennans*	Grassland Wood-sorrel		x
			AM		*Persicaria decipiens*	Slender Knotweed	x	
			MF		*Persicaria hydropiper*	Water Pepper	x	
		k	MF		*Persicaria lapathifolia (floccose form)*	Woolly Knotweed	x	
			MF		*Persicaria lapathifolia (glabrous form)*	Pale Knotweed	x	

EPBC	FFG	DSE	Wetland Dependence	Origin	*Scientific Name*	Common Name	ISW	LSW*
			T/AM	*	*Phalaris aquatica*	Toowoomba Canary-grass	x	x
			AM	*	*Phalaris minor*	Lesser Canary-grass	x	
			AM	*	*Phalaris minor*	Lesser Canary-grass		x
			MF/AM	*	*Phalaris paradoxa*	Paradoxical Canary-grass	x	
			AM		*Phragmites australis*	Common Reed	x	
			AM	*	*Phyla canescens*	Fog-fruit		x
			T	*	*Polygonum aviculare s.l.*	Prostrate Knotweed	x	x
			MF		*Polygonum plebeium*	Small Knotweed	x	
			AM	*	*Polypogon monspeliensis*	Annual Beard-grass	x	
			T		*Portulaca oleracea*	Common Purslane	x	x
			AM		*Potamogeton cheesemanii*	Red Pondweed	x	
			AM		*Potamogeton pectinatus*	Fennel Pondweed	x	
			D		*Ranunculus pumilio var. pumilio*	Ferny Small-flower Buttercup	x	x
			AM	*	*Ranunculus sceleratus subsp. sceleratus*	Celery Buttercup	x	
		v	AM		*Ranunculus undosus*	Swamp Buttercup	x	
			T/MF	*	*Raphanus raphanistrum*	Wild Radish	x	
			T		*Rhagodia spinescens*	Hedge Saltbush	x	
			AM	*	*Rorippa palustris*	Marsh Yellow-cress	x	
			AM	*	*Rumex conglomeratus*	Clustered Dock	x	
			AM	*	*Rumex crispus*	Curled Dock	x	
			AM		*Rumex tenax*	Narrow-leaf Dock	x	
			T		*Rytidosperma caespitosum*	Common Wallaby-grass		x
			T		*Rytidosperma setaceum*	Bristly Wallaby-grass		x
			T		*Salsola tragus subsp. tragus*	Prickly Saltwort		x
		k	T		*Sclerolaena muricata var. semiglabra*	Dark Roly-poly		x
			T	*	*Scorzonera laciniata*	Scorzonera	x	

EPBC	FFG	DSE	Wetland Dependence	Origin	***Scientific Name***	**Common Name**	**ISW**	**LSW***
			T		*Senecio quadridentatus*	Cotton Fireweed	x	x
			AM		*Senecio runcinifolius*	Tall Fireweed	x	
			T		*Sida trichopoda*	Narrow-leaf Sida	x	
			T	*	*Silybum marianum*	Variegated Thistle	x	
			T	*	*Sisymbrium erysimoides*	Smooth Mustard		x
			T	*	*Sisymbrium irio*	London Rocket		x
			T		*Solanum esuriale*	Quena		x
			T	*	*Solanum nigrum s.s.*	Black Nightshade	x	
			T	*	*Sonchus asper s.l.*	Rough Sow-thistle	x	
			T	*	*Sonchus oleraceus*	Common Sow-thistle	x	
			AM		*Stellaria angustifolia*	Swamp Starwort	x	
			GD		*Tecticornia pergranulata subsp. pergranulata*	Blackseed Glasswort	x	
			T	*	*Trifolium fragiferum var. fragiferum*	Strawberry Clover	x	x
			T	*	*Trifolium striatum*	Knotted Clover	x	
			T	*	*Trifolium tomentosum var. tomentosum*	Woolly Clover	x	
		r	MF		*Trigonella suavissima*	Sweet Fenugreek	x	
			AM		*Typha domingensis*	Narrow-leaf Cumbungi	x	
			AM		*Typha orientalis*	Broad-leaf Cumbungi	x	
			OA		*Vallisneria americana var. americana*	Eel Grass	x	
			MF	*	*Verbena supina*	Trailing Verbena	x	
			AM	*	*Veronica anagallis-aquatica*	Blue Water-speedwell	x	
			T		*Vittadinia cuneata var. cuneata*	Fuzzy New Holland Daisy	x	
			T		*Vittadinia gracilis*	Woolly New Holland Daisy		x
			T		*Walwhalleya proluta*	Rigid Panic		#
			OA		*Wolffia australiana*	Tiny Duckweed	x	
			MF	*	*Xanthium spinosum*	Bathurst Burr	x	

EPBC	FFG	DSE	Wetland Dependence	Origin	*Scientific Name*	Common Name	ISW	LSW*
					Total Plant Species		**124**	**56**
					Total Indigenous Plant Species		**75**	**34**
					Total Non-local native plant species		**0**	**0**
					Total Exotic Plant Species		**48**	**22**
					Total number of native wetland plant species		**66**	**13**
					Total number of threatened plant species		**7**	**4**
					Total Native plant species for entire site		**97**	
					Total exotic plant species for entire site		**57**	
					Total Number of Threatened Species		**12**	
					Total Number of Wetland Species		**71**	

* LSW = Lignum Swampy Woodland (EVC 823), ISW= Intermittent Swampy Woodland (EVC 813)

Fauna:

EPBC	FFG	DSE	Wetland Dependence	Origin	Common Name	Scientific Name
					Butterfly	
			TD		Common Brown Butterfly	*Heteronympha merope merope*
			TD	*	Cabbage White	*Pieris rapae*
			TD		Common Grass Blue	*Zizinia otis labradus*
			TD		Saltbush Blue	*Theclinesthes serpentata*
			TD		Greenish Grass-dart	*Ocybadistes walkeri*
					Frogs	
			WS		Eastern Banjo Frog	*Limnodynastes dumerilli*
			WS		Perons Tree Frog	*Litoria peroni*

			WS		Spotted Marsh Frog	*Limnodynastes tasmaniensis*
			WS		Common Froglet	*Crinia signifera*
			WS		Plains Froglet	*Crinia parinsignifera*
					Mammals	
			TD		Swamp Wallaby	*Wallabia bicolor*
			TD		Common Brushtail Possum	*Trichosurus vulpecula*
			TD		Eastern Grey Kangaroo	*Macropus giganteus*
			TD	*	Red Fox	*Vulpes vulpes*
					Reptiles	
			TD		Boulengers Skink	*Morethia boulengeri*
			TD		Tree skink	*Egernia striolata*
		EN	TD		Lace Monitor	*Varanus varius*
		dd	WS		Common Long-necked Turtle	*Chelodina longicollis*
					Total Number of Native Frogs	
					Total Number of Native Butterflies	
					Total Number of Native Mammals	
					Total Number of Native Reptiles	
					Total Number of Introduced Mammals	

Species listed in DELWP (2016b)

Scientific Name	**Common Name**	**Discipline**	**Last Record**
Acrocephalus stentoreus	**Clamorous Reed Warbler**	**Terrestrial fauna**	**1/09/1994**
Anas castanea	**Chestnut Teal**	**Terrestrial fauna**	**28/02/1997**
Anas gracilis	**Grey Teal**	**Terrestrial fauna**	**28/02/1997**
Anas rhynchotis	**Australasian Shoveler**	**Terrestrial fauna**	**28/02/1997**
Anas superciliosa	**Pacific Black Duck**	**Terrestrial fauna**	**28/02/1997**
Ardea modesta	**Eastern Great Egret**	**Terrestrial fauna**	**28/02/1997**
Ardea pacifica	**White-necked Heron**	**Terrestrial fauna**	**28/02/1997**

Aster subulatus	Aster-weed	Flora	19/04/1997
Atriplex prostrata	Hastate Orache	Flora	19/04/1997
Bos taurus	Cattle (feral)	Terrestrial fauna	25/04/1995
Chenonetta jubata	Australian Wood Duck	Terrestrial fauna	28/02/1997
Chenopodium glaucum	Glaucous Goosefoot	Flora	19/04/1997
Cotula spp.	Cotula	Flora	19/04/1997
Cygnus atratus	Black Swan	Terrestrial fauna	28/02/1997
Dittrichia graveolens	Stinkwort	Flora	19/04/1997
Duma florulenta	Tangled Lignum	Flora	19/04/1997
Dysphania pumilio	Clammy Goosefoot	Flora	19/04/1997
Egretta novaehollandiae	White-faced Heron	Terrestrial fauna	28/02/1997
Eleocharis acuta	Common Spike-sedge	Flora	19/04/1997
Elseyornis melanops	Black-fronted Dotterel	Terrestrial fauna	1/09/1994
Eragrostis infecunda	Southern Cane-grass	Flora	19/04/1997
Erythrogonys cinctus	Red-kneed Dotterel	Terrestrial fauna	18/02/1990
Eucalyptus camaldulensis	River Red-gum	Flora	19/04/1997
Eucalyptus largiflorens	Black Box	Flora	19/04/1997
Fulica atra	Eurasian Coot	Terrestrial fauna	28/02/1997
Gallinula tenebrosa	Dusky Moorhen	Terrestrial fauna	28/02/1997
Gallinula ventralis	Black-tailed Native-hen	Terrestrial fauna	1/09/1994
Heliotropium curassavicum	Smooth Heliotrope	Flora	19/04/1997
Heliotropium europaeum	Common Heliotrope	Flora	19/04/1997
Himantopus himantopus	Black-winged Stilt	Terrestrial fauna	18/02/1990
Lactuca saligna	Willow-leaf Lettuce	Flora	19/04/1997
Lactuca serriola	Prickly Lettuce	Flora	19/04/1997
Lobelia concolor	Poison Pratia	Flora	19/04/1997
Medicago polymorpha	Burr Medic	Flora	19/04/1997
Microcarbo melanoleucos	Little Pied Cormorant	Terrestrial fauna	28/02/1997
Myriophyllum verrucosum	Red Water-milfoil	Flora	19/04/1997
Nettapus coromandelianus	Cotton Pygmy-goose	Terrestrial fauna	26/07/1990

Paspalum distichum	Water Couch	Flora	19/04/1997
Phalacrocorax carbo	Great Cormorant	Terrestrial fauna	28/02/1997
Phalacrocorax sulcirostris	Little Black Cormorant	Terrestrial fauna	28/02/1997
Platalea flavipes	Yellow-billed Spoonbill	Terrestrial fauna	28/02/1997
Platalea regia	Royal Spoonbill	Terrestrial fauna	18/02/1990
Poliocephalus poliocephalus	Hoary-headed Grebe	Terrestrial fauna	18/02/1990
Polygonum aviculare s.l.	Prostrate Knotweed	Flora	19/04/1997
Polypogon monspeliensis	Annual Beard-grass	Flora	19/04/1997
Porphyrio porphyrio	Purple Swamphen	Terrestrial fauna	28/02/1997
Rumex conglomeratus	Clustered Dock	Flora	19/04/1997
Rumex crispus	Curled Dock	Flora	19/04/1997
Sonchus asper s.l.	Rough Sow-thistle	Flora	19/04/1997
Sonchus oleraceus	Common Sow-thistle	Flora	19/04/1997
Suaeda baccifera	Berry Seablite	Flora	19/04/1997
Tachybaptus novaehollandiae	Australasian Grebe	Terrestrial fauna	1/09/1994
Tadorna tadornoides	Australian Shelduck	Terrestrial fauna	1/09/1994
Threskiornis molucca	Australian White Ibis	Terrestrial fauna	28/02/1997
Threskiornis spinicollis	Straw-necked Ibis	Terrestrial fauna	28/02/1997
Vanellus miles	Masked Lapwing	Terrestrial fauna	1/09/1994