Wirra-Lo Wetland Complex

Environmental Water Management Plan

Connecting Rivers, Landscapes, People

NORTH CENTRAL
Catchment Management Authority
Connecting Rivers, Landscapes, People

Department of Environment,
Land, Water & Planning

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Front cover photo: Top Left: Red Gum Swamp – Musk Duck nest - Source; K. Hooper; Top Right: Aquatic vegetation Duck Creek North – Source: J. Hooper Middle Right: Aquatic vegetation – Growling Grass Frog habitat Source: J. Hooper Bottom: Panarama Lignum Swamp waterbirds Source K. Hooper.

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EXECUTIVE SUMMARY

The *Wirra-Lo Wetland Complex Environmental Water Management Plan 2015* sets out the long-term water management goal and the objectives to achieve the goal for priority environmental values of Wirra-Lo Wetland Complex. The EWMP is an important part of the Victorian Environmental Water Planning Framework. It provides the ten year management intentions, based on scientific information and stakeholder consultation, that 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 the Wirra-Lo Wetland Complex can support key environmental values and can provide broader social value as a site for public education. Actions such as floodplain connectivity investigations 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 Wirra-Lo Wetland Complex EWMP. A summary of the main conclusions to facilitate appropriate environmental water management into the future are summarised below.

Catchment setting

The Wirra-Lo Wetland Complex is located on the Murrabit West floodplain, one kilometre north of the junction of Barr Creek and the Loddon River in the Loddon River Basin. The wetland complex covers 66 hectares comprising a series of swamps, historic creek beds, depressions and associated margins located on 150 hectares of covenanted private land.

Hydrology and system operations

Prior to European settlement the wetland complex, being so close to the junction of three major waterways (Barr Creek, Loddon River and Murray River), would have been inundated regularly.

Since European settlement the floodplain has been intensively developed for irrigation and levee banks, roads and irrigation channels dissect the natural flow paths throughout the catchment. Prior to the drought the wetlands were maintained by winter rainfall runoff and irrigation tail-water from irrigated pasture adjacent to the wetlands. This resulted in a water regime where the wetlands were mostly wet in winter, topped up in spring and would dry out in summer. Over time, as irrigation practices improved on surrounding land, runoff and tail-water entering the wetlands was significantly reduced, and the landholder used irrigation water to maintain them. At the peak of the Millennium Drought when irrigation allocations were significantly reduced the landholder ceased watering the wetlands. In 2011, the wetland complex was flooded when floodwater in the Loddon River breached the levee bank.

Land use changes on the Murrabit West floodplain under two separate government programs have resulted in the land surrounding the property being removed from irrigation and the eventual decommissioning of irrigation water delivery infrastructure. The sale of the irrigation water entitlement and surrender of the associated water use licence on the property associated with these changes. Given the catchment will continue to be disconnected from natural flooding, these changes mean that, other than environmental water, the wetland complex no longer has a reliable source of water. A partial watering of the wetlands in the Wirra-Lo Wetland Complex occurred in May 2015.

Water dependent values

The Wirra-Lo Wetland Complex will be managed to support the nationally threatened Growling Grass Grog (*Litoria raniformis*), listed as vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999*, that was once prolific across the Barr Creek/Lower Loddon

floodplain. The wetland complex also supports River Red Gum (*Eucalyptus camaldulensis*) woodland and aquatic vegetation communities that provide habitat for a high diversity of waterbirds.

Ecological condition and threats

The current condition of the Wirra-Lo Wetland Complex is reflective of the dramatic change in water regime since it stopped receiving water during the Millennium Drought. The complex received water during the 2011 floods but has not had water since. Growling Grass Frog was once commonly heard at the wetland complex, as well as throughout the Barr Creek/Lower Loddon floodplain. The meta-population of this species has significantly declined in the last decade.

Management objectives

A long-term management goal has been defined for Wirra-Lo Wetland Complex:

Wirra-Lo Wetland Complex water management goal

To provide vital habitat including the provision of refuge and suitable breeding conditions for Growling Grass Frog (*Litoria raniformis*) and to provide high quality feeding and breeding habitat for a large diversity of waterbirds by rehabilitating the River Red Gum (*Eucalyptus camldulensis*) and aquatic vegetation communities.

The ecological objectives and water regime that sit under the long-term management goal for Wirra-Lo Wetland Complex were informed by environmental values at the site and the hydrological requirements of those values. These were scientifically peer reviewed by Butcher et al. (2015).

Managing risks to achieving objectives

The threats to achieving the ecological objectives that are external to environmental water have been identified in this EWMP. These include introduced species i.e. exotic fish, foxes and invasive plants.

Environmental water delivery infrastructure

The current connection to the Wirra-Lo Wetland Complex is the Torrumbarry Irrigation System Channel No. 4. This channel is likely to be partially decommisioned for irrigation purposes. North Central CMA and Goulburn Murray Water Connections Project (GMW CP) are collaboratively investigating water delivery infrastructure options for long term delivery to the wetland complex.

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 the implementation of the Wirra-Lo Wetland Complex EWMP. The Wirra-Lo Wetland Complex EWMP recommends a suite of intervention and long-term monitoring activities that will meet the monitoring requirements.

Consultation

Key stakeholders, including DELWP, VEWH, and Goulburn Murray Water (GMW) have been engaged during the development of this EWMP.

Knowledge gaps

The management actions in the Wirra-Lo Wetland Complex EWMP are based on the best available information. A number of knowledge gaps have been identified during the development of the EWMP, particularly around the status of the Growling Grass Frog meta-population on the Murrabit West Floodplain and its return to the wetlands in response to rehabilitation of aquatic vegetation communities.

ACKNOWLEDGEMENTS

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.

Contributions to the Wirra-Lo Wetland Complex EWMP

The information contained in the Wirra-Lo Wetland Complex 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:

- Suzanne Witteveen, Susan Watson and Paulo Lay of Department of Environment, Land, Water and Planning
- Beth Ashworth, Erin Ashcroft and Chloe Wiesenfeld of Victorian Environmental Water Holder
- Peter Egglestone, Ben Appleby and Khane Mason of Goulburn Murray Water
- Rhonda Butcher, Peter Cottingham, Doug Frood, Mark Hocking and Geoff Vietz (Scientific Review Panel)
- Emer Campbell, Michelle Maher, Bree Bisset, Camille White, Phil Dyson, Rebecca Horsburgh and Peter McRostie of North Central CMA

A very special thank you to Ken and Jill Hooper for their passion and ongoing commitment to the biodiversity values of the Wirra-Lo Wetland Complex.

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1. Introduction

Management of environmental water is planned and implemented through the framework detailed in a number of key documents. Figure 1 illustrates the strategies, scientific reports and operational documents required for environmental water management in Victoria (VEWH 2012). The North Central Catchment Management Authority (CMA) has recently developed *the North Central Waterway Strategy (NCWS) 2014-2022* which is an integrated strategy for managing and improving the region's waterways (rivers, streams and wetlands) (North Central CMA 2014). The NCWS is guided by the *Victorian Waterway Management Strategy* 2013 (VWMS) and the *North Central Regional Catchment Strategy* 2013 (RCS). Wirra-Lo Wetland Complex is a wetland on private land, so does not have a specific long-term resource condition target outlined in the NCWS, however the both the RCS and the NCWS identify that co-investment in natural assets on private land are critical to support nationally threatened species.

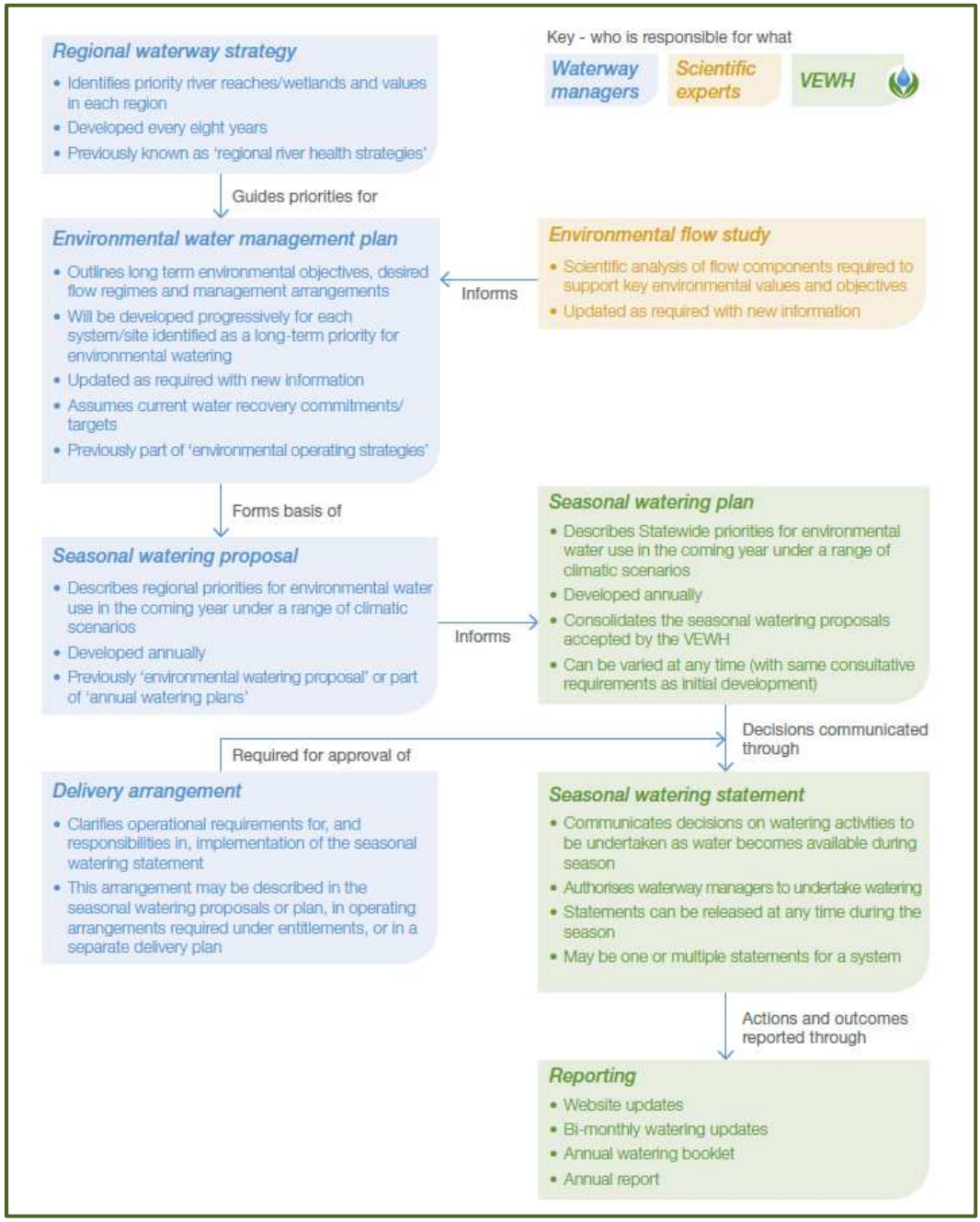

Figure 1: Planning framework for decisions about environmental water management in Victoria.

1.1. Purpose

The Wirra-Lo Wetland Complex EWMP is a ten year management plan that describes the ecological values present, the long-term goal, priority ecological objectives and required watering regimes for wetlands within the complex and the wetland complex as a whole. It is based on both scientific information and input from the landholders and will be used by the North Central CMA when making annual environmental watering decisions, as well as 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 this EWMP are to:

- identify the long-term objectives and water requirements for the wetland complex;
- inform the development of future SWPs and seasonal watering plans; and
- inform Long-term Watering Plans that will be developed by the State under the Basin Plan Chapter 8 (DEPI 2014a).

The scope of this EWMP is the complex of wetlands that are located at Vistarini Road, Murrabit West, with the exception of Cattleyard Creek. Watering of this wetland is not yet possible due to the likelihood of flooding adjacent private land.

1.2. Development Process

The Wirra-Lo Wetland Complex EWMP has been developed in collaboration with key stakeholders including the landholder, Goulburn Murray Water (GMW), DELWP and the VEWH. A number of tasks were undertaken to develop the EWMP as detailed below:

Scoping and collating information: Wirra-Lo Wetland Complex has been the subject of a number of technical assessments and scientific analysis. The history of this work is shown in Table 1.

Table 1: History of technical work undertaken for Wirra-Lo Wetland Complex

Name	Author	Date	Summary
Wetland Management Strategy – Hooper's Wetlands Murrabit West	DNRE – K. Long	2000	The report identifies and assesses the key environmental and cultural values at the Wirra-o Wetland Complex and provides water regime recommendations.
Vegetation and bird survey	N. McFarlane and T. Lowe	2004	A flora list and vegetation condition assessment undertaken to support application for a Trust for Nature Covenant of the property. As part of the process a bird list was also compiled.
MD Basin Plan EWMP Program	North Central CMA	2014	Scoping report reviewed 17 sites that are known to have high environmental values and where there is the potential to deliver environmental water. The North Central CMA recommended that an EWMP be prepared for Wirra-Lo Wetland Complex.
Assessment of infrastructure to deliver environmental water	Northern Land Solutions	2014	The report documents the capacities of each of the wetlands, assesses the capacity of the on farm channels and pipes to deliver environmental water and recommends structures to connect each wetland to on farm channels.

Name	Author	Date	Summary
Vegetation survey, mapping and analysis of Wirra-Lo Wetland Complex	Rakali Ecological Consulting	2014	Identifies, describes and maps EVC, composition, condition and extent of the vegetation. Undertakes ecological condition (IWC) assessments and provide advice on water quality and wet/ dry tolerances of the vegetation present.
Hydrogeological assessment of Wirra-Lo Wetland Complex	North Central CMA	2015	The report summarises the surface and groundwater interactions at Wirra-Lo Wetland Complex and discusses risks of salinisation.
Scientific review of ecological objectives and environmental watering requirements for Lake Wandella, Tang Tang Swamp and Wirra-Lo Wetland Complex	Butcher et al	2015	Scientific peer review of ecological objectives and water regime proposed for Wirra-Lo Wetland Complex

Expert workshop: a scientific team was engaged to review the draft ecological and water regimes proposed for Wirra-Lo Wetland Complex. Outcomes from the Wirra-Lo Wetland Complex site visit and workshop are documented in Butcher et al. (2015) and documented in Appendix 6.

Environmental Technical Advisory Group (ETAC): The ETAC provides advice to the GMW Connections Project and its membership comprises GMW Connections Project, DELWP, Parks Victoria, North Central CMA and Goulburn Broken CMA Wirra-Lo Wetland Complex was added by ETAC to the environmental asset register (a register of assets with irrigation infrastructure connections) in November 2012 and commitment to retain a connection to Wirra-Lo Wetland Complex was discussed by key stakeholders.

Workshop with GMW Connections Project, DELWP and VEWH: A workshop was held to discuss connection options as well as long-term ownership and maintenance of the current infrastructure was discussed at a workshop in February 2015. Additional work will be required to finalise the long-term connection to the wetlands.

The outputs of these tasks were analysed to provide justification and evidence for the following sections of the EWMP:

Water dependent values: environmental values were derived various sources identified during the scoping phase. Terrestrial species that, due to large-scale clearing of woodland habitat throughout the catchment, are dependent on the vegetation surrounding the wetlands are also documented. Social values (cultural heritage, recreation and economic) are further described.

Ecological condition, condition trajectory and threats: Available information, including IWC assessments, was used to describe the current condition and water related threats to Wirra-Lo Wetland Complex. 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 Wirra-Lo Wetland Complex are based on the water dependent values recorded for the wetland, the current condition and the condition trajectory. The objectives are also aligned with the broader environmental outcomes proposed in the Basin Plan Environmental Watering Strategy.

Managing risks: the risks to achieving the ecological objectives for Wirra-Lo Wetland Complex are based on community concerns and best-available scientific knowledge. Management actions to mitigate each risk have been recommended and residual risk (assuming full adoption of management action) identified.

Environmental water delivery infrastructure: Current constraints to delivery of environmental water are identified as well as recommendations to allow future environmental water delivery.

Demonstrating outcomes: monitoring to adaptively manage the delivery of environmental water and to demonstrate the outcomes against the ecological objectives are based on best available science monitoring method. Justification for a suite of long term and intervention monitoring recommendations are given.

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 as well as a priority ranking is given for each knowledge gap.

2. Site overview

2.1. Site location

The Wirra-lo Wetland Complex is a 66 hectare series of swamps, creeks, depressions and associated margins located on 150 hectares of private land about one kilometre north-east of the junction of Barr Creek and the Loddon River and approximately 25 kilometres north of the township of Kerang (Figure 2) (Long 2000).

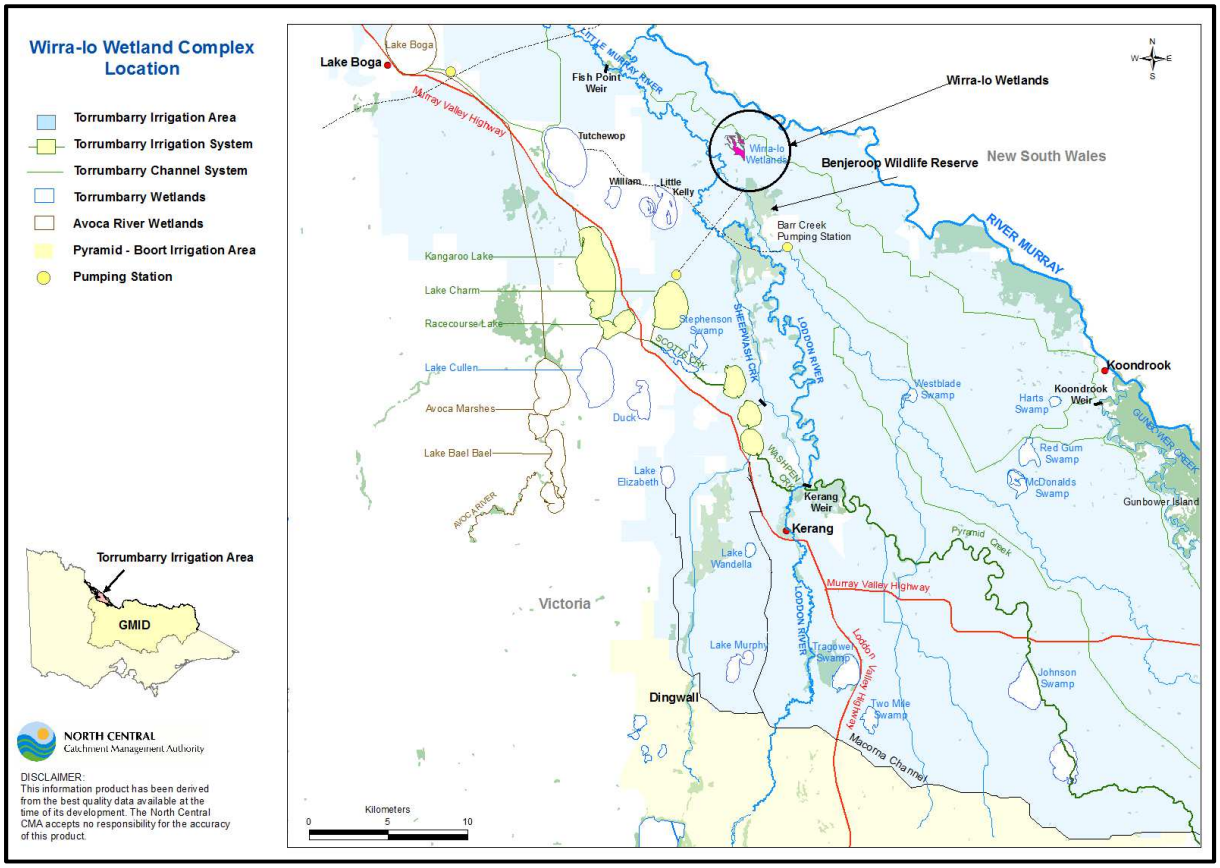

Figure 2: Location of Wirra-Lo Wetland Complex

2.2. Catchment setting

Climate

Climate data was obtained for the closest meteorological station, Kerang Station 080023, from the Bureau of Meteorology (BOM). Median rainfall in Kerang is 368 mm/year, with May to October (median of 32.08 mm/month) significantly wetter than November to April (average of 17.45 mm/month). Average temperature ranges from 31.6°C maximum in January to 4°C minimum in July at, with an average of five days a year when the temperature drops below zero degrees (BOM 2015).

Hydro-physical characteristics

The Wirra-lo Wetland Complex is situated in the Murray Fans Bioregion on the floodplain between Barr Creek, near its junction with the Loddon River, and the Murray River (Figure 2). The Murray Fans bioregion is characterised by a flat to gently undulating landscape on recent unconsolidated sediments with evidence of former stream channels, braided old river meanders and palaeochannels and broad floodplain areas associated with major river systems and prior steams (known as braided/anastomosing streams). As such, the floodplain comprises a series of tributaries and effluent streams with very change in elevation (Camp Scott Furphy 1985; SKM 2005).

Prior to development the wetlands within the complex would have been hydrologically connected, however, due to development of the property for irrigation, the wetland complex is divided into discrete wetland areas by infrastructure such as on farm channels and roads (Figure 3). These areas are named as:

- Duck Creek North (3.0 ha) and South (13.5 ha)
- Red Gum Swamp and Emu Creek (9.5 ha)
- Lignum Swamp (39.0 ha)
- Cattleyard Creek (1.5 ha)

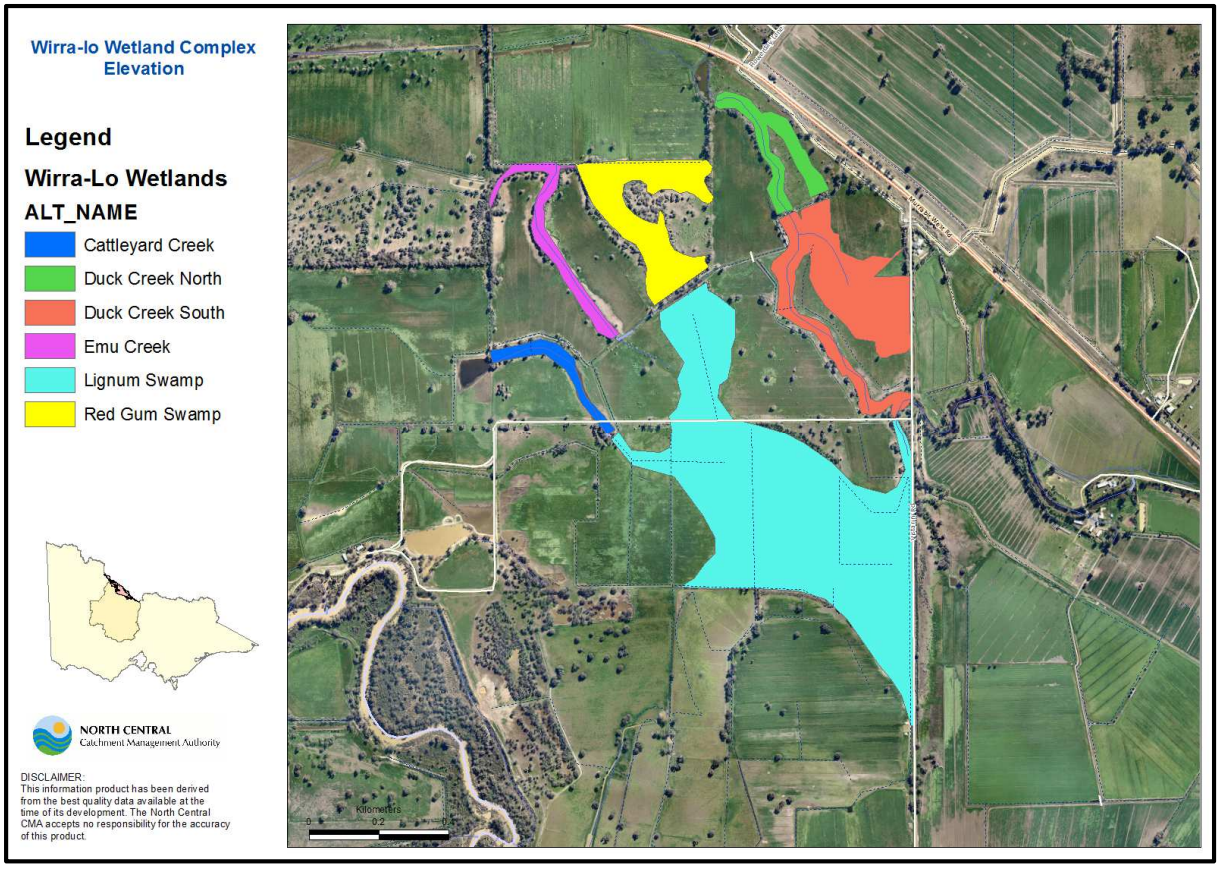

Figure 3: Wetlands within the Wirra-Lo Wetland Complex

Duck Creek North and South were the original flow path of an effluent stream from the Barr Creek. As such these wetlands are the long narrow historic creek bed that has depths averaging about 0.7 metres and a maximum depth of 1.5 metres (NLS 2014). The historic creek beds both have low lying shallow floodplain depressions to their east with an average depth between 0.3 to 0.5 metres. Duck Creek North is 2.56 hectares and Duck Creek South covers an area of 4.03 hectares.

Red Gum Swamp is located in the north central area of the property. This wetland is hydrologically connected to Emu Creek to the west through an excavated drain along the northern boundary of the property. Red Gum Swamp generally has a shallower and wider channel to Duck Creek with an average depth 0.5 metres. Prior to development this wetland would have been connected to the area named Lignum Swamp to the south. Emu Creek is similar in shape to Duck Creek although much shallower with an average depth of 0.3 to 0.4 metres. The combined area of Red Gum Swamp and Emu Creek is 9.57 hectares.

Lignum Swamp is divided into two sections by a private road (Figure 3) however hydrological connection occurs via a pipe culvert. This 40 hectares wetland is a shallow depression up to 600 metres wide with average depth of around 0.2 to 0.3 metres.

Similar to Duck Creek and Emu Creek, Cattleyard Creek is an historic creek-like drainage line. Its average depth is around 0.4 metres and it has an area of 1.5 hectares. This wetland is not currently confined within the property boundaries (Figure 3).

Wetland bathymetry is shown in Appendix 2.

Land use

The catchment surrounding Wirra-Lo Wetland Complex is undergoing significant land-use change. The catchment is part of the Torrumbarry Irrigation Area (TIA) and prior to the 2011 floods it was intensively irrigated. In response to the extensive flooding, the Victorian Government established the Lower Loddon Irrigators Recovery Package. This program comprised a voluntary land buyback and incentive package (funding for ring levees around houses) for flood affected landholders on the Lower Loddon floodplain (Rural Finance 2014). The program was implemented alongside the GMW Connections Project and landholders that participated in the program sold land and any associated water licences. Where this occurred GMW Connections Project will decommission channels, remove delivery infrastructure and negotiate domestic and stock supply to the affected properties (Rural Finance 2014).

2.3. Land status and management

In 2006-07, the property that Wirra-Lo Wetland Complex is situated was placed under a nature conservation covenant under the *Victorian Conservation Trust Act 1972*. The covenant is a permanent, legally-binding agreement placed on the property's title to ensure native plants and wildlife are protected into the future. Environmental water delivery will be managed under the agreements shown in Table 2.

Table 2: Private land management agreements

Agreement type	Purpose	Contractual parties
Deed of Agreement	Outlines the requirements for supply and use of water, land access, warranty, release and indemnity	Private landholder, North Central CMA, VEWH and GMW
Management Agreement	Defines the landholder obligations and commitments (including monitoring) regarding receipt of environmental water to their property	Private landholder and North Central CMA

Environmental water management

There are several agencies directly involved in environmental water management in Victoria. Other agencies, such as public land managers, play an important role in facilitating the delivery of environmental watering outcomes. Table 3 describes the key stakeholders that have involvement in the management of WMP Wetland Complex.

Table 3: Agencies and stakeholder groups with a responsibility or interest in the environmental water management of the Wirra-Lo Wetland Complex

Agency/group	Responsibilities/involvement
Department of Environment, Land, Water and Planning	Manage the water allocation and entitlements framework. Develop state policy on water resource management and waterway management approved 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).
Victorian Environmental Water Holder	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.
Commonwealth Environmental Water Holder	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	Implementation of 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. Integration of Basin wide water resource management
North Central Catchment Authority Waterway Manager	Identify regional priorities for environmental water management in regional Waterway Strategies In consultation with the community assess water regime requirements of priority rivers and wetlands to identify environmental watering needs to meet agreed objectives identify opportunities for, and implement, environmental works to use environmental water more efficiently. Propose annual environmental watering actions to the VEWH and implement the VEWH environmental watering decisions. Provide critical input to management of other types of environmental water (passing flows management, above cap water) report on environmental water management activities undertaken.
Goulburn Murray Water	Water Corporation – Storage Manager and Resource Manager Work with the VEWH and waterway managers in planning for the delivery of environmental water to maximise environmental outcomes Operate water supply infrastructure such as dams and irrigation distribution systems to deliver environmental water Ensure the provision of passing flows and compliance with management of diversion limits in unregulated and groundwater systems
Input and advice into environmental watering	

Agency/group	Responsibilities/involvement
Traditional Owners	The delivery of environmental water is likely to provide other benefits that depend on the condition of our waterways, such as supporting social and cultural values.

2.4. Wetland characteristics

Victoria's wetland classification and inventory was updated in 2013 and replaces the system developed by Corrick and Norman. The updated classification is based on the Australian National Aquatic Ecosystem (ANAE) Classification Framework with data on wetlands and their classification attributes converted into spatial Geographic Information System (GIS) layers. The Framework structure produces 37 wetland categories. The first level of the classification hierarchy distinguishes between naturally-occurring from human-made wetlands. The second level of the classification hierarchy distinguishes between aquatic ecosystem habitats: palustrine, lacustrine and estuarine. The third level of the hierarchy distinguishes between wetland attributes such as water regime, salinity, landscape context, soils and wetland vegetation (DEPI 2014b).

Under Corrick and Norman, Duck Creek, Emu Creek, Red Gum Swamp and part of Lignum Swamp are classified as freshwater meadows (both 1750 and 1994 classification) (DELWP 2015a). The other part of Lignum Swamp (the most southerly basin) and Cattleyard Creek have not been mapped by the State. Each wetland that is mapped under the State wetland mapping is classified as a temporary freshwater swamp (DELWP 2015a). An on ground assessment has further refined the wetland classifications for the wetlands within the complex, and the site supports a variety of wetland types including temporary freshwater meadows, marshes, and swamps (Butcher et al. 2015). An overview of the wetland characteristics is provided in Table 4.

Table 4: Wetland characteristics of Wirra-Lo Wetland Complex

Characteristics	Description					
Name	Duck Creek N	Duck Creek S	Red Gum Swamp	Emu Creek	Lignum Swamp	Cattleyard Creek
Wetland ID (1994)	619657		602667	598669	Not included in State mapping	
Wetland ID (2015)	43224		43214	43210	(part 43214)	Not included in State mapping
Area	3.0 ha	13.5 ha	7.0 ha	2.5 ha	39.0 ha	1.5 ha
Bioregion	Murray-Fans					
Conservation status	Nature Conservation Covenant					
Land status	Private Land					
Land manager	Private landholder					
Surrounding land use	Current land use change process from intensive irrigation to dryland agriculture.					
Water supply	Natural: On the Loddon-Murray Floodplain – natural water source would have been via Duck Creek, Barr Creek, Loddon River, Murray River Current: Torrumbarry Channel No.4 and internal farm channels - Capacity of 15 ML/day.					
1788 wetland category	freshwater meadow				Not included in State mapping	
1994 wetland category and sub-category	freshwater meadow				Not included in State mapping	
2013 Victorian wetland classification (DELWP 2015a)	temporary freshwater swamp				Not included in State mapping	
On ground assessment 2015 (Butcher et al. 2015)	temporary freshwater marsh	temporary freshwater marsh and meadow	temporary freshwater swamp	temporary freshwater swamp	temporary freshwater madown and swamp	N/A
Maximum capacity (Northern Land Solutions [NLS] 2014)	10ML	105ML	56ML		293ML	Not assessed

2.5. Environmental water sources

Environmental water delivery at Wirra-Lo Wetland Complex was initiated in 2014. Three environmental water sources are potentially available for use at Wirra-Lo Wetland Complex, as shown in Table 5 and described below. Water shares for these entitlements are classed by their reliability and there are two types in Victoria:

- High-reliability water shares (HRWS), which is 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 (DEPI 2014c).

It is important to note that water availability will vary from season to season, according to climatic conditions, volumes held in storage and carryover entitlements.

Bulk Entitlement (River Murray Flora and Fauna) Conversion Order 1999

The Victorian River Murray Flora and Fauna Bulk Entitlement provides 27,600 ML HRWS in the Murray System. It is held by the VEWH for the purpose of providing for flora and fauna needs. It has been used in a range of wetlands including Gunbower Forest (Living Murray icon site) and the Kerang Ramsar wetlands. It can also be traded on the water market on an annual basis. The use of this water in the Wirra-Lo Wetland Complex is not guaranteed and is at the discretion of the VEWH (VEWH 2012).

Commonwealth Environmental Water Holder (CEWH)

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. As at 31 October 2014, the Commonwealth environmental water holdings totaled 3,397 ML for the Loddon River catchment. The use of this water for wetlands in the North Central CMA region is not guaranteed and is at the discretion of the CEWH (CEWH 2015).

Temporary water allocation donations

Individuals with water shares can donate water to their local catchment management authority for environmental use. Additionally, money can be donated to non-governmental organisations to buy temporary water for environmental use. While the scale of donated water is generally small relative to other water sources, it can provide a valuable contribution, especially in times of critical needs.

Table 5: Potential environmental water sources for Wirra-Lo Wetland Complex

Water entitlement	Volume	Flexibility of management	Conditions on availability and use	Responsible agency
Bulk Entitlement (River Murray – Flora and Fauna) Conversion Order 1999 (incl. Amendments Orders and Notices 2005, 2006, 2007 and 2009)	29,783 ML 3,993 ML 40,000 ML	HRWS LRWS Unregulated	Entitlement held in Hume and Dartmouth reservoirs, with unused water able to be carried over. For use in the Murray River system, such as: 1. Murray River wetlands 2. Barmah Forest 3. Gunbower Forest 4. Kerang Lakes wetlands 5. Hattah Lakes system 6. Cardross Lakes and other Mallee wetlands systems 7. Lindsay/Walpolla/Mulcra Island systems	VEWH
Commonwealth Environmental Water Holdings – Loddon Catchment	2,870 ML 527 ML	HRWS LRWS	Managed in line with the Murray Darling Basin Plan	CEWH
Temporary water donations	Variable	N/A	Agreement is required with private donator	VEWH/ CMA

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

International treaties, conventions and initiatives:

- Japan Australia Migratory Birds Agreement (JAMBA) 1974 - Two of the species listed under this agreement have been recorded at Wirra-Lo Wetland Complex
- China Australia Migratory Birds Agreement (CAMBA) 1986 - Two of the species listed under this agreement have been recorded at Wirra-Lo Wetland Complex
- Republic of Korea Australia Migratory Birds Agreement (ROKAMBA) 2002 – One of the species listed under this agreement have been recorded at Wirra-Lo Wetland Complex
- Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention) 1979 - No species listed under this convention have been recorded at Wirra-Lo Wetland Complex

Commonwealth legislation and policy:

- *Aboriginal and Torres Strait Islander Heritage Protection Act 1984 (*Part IIA) – Wirra-Lo Wetland Complex is known to support places of cultural significance.
- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) – Two fauna species and two migratory species have been recorded at Wirra-Lo Wetland Complex
- *Water Act 2007* – provides for the protection of ecological values at Wirra-Lo Wetland Complex through appropriate management of Murray-Darling Basin water resources.

Victorian legislation:

- *Aboriginal Heritage Act 2006* – Wirra-Lo Wetland Complex is known to support places of cultural significance.
- *Catchment and Land Protection Act 1994* - governs the management of land surrounding Wirra-Lo Wetland Complex e.g. pest plant and animal control.
- *Water Act 1989* - provides a formal means for the integrated management of water in Victoria.
- *Flora and Fauna Guarantee Act 1988* (FFG Act) - Five fauna species listed and one fauna species nominated under this Act have been recorded at Wirra-Lo Wetland Complex.

Victorian policy and strategies:

- *Victorian threatened flora and fauna species (Victorian advisory lists)* – 15 fauna species and eight flora species on the Victorian advisory lists have been recorded at Wirra-Lo Wetland Complex.
- 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 overarching management objective is to maintain or improve the environmental condition of waterways to support environmental, social, cultural and economic values (DEPI, 2013).

Regional strategies and plans:

- North Central Regional Catchment Strategy (RSC) (North Central CMA 2012) – this strategy (2013-2019) sets regional priorities for the management of natural assets, sets overall direction for investment and coordination of effort by landholders, partner organisations and the wider community. Wirra-Lo Wetland Complex sits to the north of the priority biodiversity RCS asset area labelled Dartagook. Further, protecting threatened flora and fauna such as those recorded at Wirra-Lo Wetland Complex is a priority action in the RCS.
- 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 CMA region. Wirra-Lo Wetland Complex is located about 1.5 kilometres north of Benjeroop Wildlife Reserve, which is a priority asset in the NCWS.

3. Hydrology and system operations

Wetland hydrology is the most important determinant in the establishment and maintenance of wetland types and processes. It affects the chemical and physical aspects of the wetland which in turn affects the types of flora and fauna that the wetland supports (DSE 2005). 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

Prior to European settlement the wetland complex, being so close to the junction of three major waterways (Barr Creek, Loddon River and Murray River floodplain), would have regularly been inundated (informed by flood risk assessment in Camp Scott Furphy 1985; SKM 2005; Rural Finance 2014), and the water regime of the site would have varied between being intermittent and seasonal (Rakali Ecological Consulting 2015). Duck Creek and an unnamed effluent stream would have conveyed floodwaters across the floodplain toward the Loddon or the Murray rivers. Magnitude and duration would have been dependent on flows in the Loddon and in the Murray, which would have impacted the volume of flood water backing up Barr Creek (Camp Scott Furphy 1985). Flood water would have also entered the floodplain from the Murray River itself in high flood events (Camp Scott Furphy 1985; SKM 2005). Duck Creek and the unnamed effluent stream would have spilled out into the wetland areas within the property. Figure 4 shows the elevations of the Lower Loddon Floodplain (and aerial photo showing continuation of drainage lines to the Murray River).

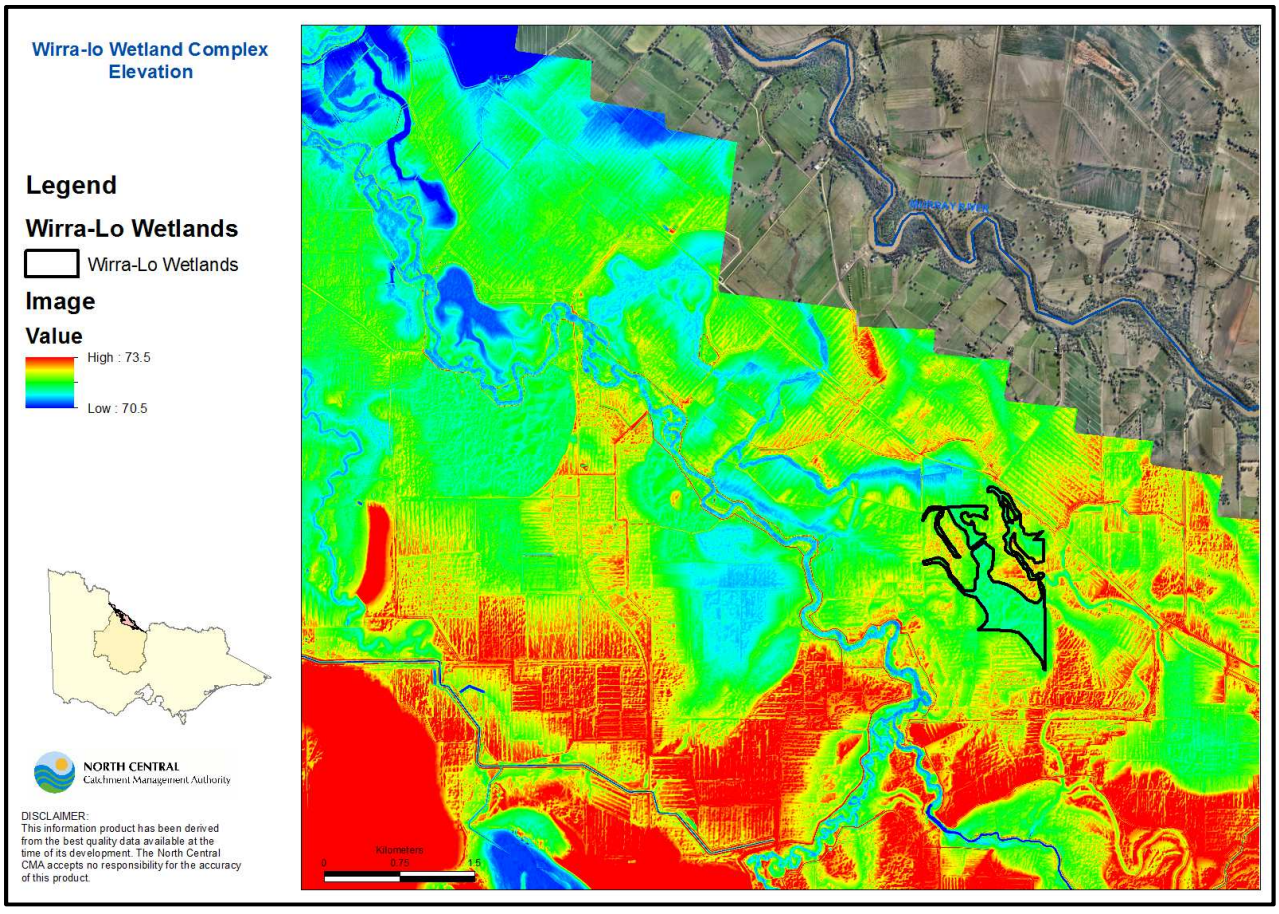

Figure 4: Elevation of Lower Loddon Floodplain showing location of Wirra-Lo Wetland Complex

3.1.2. Post-regulation

The land within the TIA has been significantly modified since European settlement. The floodplain was intensively developed for irrigation and levee banks, roads and irrigation channels dissect the natural flow paths throughout the catchment (Long 2000). Further, artificial levee banks along the Loddon River have disconnected the property from minor to moderate flooding and the wetland complex will now only receive flood water in large (1 in 20-50 year) events (White, C 2013 personal communication [North Central CMA floodplain manager]). As such, the wetland complex is now largely reliant on the provision of water through the irrigation system infrastructure.

Prior to the drought, and irrigation efficiency measures, the wetlands were watered with irrigation tail-water and winter rainfall runoff from wetted up irrigated pasture within the property and from surrounding farms. Over time, as irrigation practices improved on surrounding land, runoff to the wetlands was significantly reduced, and the landholder used irrigation water to maintain the wetlands. Prior to the drought the wetlands were mostly wet in winter, were topped up in spring with irrigation tail-water and would dry out in summer. Over the drought, as water allocations were reduced, the landholder strategically watered wetlands when possible, and priority was given to Duck Creek and Red Gum Swamp. By 2006-07 water allocations were significantly reduced and the wetland complex did not receive water until the extensive flooding that occurred in January 2011. The wetlands have not received large volumes of water since the floods, however, small volumes of irrigation tail-water from adjacent property has runoff to the lower lying areas of the complex (Rakali Ecological Consulting 2015).

3.1.3. Groundwater/surface water interactions

Recent drilling has confirmed the that the wetland sits within a grey silty clay called the Yando Clay extended from the land surface to a depth of 60 metres. At this depth it gave way to the much coarser sediments (sands and gravel) of the Calvil/Renmark formation. These sediments were deposited within the channels of the ancestral river systems at the base of the plain. They form the principal regional aquifer within the Riverine Plains (North Central CMA 2015c).

The Yando Clay, which is a member of the lower Shepparton formation, formed through the deposition of fine-grained alluvium initiated by the drowning of the lower reaches of the ancient ancestral rivers during the most recent marine transgression in late Miocene times. The shoreline occurred to the immediate west of the area (North Central CMA 2015c).

Groundwater monitoring bores (piezometers) have been established to ascertain any salinity risk associated with possible surface water interaction with groundwater following filling of the wetland with environmental water. These were screened within the regional Calivil/Renmark aquifer at a depth of 72 metres, and within the uppermost (watertable) sections of the Yando Clay at a depth of 10 metres. Initial measurements of heads recorded groundwater at depth of three metres within the deep bore and 4.5 and five metres within the two shallow wells. Accordingly, there is an upward pressure gradient that has some potential to recharge the Yando Clay from the deeper aquifer (North Central CMA 2015c).

The extensive thickness of the clay, combined with the low hydraulic conductivity of the fine-grained sediments is most likely to mitigate salinity risk inferred by upward discharge from the underlying Calivil/Renmark beds. It is still possible, however, that filling of the wetland with environmental water may raise the watertable within the immediate area of the wetland. The heavy clay will most likely limit the extent of this issue. Equally the addition of fresh water to sodic soils and sediments may also produce swelling and dispersion that will assist in preventing leakage.

The extent to which filling of the wetland influences local groundwater conditions will be further understood as electronic monitoring of the watertable and deeper groundwater heads proceed following filling and drying of of the wetlands both now and into the future (North Central CMA 2015c; Butcher et al. 2015).

3.1.4. Environmental watering

As discussed in section 3.1.2 the Wirra-Lo Wetland Complex was watered with rainfall run-off (from wetted up irrigation properties) and irrigation tailwater prior to 2006. In Autumn of 2015, the wetlands received 140 ML to partially fill the wetlands with a primary aim of rehabilitating stressed River Red Gum (*Eucalyptus camaldulensis*) trees. Table 6 shows the watering history of the Wirra-Lo Wetland Complex.

Table 6: Watering history of the Wirra-Lo Wetland Complex

Year	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Wetting drying cycle[1]	W	W	W	W	W	W	W	W	W	W	W	D	D	D	D	D	W	W-D	D	W
Water Source[2]	R/T	R/T	R/T	R/T	R/T	R/T	R/T	R/T	R/T	R/T	R/T	-	-	-	-	-	F	-	-	E

1 W - Wet /D- Dry / W-D – Drying
2 E – Environmental Water/ F - Flood Inundation/R – Rainfall runoff/T - Irrigation Tail-water

4. Water dependent values

4.1. Environmental values

4.1.1. Listings

The Wirra-Lo Wetland Complex is ecologically significant due to the high diversity of water dependent flora and fauna it supports. A complete flora and fauna species list is shown in Appendix 1. Many environmental values recorded at the wetland complex are listed under legislation, agreements and conventions detailed in Table 7. The management of the wetland complex falls within three international agreements as well as one national and two state listings.

Table 7: Legislation, agreements, convention and listings relevant to the site, or species recorded at the Wirra-lo Wetland Complex

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. Fauna

The wetland plays an important role within the broader Benjeroop floodplain, providing a variety of habitat types that are capable of supporting a high diversity of, waterbirds, frogs, mammals, reptiles and macroinvertebrates (MacFarlane 2005). Two water dependent EPBC-listed species, three migratory species, six FFG-listed and one FFG nominated species have been recorded at the Wirra-lo Wetland Complex and are shown in Table 8 (Long 2000; MacFarlane 2005; Hooper, K 2012, personal communication [landholder] 13 July; DEPI 2014b; Rakali Ecological Consulting 2015).

The landholders report regular calling of the EPBC-listed Growling Grass Frog (*Litoria raniformis*) during wet phases, adjacent to Duck Creek, up until 2003. Significantly, the landholder does not live on the property and the calls were heard during opportunistic visits (Hooper, K 2012, personal communication [landholder], 13 July). The observations are consistent with research suggesting that a meta-population of Growling Grass Frog has persisted in waterbodies on the floodplain between Murrabit West and Benjeroop (Scrogie & Clemann 2003; Smith et al. 2008a; Clemann et al. 2013). The one and only sighting of the Australasian Bittern (*Botaurus poiciloptilus*) occurred in 1998. Images of the wetland during the 1990s indicate that the wetlands had beds of rushes and reeds, the Australasian Bittern's preferred habitat (Plate 1). These birds are very cryptic well camoflagued bird, so if it is likely that it was present more frequently (Butcher, R. 2015, personal communication [expert wetland ecologist], March).

The wetlands also provide habitat for the FFG-listed and CAMBA/JAMBA migratory species Eastern Great Egret (*Ardea modesta*) that has been observed feeding in the shallower depressions east of Duck Creek. Prior to the drought these depressions had very high concentrations of calling frogs when wet. The FFG-nominated and CAMBA/JAMBA/ROKAMBA listed migratory species Latham's Snipe (*Gallinago hardwickii*) was recorded during a bird survey in 2005 (McFarlane 2005). Australia is the non-breeding grounds for this species from August to late February/ early March each year. It is associated with littoral vegetation such as reeds, sedges and lignum and feeds on vegetation and mudflat macroinvertebrates (Higgins & Davies 1996). A single FFG listed and CAMBA migratory species, the White-bellied Sea-eagle (*Haliaeetus leucogaster*), was observed perching at the wetland

complex in Autumn 2015 (Rogers L 2015 [North Central CMA], 25 May). Wirra-Lo Wetland Complex potentially provides suitable breeding habitat and extension of feeding habitat for the White-bellied Sea-Eagle as it prefers forested margins of waterways (DSE 2003).

Since owning the property in the early 1990s the landholders have observed a high diversity and abundance (in the hundreds to thousands) of waterbirds throughout the different wetland areas (Hooper, K, 2012, personal communication, [landholder] 13 July). The wetland areas also support large numbers of water dependent macro-invertebrates including yabbies, aquatic insects and freshwater mussels (MacFarlane 2005).

Table 8: Significant fauna species recorded at Wirra-lo Wetlands

Common Name	Scientific name	Type	Last record	International agreements	EPBC status	FFG status	Vic status
Growling Grass Frog	*Litoria raniformis*	A	2003	-	VU	L	EN
Australasian Bittern	*Botaurus poiciloptilus*	WB	1998		EN	L	EN
Eastern Great Egret	*Ardea modesta*	WB	2011	C/J		L	VU
White-bellied Sea Eagle	*Haliaeetus leucogaster*	WB	2015	C		L	VU
Latham's Snipe	*Gallinago hardwickii*	WB	2005	C/J/R		N	NT
Australasian Shoveler	*Anas rhynchotis*	WB	2011				VU
Hardhead	*Aythya australis*	WB	2011				VU
Musk Duck	*Biziura lobate*	WB	2011				VU
Nankeen Night Heron	*Nycticorax caledonicus hillii*	WB	2011				NT
Pied Cormorant	*Phalacrocorax varius*	WB	2007				NT

Conservation Status:
Type: Amphibian, Waterbird
International: J/C/R/B: JAMBA/CAMBA/ROKAMBA/ Bonn Convention, N/A: Not Applicable
EPBC status: EN – Endangered, VU – Vulnerable,
FFG status: L – Listed as threatened, N – Nominated to be listed as threatened
Vic status: EN – Endangered, VU – Vulnerable, NT – Near Threatened
Source: Long 2000; McFarlane 2005; Rakali Ecological Consulting 2015, Hooper, K (observations since 1992)

4.1.3. Vegetation communities and flora

Eight ecological vegetation classes (EVC) have been identified at the Wirra-lo Wetland Complex (Rakali Ecological Consulting 2015). The EVCs and their conservation status are shown in Table 9. The distribution of EVCs, as mapped in 2014, is shown Appendix 3.

Table 9: Current EVCs and conservation status (Source: Rakali Ecological Consulting 2015).

EVC No.	EVC	Bioregional Conservation Status
653	Aquatic Herbland	Depleted
813	Intermittent Swampy Woodland	Depleted
107	Lake Bed Herbland	Vulnerable
823	Lignum Swampy Woodland	Vulnerable
103	Riverine Chenopod Woodland	Endangered
295	Riverine Grassy Woodland	Vulnerable
815	Riverine Swampy Woodland	Vulnerable
821	Tall Marsh	Least Concern

The vegetation communities and flora for Wirra-Lo Wetland Complex have been described for each wetland area.

Duck Creek

Duck Creek is characterised by Intermittent Swampy Woodland (EVC 813) located along the banks of the historic creek bed. This EVC is dominated by a River Red Gum canopy, with a scattered shrub layer of Tangled Lignum (*Duma florulenta*) and a diversity of flood tolerant and flood responsive understorey species such as Common Spike sedge (*Eleocharis acuta*), Common Swamp Wallaby-grass (*Amphibromus nervosus*), Common Sneezeweed (*Centipeda cunninghamii*), Common Nardoo (*Marsilea drummondii*), Star Fruit (*Damasonium minus*), Common Blown-grass (*Lachnagrostis filiformis s.l.)* and River Bluebell (*Wahlenbergia fluminalis*) (Rakali Ecological Consulting 2015). Photographs of Duck Creek from the 1990s show that Intermittent Swampy Woodland formed a complex with Aquatic Herbland (EVC 653) and Tall Marsh (EVC 821) when wet (Plate 1 and Plate 2). During the 2014 survey Aquatic Herbland had been replaced by Lake Bed Herbland (EVC107) and Tall Marsh existed as dormant *Typha spp.* rhizomes recorded along the verges of the historic creek bed (Rakali Ecological Consulting 2015).

To the east of Duck Creek Riverine Swampy Woodland (EVC 55) is located at a higher elevation. This EVC has open River Red Gum canopy, including some large old trees, and a groundcover layer dominated by tussock grasses (such as Common Wallaby-grass (*Rytidosperma caespitosum*) in association with wetland herbs and ferns including Poison Pratia (*Lobelia concolor*), Pale Goodenia (*Goodenia glauca*) and Common Nardoo (*Marsilea drummondii*) (Rakali Ecological Consulting 2015).

Red Gum Swamp and Emu Creek

Vegetation communities in the Red Gum Swamp comprise Intermittent Swampy Woodland in the deepest area of the wetland, transitioning to Lignum Swampy Woodland (EVC 823) at higher elevations. Intermittent Swampy Woodland in Red Gum Swamp comprises River Red Gum trees throughout the wetland bed with a Tanged Lignum understory (Plate 3). Lignum Swampy Woodland is characterised by a Tangled Lignum understory and low density overstory of River Red Gum and predominantly Black Box (*Eucalyptus longifolia*). Emu Creek is characterised by Lignum Swampy Woodland with a predominantly Black Box overstory (Rakali Ecological Consulting 2015).

Lignum Swamp

Lignum Swamp has been classified as Intermittent Swampy Woodland. This area has dead large old River Red Gum trees and a number of River Red Gum saplings that recruited after the 2011 floods (Rakali Ecological Consulting 2015). Lignum Swamp has an open to dense Tangled Lignum layer, with Lignum shrubs measuring greater than 2 metres high in some areas (Plate 4). Small farm drains and a small dam that held water or were damp during the 2014 survey were characterised by wet phase Intermittent Swampy Woodland species including Common Spike Sedge, Star Fruit and Common Swamp Wallaby Grass, as well as a high diversity of species associated with Aquatic Herbland, including the rare Winged Water Starwort (*Callitriche umbonata*) (Table 10). Lignum Swamp is bound by Lignum Swampy Woodland.

Surrounding woodlands

The higher elevations fringing the wetlands comprise Riverine Chenopod Woodland (EVC 815) in the center and to the west of the property and Riverine Grassy Woodland (EVC 295) to the north east (Rakali Ecological Consulting 2015). Riverine Chenopod Woodland is characterised by Black Box overstory and has a diverse shrubby-grassy understorey. This EVC supports the rare Spiny Lignum (*Duma horrida subsp. horrida*), Spreading Emu-bush (*Eremophila divaricata subsp. divaricata*) and Spotted Emu-bush (*Eremophila maculata subsp. maculata*) (Table 10).

Table 10: Significant flora species recorded at Wirra-Lo Wetlands (Long, 2000; Macfarlane, 2005; Rakali Ecological Consulting 2015).

Common Name	Scientific Name	Type	Last record	EPBC status	FFG status	Vic status
Spiny Lignum	*Duma horrida subsp. horrida*	AM	2014			r
Spotted Emu-bush	*Eremophila maculata subsp. maculata*	AM	2014			r
Spreading Emu bush	*Eremophila divaricata subsp. divaricata*	AM	2014			r
Winged Water-starwort	*Callitriche umbonata*	AM	2014			r

Conservation Status:

- Vic Status: e – endangered, v – vulnerable, k – poorly known and suspected, but not definitely known, to belong to one of the categories (x, e, v or r) within Victoria (DEPI 2015).
- Type: AM – Amphibious,

Plate 1: Duck Creek North - Aquatic Herbland (foreground) and Tall Marsh (background) (Source: J Hooper)

Plate 2: Close up open water and Aquatic Herbland (Growling Grass Frog habitat) (Source: J. Hooper)

Plate 3: Red Gum Swamp - Intermittent Swampy Woodland - Musk Duck nest in Tangled Lignum (Soure: K. Hooper)

Plate 4: Lignum Swamp – Open water and Intermittent Swampy Woodland (Background) (Source: K. Hooper)

4.1.4. Terrestrial fauna that depend on the water dependent vegetation communities

Three permanent populations of FFG-listed Grey-crowned Babbler (*Pomatostomus temporalis*) have regularly been recorded (Long 2000; McFarlane 2005; Rakali Ecological Consulting 2015). While this species is not water dependent it is dependent on the River Red Gum and Black Box communities within and fringing the wetlands (Long 2000; Macfarlane 2005; Rakali Ecological Consulting 2015). The call of the FFG- listed Bush-stone Curlew (*Burhinus grallarius*) was recorded during the bird survey in 2005 (McFarlane 2005). This is a terrestrial species, but is most often associated with open eucalypt woodlands, including River Red Gum woodlands, with day time roosts usually less than 250

metres from water (DSE 2004). Terrestrial mammals and reptiles, such as the Eastern Grey Kangaroo (*Macropus giganteus*), Swamp Wallabies (*Wallabia bicolor*), Lace Monitor (*Varanus varius*) and Bearded Dragon (*Pogona barbata*) also regularly use the wetlands' margins and surrounding terrestrial vegetation communities (McFarlane 2005).

Table 11: Significant terrestrial species that depend on wetland vegetation at Wirra-lo Wetland Complex

Common Name	Scientific name	Type	Last record	EPBC status	FFG status	Vic status
Grey-crowned Babbler	*Pomatosomus temporalis*	TB	2014		L	EN
Bush Stone Curlew	*Burhinus grallarius*	TB	2005		L	EN
Brown Treecreeper	*Climacteris picumnus*	TB	2014			NT
Black Falcon	*Falco subniger*	TB	2014			VU
Lace Monitor	*Varanus varius*	R	2010			VU
Bearded Dragon	*Pogona barbata*	R	2014			VU

Conservation Status:
Type: Terrestrial Bird, Reptile
FFG Status: L – Listed as threatened
Vic status: EN – Endangered, VU – Vulnerable, NT – Near Threatened
Source: Long 2000; McFarlane 2005; Rakali Ecological Consulting 2015, Hooper, K (observations since 1992)

4.2. Wetland depletion and rarity

Victoria's wetland classification system was recently updated to align with the ANAE national framework for aquatic ecosystems. DELWP has created *WETLAND_CURRENT* geospatial layers (DELWP 2015b). The depletion and rarity of both classifications in Victoria, the North Central CMA region, the Loddon River catchment and Victoria Riverina bioregion are discussed below (Table 12).

Freshwater meadow (Corrick and Norman Classification)

Under Corrick and Norman classification Wirra-Lo Wetland Complex's pre-European and current wetland classification is freshwater meadow (DELWP 2015a). This wetland type is depleted in Victoria, the North Central CMA region, Victoria Riverina bioregion and the Loddon River catchment with the loss ranging from 34 to 57 percent since European settlement. Due to the size of Wirra-Lo Wetland Complex (approximately 66 hectares), its contribution to the state, North Central, Loddon Catchment and Victorian Riverine bioregion freshwater meadow is small.

Temporary freshwater swamp (Victorian Wetland Classification)

Under the 2013 Victorian Wetland Classification framework, Wirra-Lo Wetland Complex is classified as a temporary freshwater swamp (DEPI 2014b). Wirra-Lo Wetland Complex represents less than 0.5% of this classification in all of the Victoria, North Central CMA region, Loddon and Murray Fans bioregion landscapes. A comparison of percentage reduction since European settlement could not be undertaken as the system does not include a comprehensive update of the WETLAND_1788 layer to meet the new wetland classification categories.

Table 12 illustrates the area, proportion, depletion and rarity of each wetland classification across various defined landscapes. It is important to note that an on ground assessment has indicated that the wetland classification for each of the wetlands is different to the statewide desktop analysis (Table 4; Butcher et al. 2015).

Table 12: Area, depletion and rarity of wetland classifications in the region

Region	Corrick and Norman classification Freshwater Meadow				Current classification Temporary freshwater swamp	
	Pre-European area (ha)	Current area (ha)	Reduction (%)	Wirra-Lo Wetland Complex contribution to current area (%)	Current area (ha)	Wirra-Lo Wetland Complex contribution to current area (%)
Victoria	181,089	118,222	35	0.05	53,953	0.1
North Central catchment	75,017	40,558	46	0.1	26,421	0.2
Loddon catchment	53,518	21,968	59	0.3	16,568	0.3
Murray Fans bioregion	15,086	13,147	13	0.5	12,770	0.5

4.2.1. Ecosystem function

'Ecosystem function' is a term 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. This includes 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, the Wirra-Lo Wetland Complex is of high value representing a number of depleted wetland types. The Wirra-Lo Wetland Complex is located in close proximity to two major waterways, Loddon River (500 metres) and the Murray River (1.5 kilometres). A corridor of remnant riparian vegetation along the Loddon River provides an opportunity to link the wetlands with the Benjeroop Forest a priority asset in the NCWS and Dartagook Forest, which is a high priority biodiversity area in the North Central RCS (Long 2000). It also supports a diversity of threatened flora and fauna species as well as vulnerable and depleted vegetation communities. The Basin Plan specifies the need to "identify priority environmental assets and priority ecosystem functions, and their environmental watering requirements" (Australian Government 2012, p68). Section 8.50 of the Basin Plan outlines the method for identifying ecosystem functions that require environmental watering and their environmental watering requirements (Schedule 9—Criteria for identifying an ecosystem function). The ecosystem functions of Wirra-Lo Wetland Complex that meet the assessment indicators are described Appendix 4.

Table 13 broadly shows the ecosystem functions provided by Wirra-Lo Wetland Complex from a local and regional perspective.

Table 13: Ecosystem function of Wirra-Lo Wetland Complex from 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. rocks, woody debris, gravel) 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 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.	• **Provision of refugia –** refugia is an important ecological function for many aquatic biota in Northern Victoria. Refugia generally comprises wet areas that persist when the landscape dries and are points of dispersal when flooding occurs. • **Population persistance**- a number of species require specific habitat componants to breed. With the significant reduction suitable wetland habitat on the Benjeroop floodplain, the population of species such as growling Grass Frog is declining. • **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. • **Biological diversity**- the provision of a sufficient number and range of habitat types in the landscape supports a diversity of native species. This in turn assists to safe guard the region from the impacts of local catastrophic events (i.e. loss of habitat through fire and clearing) due to there being sufficient alternative habitats available. This supports the maintenance of genetic and species diversity in the region.
Note: The above ecosystem functions are particularly important for species with low or restricted mobility such as Growling Grass Frog.	

4.3. Social values

4.3.1. Cultural heritage

The Barapa Barapa Nation are traditional owners of the Wirra-LO Wetland Complex.Archaeological evidence of Aboriginal inhabitancy (ovens and middens) indicates that the wetlands were very productive (Long 2000; Rakali Ecological Consulting 2014).

4.3.2. Recreation

As Wirra-Lo Wetland Complex is located on private land it currently does not have any broader community recreational values. The landholders have indicated that once the wetland returns to its former condition that they would like to open the wetlands up to organised groups (with permission from the landholders) for supervised educational, bird watching and other passive recreation activities (such as walking). The landholders would also like to establish an education program about

the wetlands and about protecting biodiversity values on private land (Hooper, K & J, 2015, personal communication [landholders], March 2015).

4.4. Economic

The economic value of a particular wetland or complex to the regional economy can be quite difficult to measure. As the Wirra-Lo Wetland Complex is located on private land, a general discussion of the public economic benefit of wetlands is provided, based on Heimlich et al. (1998) and the Australian Conservation Foundation (2010).

There are direct and indirect uses of wetlands which generate economic benefit on a local, regional and wider scale. Indirect 'uses' include ecosystem services such as flood retention, nutrient treatment, carbon storage and wildlife habitat (Heimlich et al. 1998; Australian Conservation Foundation [ACF] 2010).

4.5. Conceptualisation of the site

The conceptual understanding of the requirements to support Growling Grass Frog is shown in Figure 5

Figure 5: Conceptual understanding of environmental watering requirements of Growling Grass Frog (Butcher et al. 2015).

Figure 6: Cross section indicating conceptual understanding of Wirra-Lo Wetland Complex ecology

Key:

1. Well vegetated seasonal wetland critical breeding habitat for EPBC- listed Growling Grass Frog
2. Fallen timber provides critical feeding and overwintering habitat for EPBC- listed Growling Grass Frog
3. Swampy Woodland vegetation communities provide important roosting, nesting and feeding habitat for a diversity of waterbirds

4.6. Significance

The Wirra-Lo Wetland Complex is located on a floodplain that once comprised extensive freshwater marsh, swamp and meadow wetland habitats that would have been intermittently or seasonally inundated. These would have supported high densities of aquatic and water dependent fauna such as the EPBC-listed Growling Grass Frog and Australasian Bittern. The loss of these habitats has occurred not only on the Benjeroop and Murrabit floodplains, but throughout the Lower Loddon and Murray River floodplains. The Wirra-Lo Wetland Complex has high ecological significance as it provides all of these wetland habitat types which in turn provide high quality habitat for a large diversity of waterbirds and feeding and breeding habitat for less mobile aquatic species, in particular the Growling Grass Frog.

Appendix 4 demonstrates that the Wirra-Lo Wetland Complex meets a number of the criteria specified in Murray Darling Basin Plan for identifying an environmental asset as a priority for environmental water management, as per schedule 8 of the Basin Plan.

5. Ecological condition and threats

5.1. Context

Active management of the wetlands ceased in the 2006/07 irrigation season, which had a significant impact on the wetland areas that, up to that point, had received water on an annual basis (Table 6). Loss of aquatic vegetation and decline in tree condition were observed by the landholder in the latter years of the drought. The flooding of January 2011 occurred as the result of a breach in a river levee bank to the south of the property. As a consequence, significant volumes of high velocity floodwater flowed through the wetlands. Anecdotally this had disastrous impact on the insects and small reptiles that did not have time to move to higher ground or into trees. It has only been in the last 12 – 18 months that the landholder has seen the return of animals such as ants and lizards to the property (Hooper, K, 2015, personal communication [landholder], 4 March).

The floodwater, however did improve the condition of vegetation such as Lignum and River Red Gum and Black Box trees. The floodwaters also resulted in the germination of threatened species such as Spiny Lignum and Spreading Emu-bush (Hooper, K, 2014, personal communication [landholder], 4 November 2014; Rakali Ecological Consulting 2015). Prior to the delivery of environmental water in Autum 2015 (which at the time of writing was too soon to make any changes in condition), the wetlands had not been inundated since the floods. Small volumes of irrigation tail-water from adjacent property has runoff to the lower lying areas of the complex. These areas support a high diversity of aquatic plants and abundance of common frogs (Rakali Ecological Consulting 2015).

5.2. Current condition

Wetland

An Index of Wetland Condition (IWC) assessment, undertaken in November 2014, when the wetlands had been dry for between 2-2.5 years, found that the wetland is currently in moderate condition (Table 14).

The wetland catchment score of poor is based on the intensity of surrounding land use and the extent of the wetland buffer. The landuse on adjacent property is irrigated agriculture to the south and land transitioning from irrigated to dryland agriculture on the other boundaries. Irrigated agriculture is a high intensity land use. Further, the wetland buffer within the complex is located around only 20% of the perimeter and where it is located is between 5-20 metres (Rakali Ecological Consulting 2015).

The physical form of the wetland has been altered by the construction of on farm channels, drains, and landforming activities such as laser grading from when the property was used for irrigated agriculture (Long 2000; Rakali Ecological Consulting 2015), however the bathymetry is largely uncompromised so the IWC score for physical form is good (Rakali Ecological Consulting 2015).

The hydrology score of poor recognises, as mentioned in Section 3.1.2, that modification to the catchment morphology has changed the frequency, magnitude and duration of inundation of the Wirra-Lo Wetland Complex. Further, the loss of artificial watering since the drought has changed the water regime from seasonal to episodic (Rakali Ecological Consulting 2015).

Water properties were scored as moderate. The IWC assessment was undertaken when the wetland was predominantly dry, however weeds are proposed to be evidence of some nutrient enrichment and minor evidence of change in salinity regime from pre-European state (Rakali Ecological Consulting 2015), although currently the wetland complex exhibits very little evidence of salinity issues (Butcher et al. 2015).

Biota, which is a measure of EVC condition, was scored as poor. However, the EVCs were mapped into a number of zones based on condition with EVCs in Zone 1 assessed as being in relatively good

condition compared to the benchmark. The zonation ranges to Zone 4 which represents the most altered from the benchmark or most degraded condition. The locations of the EVCs and their zonation shown in Appendix 3.

Table 14: IWC for Wirra-Lo Wetland Complex (Source Rakali Ecological Consulting 2015)

IWC Sub index Name	Sub Index Score (weight adjusted)	Condition Category
Wetland catchment	2.34	poor
Physical form	1.36	good
Hydrology	1.55	poor
Water properties	5.64	moderate
Soils	1.40	excellent
Biota	6.50	poor
Overall Score	**6.00**	**Moderate**

The landholder noted that tree decline across the property became apparent during the drought when water allocations were reduced and then subsequently ceased. While these trees were flooded during the 2011 flood, the water was very deep and warm for many months, and the landholder stated that while some trees responded well, others did not. In the past twelve months a number of trees appear to be affected by insect attack (Hooper, K, 2014, personal communication [landholder], 3 November).

Intermittent Swampy Woodland was the predominant EVC mapped by Rakali Ecological Consulting (2015) and it was classified into four zones. Zone 1 is relatively intact, with a healthy canopy of large old River Red Gum trees. The canopy trees in Zone 2 are exhibiting indications of stress (evidence in low crown condition, leaf die off and minor to moderate cracking bark). The extent of Tangled Lignum in Zone 2 is denser than it should be for this EVC (Rakali Ecological Consulting 2015) although the vigour of the shrubs is significantly reduced (most branches are dry and brittle) (Rogers, L, 2014, personal observation [North Central CMA], 3 November). The canopy in Zone 3 and Zone 4 had been cleared (a consequence of prior agricultural activities) and in both zones recruitment of new River Red Gum trees was evident. Zone 3 has a healthy Tangled Lignum layer whereas Zone 4 has more evidence of weeds than Zone 3 (Rakali Ecological Consulting 2015).

Lignum Swampy Woodland, the second most dominant wetland EVC, was classified into three zones. Zone 1 is a relatively intact representation of this EVC, with a healthy canopy and relatively diverse understory and groundcover species. Zone 2 has a less dense Tangled Lignum layer and weedier understory and Zone 3 is predominantly cleared and weedy.

Two small zones of Riverine Swampy Woodland are located outside of the area that can be influenced by water. Zone 1 has an intact open River Red Gum canopy, including some large old trees, whereas Zone 2 is relatively cleared of trees

Riverine Chenopod Woodland also sits outside the managed flooded area. This EVC was classified into three zones. Zone 1 is a relatively intact representation of this EVC, with a mature canopy of Black Box and a diverse shrub and ground layer with a relatively low cover of weeds. Zone 2 has mostly been cleared for agriculture but is regenerating exceptionally well since farming ceased and while still with a relatively weedy ground layer it has an appropriate density of recruiting Black Box and shrub species and large areas of recruiting Wallaby Grass. Zone 3 is less intact having scattered recruiting Black Box trees, Lignum shrubs and areas of Wallaby Grass but with a ground layer predominantly composed of exotic species (Rakali Ecological Consulting 2015).

Wetland EVCs that are vital habitat for aquatic species such as Growling Grass Frog have significantly been impacted by the dry conditions. Aquatic Herbland is restricted to small drainage lines in Lignum Swamp that receive small volumes of water from irrigated land to the south of the property and Tall Marsh consists of dried rhizomes along the verges of Duck Creek North and South.

Species

The Growling Grass Frog was once very common across the Benjeroop/Murrabit floodplain, with a decline in abundance observed by the local community beginning in the 1970s (SKM 2014). Surveys in the region continued to detect Growling Grass Frog on the floodplain during the drought, with records located within five kilometres of the property (Smith et al. 2008a; Clemann et al. 2013). A survey undertaken to determine the likelihood of Growling Grass Frog populations in irrigation channels targeted for decommissioning by GMW, to the south of the Wirra-Lo Wetland Complex by SKM in 2013 and 2014, failed to detect the presence of any Growling Grass Frogs. The study states that it is not possible to prove absence but given the intensity of the survey study[1] it was unlikely that Growling Grass Frog were present in the study area, and if present the species is in extremely low abundance in the Kerang-Koondrook-Murrabit region (SKM 2014). The authors did speak to a landholder that had heard Growling Grass Frogs in the north of the study area in NSW during the time of the survey, indicating that they are still within the broader region.

The reasons for this decline is not clearly understood, however fragmentation of aquatic and adjacent terrestrial habitats, altered water regimes in wetlands, the impact of invasive species, especially predatory fish such as Eastern Gambusia (*Gambusia holbrookii*) and the disease chytridiomycosis[2]are likely causes (Clemann & Gillespie 2012; Clemann et al. 2013). The *National Recovery Plan for Litoria raniformis* seeks to reduce the threat category of the species by securing known populations and addressing predicted threatening processes through management activities such as habitat retention (Clemann & Gillespie 2012). The provision of refuge habitat that excludes predatory fish, particularly during drought, is considered important for the long-term viability of the species (Clemann et al. 2013).

5.3. Condition trajectory – do nothing

It is important to note that the large-scale rationalisation of irrigation infrastructure on the Benjeroop floodplain area (Rural Finance 2014) will see a significant loss of water in the landscape. While this policy was in recognition that the junction of the Loddon and Murray rivers is an active floodplain with a high risk of flooding, artificial levee banks along the rivers have not been removed so the floodplain is still protected from minor to moderate flooding.

The River Red Gum and aquatic vegetation communities at the Wirra-Lo Wetland Complex are in various phases of decline due to water stress. Without environmental water this decline will continue. Further, while the return of Growling Grass Frog to the wetland is uncertain, this species was once prolific on the Benjeroop/ Murrabit floodplain and it is important to rehabilitate the wetland habitat that previously supported breeding populations of this species. Although the status of the meta population is unknown, given that the site supported Growling Grass Frog in the past, it is probable that this species will utilise the complex again once habitat is suitable (Clemann, N, 2015, personal communication [Arthur Rylah Institute – Director Threatened Species], 18 February).

This is particularly important in light of the findings of the *North Central Climate Change Adaptation and Mitigation Plan 2014* that predicts the long term impacts of climate change include increased temperature across all seasons, more hot days and less very cold days and a decrease in winter rainfall under a range of scenarios (North Central CMA 2015b). The impacts of less rainfall and higher evaporation could be disastrous for aquatic fauna such as the Growling Grass Frog, without the provision of refuge (Clemann & Gillespie 2012).

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[1] The methodology to detect Growling Grass Frog that is recommended EPBC Act Policy Statement 3.14 was established in southern Victoria. The inland and coastal populations of Growling Grass Frog exhibit differences in biology and ecology (Clemann & Gillespie 2013) it is possible that different detection methods may be more effective for the northern meta-population.

[2] caused by the fungal pathogen *Batrachochytrium dendrobatidis* – known as Chytrid Fungus

6. Management objectives

6.1. Management goal

The long term management goal for Wirra-Lo Wetland Complex has been derived from a variety of sources including technical reports, wetland characteristics and the site specific environmental values. The management goal, ecological objectives and water regimes have been scientifically peer reviewed by a team of wetland specialists. The outcomes of the peer review shown in the long term management goal which seeks to address the decline in the health of the River Red Gum and aquatic vegetation communities to rehabilitate habitat for water dependent fauna such as the EPBC-listedGrowling Grass Frog.

Wirra-Lo Wetland Complex water management goal

To provide vital habitat including the provision of refuge and suitable breeding conditions for Growling Grass Frog (*Litoria raniformis*) and to provide high quality feeding and breeding habitat for a large diversity of waterbirds by rehabilitating the River Red Gum (*Eucalyptus camldulensis*) and aquatic vegetation communities.

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 Wirra-Lo Wetland Complex are based on the key values of the site. They are presented as primary objectives at a complex scale for fauna, which are mobile (Table 15), and secondary or supporting objectives at an individual wetland scale for vegetation communities that are relevant for the different wetland types present in the complex (Table 16, Table 17).

Where appropriate, the ecological objectives 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.
- increase the extent – increase the spatial extent of a the value that is present but not at optimum coverage

Table 15: Ecological objectives and their justifications for Wirra-Lo Wetland Complex

Objective	Justification
1. Primary Objective – Species	
1.1 Restore the population of EPBC-listed Growling Grass Frog (*Litoria raniformis*) at the Wirra-Lo Wetland Complex through the provision of habitat for refuge and breeding	▪ This species was supported at the wetlands prior to the Millennium Drought and was recorded at a broader landscape scale in the latter years of the drought. ▪ Wirra-Lo Wetland Complex presents a unique opportunity to provide permanent refuge while eliminating the risk of providing conditions for predatory fish. The wetlands in the complex can be managed so that in any given year some wetlands hold water permanently, yet they can all be dried to cracking clay to exclude fish.
1.2 To provide feeding and breeding habitat for a high diversity of waterbirds.	▪ The wetland complex provides a wide range of habitat types that supports a high diversity and abundance of waterbirds. Use of the wetland for waterbird breeding is a knowledge gap (due to the landholders not residing on the property).
2. Secondary Objective – Process	
2.1 Maintain/ rehabilitate appropriate seasonality and duration of wetting and drying	▪ Wetlands are most productive when appropriate timing of wetting and drying occurs. Drying is required to allow seed germination and aerate the sediments. Rewetting releases nutrients, facilitates germination and regeneration of aquatic and amphibious vegetation and triggers emergence of macroinvertebrates and frogs.

Table 16: Ecological objectives and their justifications for Duck Creek North and Duck Creek South and Lignum Swamp

Objective	Justification
3. Secondary Objective - Habitat	
3.1 To increase the extent of floating, submerged and emergent aquatic vegetation associated with Aquatic Herbland (e.g. *Triglochin* spp., *Potamogeton* spp.)	▪ Aquatic Herbland is a depleted EVC in the Murray Fans bioregion. ▪ A high coverage of aquatic vegetation has been shown to strongly correlate with the detection of Growling Grass Frog in Northern Victoria (Clemann et al. 2013). ▪ Aquatic Herbland supports a high abundance of common frog species which are important food source for dabbling ducks, egrets and other piscivorous waterbirds. ▪ Aquatic Herbland supports threatened flora species Winged Water Starwort.
3.2 To increase the longitudinal extent of emergent aquatic vegetation along Duck Creek associated with Tall Marsh (including *Typha* spp., *Juncus* spp. and *Eleocharis* spp.)	▪ A high coverage of aquatic vegetation has been shown to strongly correlate with the detection of Growling Grass Frog in Northern Victoria (Clemann et al. 2013). ▪ Tall Marsh vegetation provides habitat for waterbirds such as Australasian Bittern, Latham's Snipe, Hardhead, as well as other ducks, crakes and rails
3.3 To maintain/ rehabilitate the health of adult River Red Gum trees (Intermittent Swampy Woodland).	▪ Intermittent Swampy Woodland is a depleted EVC in the Murray Fans bioregion ▪ Terrestrial vegetation and fallen debris is important foraging and overwintering habitat for the Growling Grass Frog (Clemann & Gillespie 2013). ▪ River Red Gum trees provide critical habitat for threatened terrestrial species such as Grey Crowned Babbler ▪ River Red Gum communities provide habitat for a diversity of waterbirds, including roosting habitat for Eastern Great Egrets, Pied Cormorants and Nankeen Night Herons ▪ River Red Gum trees provide hollows for hollow nesting ducks and other birds
3.4 To facilitate recruitment of River Red Gum trees (Intermittent Swampy Woodland)	▪ Land clearing has occurred across the floodplain of Duck Creek South and Duck Creek North. Small areas of regeneration of River Red Gum trees has occurred post floods. ▪ Regenerating River Red Gum trees has the potential to sequester carbon from the atmosphere.
3.5 To maintain open water and associated mud-flat habitat	▪ A high diversity and abundance of waterbirds utilise the open water (e.g. Hardhead, Musk Duck, swans), mudflat habitat (Latham's Snipe, spoonbills, wading migratory birds) in the wetland complex

Table 17: Ecological objectives and their justifications for Red Gum Swamp and Emu Creek

Objective	Justification
4. Secondary Objectives - habitat	
4.1 To maintain and rehabilitate the health of adult River Red Gum trees (Intermittent Swampy Woodland and Lignum Swampy Woodland).	▪ Lignum Swampy Woodland is vulnerable. Intermittent Swampy Woodland is depleted. ▪ Terrestrial vegetation and fallen debris is important foraging and overwintering habitat for the Growling Grass Frog. ▪ River Red Gum trees provide critical habitat for threatened terrestrial species such as Grey Crowned Babbler ▪ River Red Gum communities provide habitat for a diversity of waterbirds, including roosting habitat Eastern Great Egrets, Pied Cormorants and Nankeen Night Herons ▪ River Red Gum trees provide hollows for hollow nesting ducks, owls
4.2 To facilitate recruitment of River Red Gum Trees (Intermittent Swampy Woodland and Lignum Swampy	▪ Recruitment of trees will replace those tress lost during the drought or floods. ▪ Regenerating River Red Gum trees has the potential to sequester

Objective	Justification
Woodland)	carbon from the atmosphere.
4.3 Where feasible maintain/ rehabilitate the health of Black Box trees (Lignum Swampy Woodland)	▪ Lignum Swampy Woodland is a Vulnerable EVC in the Murray Fans bioregion. ▪ Black Box trees provide critical habitat for threatened terrestrial birds such as Grey Crowned Babbler ▪ Black Box trees provide hollows for hollow nesting ducks ▪ Open woodlands are important habitat for Bush-stone Curlew
4.4 To maintain an appropriate extent of Tangled Lignum vegetation	▪ Tangled Lignum provides habitat for waterbirds such as Latham's Snipe

6.3. Hydrological requirements

The hydrological requirements of the ecological objectives for the Wirra-Lo wetland Complex are shown in Table 18.

Table 18: Hydrological requirements for ecological objectives for the wetland complex

Ecological Objectives	Water management area	Hydrological Requirements										
		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		
COMPLEX												
1. Primary Objectives - species												
Restore the population of EPBC-listed Growling Grass Frog (*Litoria raniformis*) at the Wirra-Lo Wetland Complex through the provision of habitat for refuge and breeding	Bed and Fringe of Marshes and Meadows	7	8	10	Unknown, prefers seasonal to permanent water bodies			5	7	-	Spring/ Summer	N/A
To provide feeding and breeding habitat for a high diversity of waterbirds.	Variety of wetland types and areas	Variable feeding and breeding needs dependent on the species.						4	5-12	Until fledged	Late Winter/ early spring	0.2 – 1 metre
2. **Secondary objectives - process**												
Maintain/ rehabilitate appropriate seasonality and duration of wetting and drying	Complex	Dependent on implementing the above objectives										

Ecological Objectives	Water management area	Hydrological Requirements										
		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		
To increase the extent of floating, submerged and emergent aquatic vegetation associated with Aquatic Herbland (e.g. *Triglochin* spp., *Potamogeton* spp.)	Bed and fringe	5	6-7	8	Varies depending on seed bank			4	3-6[3] 8-10[4]	12	Autumn/ Spring	0.3 – 1.0 (~0.8 initial)
To increase the longitudinal extent of emergent aquatic vegetation along Duck Creek associated with Tall Marsh (including *Typha* spp., *Juncus* spp. and *Eleocharis* spp.)	Fringe	5	6-7	8	12	24-48	60	4	8	12	Spring	0.2 – 1.0
To maintain/ rehabilitate the health of adult River Red Gum trees (Intermittent Swampy Woodland).	Bed and fringe	2	3-6	7	6	18-30	54	2	4	18	Spring/ Summer	Not critical

[3] Shallow floodplain
[4] Within historic creek channel

Ecological Objectives	Water management area	Hydrological Requirements										
		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		
To facilitate recruitment of River Red Gum trees (Intermittent Swampy Woodland)	Bed and Fringe	2*	3*	5*	Follow up flooding required then as per adult			1	2	-	Late Spring/ Summer	Not critical
To maintain open water and associated mud-flat habitat	Fringe	3	5	7	NA			2	3	6	Not critical	Not critical
To increase the extent of floating, submerged and emergent aquatic vegetation associated with Aquatic Herbland (e.g. *Triglochin* spp., *Potamogeton* spp.)	Fringe	2	5	10	12	60	84	1	3	7	Not critical	Not critical
To increase the longitudinal extent of emergent aquatic vegetation along Duck Creek associated with Tall Marsh (including *Typha* spp., *Juncus* spp. and *Eleocharis* spp.)	Bed	Dependent on implementing the above objectives										

*number of desired recruitment events, follow up flooding required

6.4. Watering regime

The water regimes for Wirra-Lo Wetland Complex are based on the ecological objectives and hydrological requirements outlined in Section 6.2 and 6.3. To allow for adaptive and integrated management, the watering regime is framed using a seasonally adaptive approach. This means that a watering regime is identified for optimal conditions, as well as the maximum and minimum tolerable watering scenarios. The minimum watering regime is likely to be provided in drought or years with low water allocations, the optimum watering regime in average conditions and the maximum watering regime in wet or flood years.

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

6.4.1. Duck Creek North watering regime

The water regime for Duck Creek North is intended to provide open water with associated aquatic and littoral vegetation to provide optimal feeding and breeding habitat for Growling Grass Frog and other frog species. The wetland will be managed as near permanent, with at least two complete drying (to cracking clay) periods in the ten years to reduce the risk of predatory fish species (e.g. Eastern Gambusia).

Minimum watering regime

Fill to 71.65 m AHD five in every ten years in late winter/early spring[5]. Maintain depth between 50 cm to one metre for up to six months; allow to draw down late summer.

Dry years: Allow wetland to remain dry for two consecutive years

Optimum watering regime

Fill to 71.65 m AHD six to seven years in ten in late winter/early spring. Maintain depth between 50 cm to one metre for up to six months; allow drawing down late summer.

Dry years: Allow at least two occurrences of complete drying (exhibits cracking clay)

Maximum watering regime

Fill to 71.65 m AHD eight in ten years in late winter/early spring. Maintain depth between 50 cm to 1 metre for up to six months; allow drawing down late summer.

Dry years: Allow at least occurrence of complete drying (exhibits cracking clay)

The modelled average volume of water required to manage the optimal regime Duck Creek in a watering year is 10 ML. The volume required in a year with maximum losses (high evaporation, low precipitation and filling from cracked clay) would be 15 ML (Table 19).

[5] An partial watering is proposed for autumn 2015 to specifically rehabilitate water stressed River Red Gum trees and aquatic vegetation.

6.4.2. Duck Creek South watering regime

The aim of the water regime for Duck Creek South is similar for Duck Creek North in the historic creek bed, however is also aiming to inundate the floodplain to its east to rehabilitate open woodland vegetation and to provide foraging habitat for shallow wading waterbirds and then mud-flat specialists once the water recedes. It is intended that Duck Creek South management of Duck Creek South, particularly the drying phase, will be aligned with the management of Duck Creek North and the northern section of Lignum Swamp to ensure permanent water availability for Growling Grass Frog, while facilitating complete drying, to cracking clays, at each of the wetlands.

Minimum watering regime

Fill to 72.1 m AHD five in ten years in late winter/early spring. Maintain depth between on floodplain between 30 and 50 cm for three to six months. Allow to draw down to 71.6 mAHD (average depth of 30 - 50 cm) for an additional two to four months (eight to ten months in total).

Dry years: Allow wetland to remain dry for up to two years

Optimum watering regime

Fill to 72.1 mAHD six to seven years in ten in late winter/early spring. Maintain depth between on the floodplain between 20 and 50 cm for three to six months. Allow to draw down to 71.6 mAHD(average depth of 20-50 cm) for an additional two to four months (eight to ten months in total).

Dry years: Allow at least two occurrences of complete drying (exhibits cracking clay)

Maximum watering regime

Fill to 72.1 mAHD eight in ten years in late winter/early spring. Maintain depth between on floodplain between 30 and 50 cm for three to six months. Allow to draw down to 71.6 mAHD (average depth of 20-50 cm) for an additional two to four months (eight to ten months in total).

Dry years: Allow at least occurrence of complete drying (exhibits cracking clay)

The modelled average volume of water required to manage the optimal regime Duck Creek South in a watering year is 105 ML. The volume required in a year with maximum losses (high evaporation, low precipitation and filling from cracked clay) would be 129 ML (Table 19).

6.4.3. Red Gum Swamp and Emu Creek

The aim of the water regime for Red Gum Swamp and Emu Creek is to rehabilitate and then the wetland woodland vegetation communities, providing a significantly different habitat type within the wetland complex that will provide feeding, roosting and breeding habitat for a diversity of waterbirds.

Minimum watering regime

Fill to 71.9 m AHD two years in ten in late winter/early spring. Maintain depth for two months and allow to draw down to dry over six months.

Fill to 71.6 mAHD an additional two years in ten. Maintain depth for four to six months.

Top-ups may be required to support bird breeding.

Optimum watering regime

Fill to 71.9 m AHD three years in ten in late winter/early spring. Maintain depth for two months and allow to draw down to dry over six months.

Fill to 71.6 m AHD an additional four years in ten. Maintain depth for four to six months.

Top-ups may be required to support bird breeding.

Maximum watering regime

Fill to 71.9 m AHD four in ten years in late winter/early spring. Maintain depth for two months and allow to draw down to dry over six months.

Fill to 71.6 m AHD an additional four years in ten. Maintain depth for four to six months.

Top-ups may be required to support bird breeding.

The modelled average volume of water required to manage the optimal regime Red Gum Swamp and Emu Creek in a watering year is 56 ML. The volume required in a year with maximum losses (high evaporation, low precipitation and filling from cracked clay) would be 122 ML (Table 19).

6.4.4. Lignum Swamp

The water regime for Lignum Swamp is intended to promote a diversity of wetland habitat types. Large areas of open water with associated aquatic and littoral vegetation will provide optimal feeding and breeding habitat for Growling Grass Frog, dabbling ducks and deep water foragers. Shallow areas will provide foraging habitat for shallow wading waterbirds. Mud-flat specialists will utilise the site as the water the water recedes. The water regime also aims to rehabilitate open woodland vegetation and to maintain the extensive Tangled Lignum community that provides roosting and breeding habitat for a high diversity of waterbirds.

Minimum watering regime

Fill to 71.6 m AHD three years in ten in late winter/early spring. Maintain depth for three to six months and allow to draw down over summer.

Top-ups may be required to support bird breeding.

Optimum watering regime

Fill to 71.6 m AHD four to five years in ten in late winter/early spring. Maintain depth for three to six months and allow to draw down over summer.

Allow at least two occurrences of filling events occurring in two consecutive years. Ensure one occurrence of two consecutive dry years in ten years.

Top-ups may be required to support bird breeding.

Maximum watering regime

Fill to 71.6 m AHD six years in ten years in late winter/early spring. Maintain depth for three to six months and allow to draw down over summer.

Allow at least two occurrences of filling events occurring in two consecutive years. Ensure one occurrence of two consecutive dry years in ten years.

Top-ups may be required to support bird breeding.

The modelled average volume of water required to manage the optimal regime for Lignum Swamp in a watering year is 293 ML. The volume required in a year with maximum losses (high evaporation, low precipitation and filling from cracked clay) would be 441 ML (Table 19).

Table 19: Modelled volume of water required in a watering year (optimal water regime) under average and dry conditions for each wetland.

Wetland	Average Volume (ML)	95th Percentile Volume (ML)
Duck Creek North	10	15
Duck Creek South	105	129
Red Gum Swamp and Emu Creek	56	122
Lignum Swamp	293	441

7. Risk Assessment

A qualitative risk assessment has been undertaken for the Wirra-Lo Wetland Complex EWMP to assign the level of long-term risk associated with:

- Threats external to watering that can impact achievement of objectives (e.g. grazing restricting vegetation recruitment)
- Threats that the watering proposes (e.g. cumulative increases in salinity with each filling event)

The relationship between likelihood (probability of occurrence) and the severity (severity of the impact) provide the basis for evaluating the level of risk (Table 20).

Table 20: Risk Matrix

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

The results from the EWMP site risk assessment for threats that are considered to be a high or moderate risk are presented in Table 21. Management measures are recommended and the residual risk is then recalculated assuming implementation of the management measures using the same risk matrix. Please note that short-term operational risks (e.g. environmental releases causes flooding of private land) are assessed as part of the development of the Central Murray Wetlands Seasonal Watering Proposal.

Table 21: Possible risks and management measures associated with environmental water delivery to Wirra-Lo Wetland Complex

Risk No.	Threat	Outcome	Likelihood	Severity	Risk rating	Management Measure	Residual Risk rating
1.	**Threats from environmental water**						
1.1	Excessive recruitment of River Red Gum	River Red Gum woodlands are a key habitat feature of the Wirra-Lo Wetland Complex. However excessive recruitment will result in a reduction in the diversity of habitat types and thereby reducing the value of the complex	Possible	Major	High	• The watering regime will be adaptively managed to ensure the risk of excessive recruitment reduced. • If required management intervention in the form of slashing/ spraying will occur to control seedling recruitment • Implementation of the management measures will reduce the severity to moderate which reduces the residual risk to moderate.	Moderate
1.2	Tangled Lignum that germinated throughout the Lignum Swamp afer the 2011 floods increases in density	Tangled Lignum has germinated in many areas that are open water/freshwater meadow/freshwater marsh areas. If the young plants continue to grow they will significantly reduce the diversity of wetland habitat types in the complex.	Probable	Major		• All young plants are killed either through removal or cutting and painting. • Implementation of the management measure reduces the likelihood to improbably and the severity (due to reduced spatial impact) to Moderate	Low

Risk No.	Threat	Outcome	Likelihood	Severity	Risk rating	Management Measure	Residual Risk rating
1.3	Lateral *Typha* spp. Encroachment into wetlands	Lateral encroachment of *Typha* into open water will result in the reduction of Aquatic Herbland and open water, which is critical habitat for Growling Grass Frog and other open water species.	Possible	Major	High	• A proposed optimal water regime for each wetland area includes at least one event of two consecutive years of dry. • Monitoring of vegetation response to environmental water includes a 5-10% lateral encroachment of Typha on channel triggers drying (2 years) • Implementation of the management measure reduces the likelihood to improbable which reduces the residual risk to moderate.	Moderate
1.4	Prolonged inundation from follow up to natural flooding event	There is a risk that natural flooding may occur after the delivery of environmental water. This would prolong the duration of inundation. Potential impacts include drowning of River Red Gums and change in species composition	Possible	Moderate	Moderate	• Management would include regular tree health monitoring throughout inundation event to determine need for action • Management actions could include draining water back to the Loddon river (large drain and outfall located to the west of the property (see Section 8) • Residual risk remains relatively unchanged as the feasibility of undertaking the above management action has not been investigated	Moderate

Risk No.	Threat	Outcome	Likelihood	Severity	Risk rating	Management Measure	Residual Risk rating
2	**Threats to achieving objectives**						
2.1	Introduced species-fish	It is likely that European Carp and Eastern Gambusia will enter the wetland complex via the irrigation channel network. A high abundance of these species may limit the establishment of aquatic plants, predate on Growling Grass Frog and other frogs (food sources) and reduce water quality. However they may also provide a source of food for piscivorous waterbirds.	Probable	Major	High	• Alternating drying of wetlands within the complex will prevent populations from perpetuating in the wetlands • Prevention option includes: Carp Screen at channel offtake to exclude Carp • Investigate options to exclude through traps (at channel inlet) that exploit Eastern Gambusia's attraction to light and heat may maximize capture of eastern Gambusia while having a minimal impact on native fish (Macdonald & Tonkin 2008). • Residual risk calculated on the implementation of water regime reducing severity to moderate and implementation of prevention measures reducing the likelihood to improbably to possible	Low to moderate
2.2	Introduced species-Foxes	Foxes have been regularly observed by the author at Wirra-Lo Wetland Complex. Foxes will predate on aquatic species, including Growling Grass Frog, as well as the eggs and chicks of waterbirds	Probable	Major	High	• Fox Control program (baiting and/or shooting) during watering events • Residual risk calculated on implementation of the management measure reducing the likelihood to improbable	Low

Risk No.	Threat	Outcome	Likelihood	Severity	Risk rating	Management Measure	Residual Risk rating
2.3	Introduced species-rabbits	Herbivory of emergent vegetation as well as recruited understorey and overstory (i.e. River Red Gums) impacts on the health and extent of native vegetation. The presence of warrens may also disrupt sites of cultural heritage and impact on soil structure.	Probable	Moderate	High	• Continued rabbit control program required • Erect rabbit proof fencing around the perimeter of the property (if deemed required after implementation of rabbit control program) • Residual risk calculated on the implementation of the management measures reducing the likelihood to possible and severity to minor	Low
2.4	Chytridiomycosis	The disease chytridiomycosis caused by the fungal pathogen *Batrachochytrium dendrobatidis* impairs osmoregulation of frog species. It is considered a possible cause of the decline of the Growling Grass Frog. Mortality rates of up to 100% are common, with adults more vulnerable than tadpoles.	Possible	Moderate	Moderate	• undertake zoospore counts to identify presence of disease- N.B. the disease is not as prevalent in semi-arid regions (vivacity linked to wet and cold conditions) • There has been some success with early stage of the infection, with sodium chloride and thermal manipulation found to reduce growth. However no current treatment available to wild population • No change to residual risk due to limited control measures available.	Moderate

8. Environmental water delivery infrastructure

The current connection to the wetland is via the Torrumbarry No. 4 channel outfall (ST011243 / TO4579) and via existing internal channel system on the private property. The internal channel system has been calculated to have a capacity of between 19 -37 ML/day. The current wheel LMO4579 has an operating capacity of 15 ML/day (NLS 2014). The landholders have invested in four regulating structures that connect each of the wetlands to the internal channel system, as recommended by NLS (2014), to enable the wetlands to be watered separately (Hooper, K, 2014, personal communication, [landholder], 4 November).

8.1. Infrastructure constraints

GMW Connections Project has indicated that it is seeking to rationalise the Torrumbarry No. 4 channel about two kilometres east of Wirra-Lo Wetland Complex (P. Egglestone pers. comm. [GMW Connection Project], 4 March 2015. GMW Connections project is still in negotiations with landholders downstream of the Wirra-Lo offtake

8.2. Operation constraints

The responsibility for ongoing operation the internal regulators to implement the discrete water regimes at each of the wetlands in the Wirra-Lo Wetland complex will need to be determined and documented in an operational protocol for long-term management. The landholders do not live near the wetlands and are aging so are likely to be constrained in operating the internal structures in the future. Once the connection option has been resolved (see Section 8.3), the North Central CMA will engage with VEWH and GMW to develop agreed operating protocols.

8.3. Infrastructure recommendations

The North Central CMA and GMW Connections project are currently investigating a number of options to connect the Wirra-Lo Wetland Complex into the future. It is anticipated that a cost benefit analysis will completed by the end of 2015.

Options that are currently under consideration are described below.

Retain current infrastructure

If the current infrastructure is retained an agreement will need to be reached between agencies regarding ongoing ownership and maintenance of the No. 4 channel. De-irrigation negotiations between the landholder and GMW include a sum of money in lieu of backfilling the channel once it is decommissioned as a public irrigation asset (Egglestone, P, 2015, personal communication, [GMW Connections Project], 4 March). The landholders have proposed to invest this money into maintenance and possible retrofitting of the channel to improve its condition (Hooper, K, 2015, personal communication, [landholder], 4 March).

Connection from the backbone via Duck Creek

There is potential to connect the GMW channel No. 4 to Duck Creek South via the Duck Creek channel located on private land to the east of the wetland complex. An agreement with the relevant landholder would need to be obtained and an easement negotiated. Works may be required to facilitate flow. This option may impact the ability to alternate wetting and drying of Duck Creek south with the other wetlands.

Connection to the Loddon River

A pipe that runs under the levee bank approximately 300 metres to the west of the Wirra-Lo Wetland Complex could be retrofitted to become an offtake, with water able to move through a series of depressions to the wetlands. This option would require:

- retrofitting the pipe to increase capacity
- an agreement with the landholder to move water through the depressions
- operation of the Loddon River to allow enough head when water was required at Wirra-Lo Wetland Complex or operation of a pump

9. Complementary actions

Table 22 documents the recommended actions that should be adopted to complement the delivery of environmental water to Wirra-Lo Wetland Complex.

Table 22: Complementary actions to enhance the outcomes of environmental water

Activity	Rationale	Recommendation	Priority
Prevention measures for Common Carp	Common Carp feeding behaviour will potentially impact the establishement of aquatic vegetation	Fit carp screens to the channel offtake	High
Management of Tangled Lignum	Tangled Lignum has germinated extensively in areas that were once open water and marsh habitat. The current watering regime may encourage promote its growth	Implement control of inappropriately placed young Tangled Lignum plants, before they take hold	High
Prevention measures for Eastern Gambusia	Eastern Gambusia predate on tadpoles, which presents a high risk to Growling Grass Frog (current risk a knowledge gap)	Investigation into light traps for Eastern Gambusia at the channel offtake	Moderate
Rabbit/Hare control	Impact of rabbits/hares is evident at Wirra-Lo Wetland Complex with the presence of warrens, scatters and grazed vegetation.	Undertake rabbit/hare control measures such as warren fumigation, baiting and education activities to encourage compliance by surrounding landholders. Consider rabbit proof fence around the property (low priority)	Moderate
Fox control	Foxes are commonly observed at Wirra-Lo Wetland Complex. Impacts include predation on juvenile waterbirds.	Undertake fox control measures such as baiting, fox drives and education activities to encourage compliance by surrounding landholders. Particularly important during watering events.	Moderate

10. Demonstrating outcomes

Monitoring is required to enable the North Central CMA and VEWH to justify the application of environmental water by demonstrating that watering is achieving environmental outcomes. Monitoring is undertaken to assist with determining the success of the hydrological outcome, in consideration of other limiting factors that may inhibit full realisation.

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

- Long-term condition monitoring
- Intervention monitoring

DELWP is currently developing WetMAP (Wetlands Monitoring and Assessment Program), which will be a long-term monitoring program aimed at assessing the effect of environmental water on Victorian wetlands. As the program is in its early stages of development monitoring activities have been proposed below that will demonstrate the achievement of the short and long-term objectives documented in this EWMP.

10.1. Long-term condition 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). Table 23 details the monitoring that is required to demonstrate change in condition over time specifically focusing on the long-term outcomes of the Wirra-Lo Wetland Complex EWMP.

Table 23: Required long-term condition monitoring for the Wirra-Lo Wetland Complex

Ecological Objective	Method	When
Restore the Growling Grass Population at Wirra-Lo Wetland Complex	As per EPBC methodology for adult frogs (Department of Environment, Water, Heritage and the Arts [DEWHA] 2010), as well as any new detection methods more appropriate for Northern Victoria	During watering events (in warmer weather)
To provide suitable conditions for feeding and breeding of a high diversity of waterbirds	Comprehensive waterbird monitoring including abundance, diversity and breeding.	Ideally annually with no more than two years between surveys
To increase the extent of floating, submerged and emergent aquatic vegetation associated with Aquatic Herbland (e.g. Triglochin spp., Potamogeton spp.) and the longitudinal extent of emergent aquatic vegetation associated with Tall Marsh (including *Typha* spp., *Juncus* spp. and *Eleocharis* spp.)	Comprehensive vegetation assessment to be compared to baseline assessment conducted in 2014. Surveys to include tree health, EVC mapping, IWC as well as species presence and abundance.	Year 3, 6 and 9
To maintain/ rehabilitate the health of adult and facilitate recruitment of River Red Gum trees (Intermittent Swampy Woodland, Lignum Swampy Woodland).		

10.2. Intervention monitoring

Intervention monitoring will assess the responses of key environmental values to the changes in the water regime (intervention) and the achievement of ecological objectives e.g. breeding of Growling Grass Frog. Intervention monitoring may include monitoring of water quality, vegetation and biota (i.e. waterbirds).

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 management or determine if any risk management actions need to be enacted.

An ongoing environmental watering resource planning program for wetlands in the North Central CMA region is implemented as part of the Seasonal Watering Proposal. This includes the delivery of environmental water based on an assessment of the previous year's monitoring data and water availability. Due to limited resourcing the program focuses primarily on the collection of basic habitat condition (using a rapid condition assessment and photopoint monitoring) and water depth and extent data. Table 24 details the intervention monitoring required to adaptively manage Wirra-Lo Wetland Complex over the next ten years.

Table 24: Required intervention monitoring for the implementation of the Wirra-Lo Wetland Complex

Ecological objective	Monitoring question	When	Method
Restore the Growling Grass Population at Wirra-Lo Wetland Complex	Have Growling Grass Frogs returned to the site?	During watering events (during warmer weather)	Accoustic recording devices and analysis software
	Are Growling Grass Frogs breeding and are tadpoles successfully metamorphosing?	Late Spring and throughout summer	As per EPBC methodology for eggs and larvae sampling (DEWHA 2010).
Support opportunistic breeding events for waterbirds	Are waterbirds breeding at the Wirra	Through-out watering event	Visual monitoring as well as the use of monitoring cameras in key areas of the wetland (i.e. in trees over water)
To increase the extent of floating, submerged and emergent aquatic vegetation associated with Aquatic Herbland and the longitudinal extent of emergent aquatic vegetation associated with Tall Marsh	Do the wetlands have sufficient cover (as determined by the EVC) of aquatic flora species?	During watering events	Photopoint[2] and rapid condition assessment monitoring
Rehabilitate the health of River Red Gum trees	Is the health of the River Red Gum trees improving	During watering events	

11. Knowledge gaps and recommendations

Identify knowledge gaps for objectives and risks, recommend a way to resolve the knowledge gap, nominate a responsible agency and prioritise.

Knowledge Gap	Objective/ Risk	Recommendation	Who	Priority
Objectives				
The current status of the Growling Grass Frog meta-population on the Benjeroop floodplain. This is relevant to this EWMP, but prediominantly a knowledge gap from a meta-population perspective.	1.1	A comprehensive survey of the entire floodplain that extends north of the previous survey study area and into NSW to determine the current extent of the extant meta-population of the floodplain.	DELWP ARI/ North Central CMA	High
Risks				
Effective measure to exclude Eastern Gambusia from the wetlands		Trialling light traps at the channel offtake	DELWP ARI/ North Central CMA	High

12. References

Australian Conservation Foundation (ACF) 2010, *Wetlands- underpinning a robust rural economy: Brief paper on the economic benefits of Australia Wetlands- Hattah Lakes case study*, Australian Conservation Foundation, Melbourne, Victoria.

Butcher, R, Cottingham, P, Frood, D, Hocking, M & Vietz, G 2015, *Scientific review of ecological objectives and environmental watering requirements for Lake Wandella, Tang Tang Swamp and Wirra-Lo Wetland Complex*, Report prepared for the North Central Catchment Management Authority by Water's Edge Consulting.

Bureau of Meteorology (BOM) 2015, *Climate statistics for Australian locations-Summary statistics Kerang-Site: 080023,* viewed March 2015, <http://www.bom.gov.au/climate/averages/tables/cw_080023.shtml>.

Camp Scott Furphy Pty Ltd & Associated Firms 1985, *Lower Loddon Flood Plain Management Study: Kerang to Little Murray R. Final Report Volume 1*, Report prepared for the Rural Water Commission, Victoria and Lower Loddon Municipalities.

Commonwealth Environmental Water Holder (CEWH) 2015, *Environmental water holdings,* viewed 24 February 2015, <http://www.environment.gov.au/water/cewo/about/water-holdings>.

Clemann N & Gillespie GR 2012, *National Recovery Plan for the Southern Bell Frog Litoria raniformis*, Victorian Government Department of Sustainability and Environment (DSE) Melbourne.

Clemann N, Scroggie, MP, Smith MJ, Peterson, GNL & Hunter D 2013, 'Characteristics of refugia used by the threatened Australian growling grass frog (*Litoria raniformis*) during a prolonged drought', *Wildlife Research,* vol. 40, no. 5, pp. 385 – 392.

DEWHA 2010, *Survey guidelines for Australia's threatened frogs Guidelines for detecting frogs listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999*, Department of Water, Heritage and the Arts, Canberra, ACT.

DELWP 2015a, *IWC Interactive Wetland Mapping Tool,* viewed 26 March 2015, <http://mapshare2.dse.vic.gov.au/MapShare2EXT/imf.jsp?site=iwc>.

DELWP 2015b, *'WETLAND_CURRENT'*, Department of Environment, Land, Water and Planning, viewed 10 February 2015 < http://mapshare2.dse.vic.gov.au/MapShare2EXT/imf.jsp?site=iwc>.

DEPI 2014a, *Guidelines: Wetland Environmental Water Management Plans,* Version 5, Department of Environment and Primary Industries, Melbourne.

DEPI 2014b, *The Victorian Wetland Classification Framework 2014,* Department of Environment and Primary Industries, East Melbourne, Victoria.

DEPI 2014c, *Water Dictionary*, viewed 31 October 2014, <http://waterregister.vic.gov.au/water-dictionary>.

DSE 2005, *Advisory List of Rare or Threatened Plants in Victoria*, Department of Sustainability and Environment, Melbourne, Victoria.

DSE 2004, *Action Statement- Flora and Fauna Guarantee Act 1988 – No. 78: Bush Stone-Curlew Burhinus grallarius*, Department of Sustainability and Environment, Melbourne, Victoria.

DSE 2003, *Action Statement – Flora and Fauna Guarantee Act 1988 – No. 60: White-bellied Sea-eagle Haliaeetus leucogaster,* Department of Sustainability and Environment, Melbourne, Victoria.

Heimlich, RE, Weibe, KD, Claassen, DG & House, RM 1998, *Wetlands and Agriculture: Private Interests and Public Benefits*, Resource Economics Division, Economic Research Service, U.S. Department of Agriculture, Agricultural Economic Report No. 765.

Higgins, PJ, & Davies, SJF 1996, *Handbook of Australian, New Zealand and Antarctic Birds: Volume 3. Snipe to Pigeons*, Oxford University Press, Melbourne, Australia.

Long K 2000, *Wetland management strategy: Hooper's Wetlands Murrabit West,* Department of Natural Resources and Environment.

MacFarlane, N 2005, *Plant List – Hooper's Property – Murrabit West: CVA Survey for Trust for Nature.*

Mitsch, W & Gosselink, J 2000, *Wetlands,* John Wiley and Sons, New York.

North Central CMA 2015a, *Victorian Environmental Water Holder 2014-15 Seasonal Watering Plan Variation Proposal For Wirra-Lo Wetland Complex*, North Central Catchment Management Authority, Huntly.

North Central CMA 2015b, *North Central climate change adaption and mitigation plan (draft),* North Central Catchment Management Authority, Huntly, Victoria.

North Central CMA 2015c, *Wirra-Lo Wetland Complex – Hydrogeological assessment*. North Central Catchment Management Authority, Huntly, Victoria.

North Central CMA 2014, *2014-2022 North Central Waterway Strategy*, North Central Catchment Management Authority, Huntly, Victoria.

North Central CMA 2012, *North Central Regional Catchment Strategy 2013-19*, North Central Catchment Management Authority, Huntly, Victoria.

Northern Land Solutions (NLS) 2014, *Wetland and channel bathymetry and features survey*, unpublished data prepared for the North Central Catchment Management Authority by Northern Land Solutions.

Rakali Ecological Consulting 2015, *Vegetation survey, mapping and analysis of Wirra-Lo Wetland Complex, Benjeroop*, unpublished client report for the North Central Catchment Management Authority prepared by Rakali Ecological Consulting Pty Ltd.

Rural Finance 2014, *Voluntary land buyback and incentives component final report 2014 under the Lower Loddon irrigators recovery package,* report prepared for the Department of Environment and Primary Industries, Melbourne.

Scroggie, M & Clemann, N 2003, *Habitat assessment and ecological requirements of the Growling Grass Frog Litoria raniformis in the area of proposed drainage works, Benwell-Koondrook region,* Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, Heidelberg, Victoria.

Smith, MJ, Scroggie, MP & Lennie, R 2008a, *The Growling Grass Frog and the late-spring and summer breeding frogs of north-western Victoria: status distribution and habitat requirements in the Kerang and Mildura regions,* Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, Heidelberg, Victoria.

Smith, MJ, Clemann, N, Scroggie, MP & Peterson, GNL 2008b, *The threatened Growling Grass Frog in the Wimmera and Corangamite catchments; An assessment of habitat requirements and the utility of automatic call recording devices as a survey tool*, Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, Heidelberg.

SKM 2014, *Growling Grass Frog Survey Kerang, Koondrook, Murrabit Region*, report prepared for Goulburn Murray Water Connections project by Sinclair Knight Merz, Melbourne.

SKM 2005, *Kerang to Little Murray River Floodplain Management Plan: Assessment of options, r*eport prepared for the North Central Catchment Management Authority by Sinclair Knight Merz, Melbourne, Australia.

Victorian Environmental Water Holder (VEWH) 2012, *Water Holdings*, viewed 24 February 2015, <http://www.vewh.vic.gov.au/managing-the-water-holdings>.

Abbreviations and acronyms

ARI	Arthur Rylah Institute
BE	Bulk Entitlement
BOM	Bureau of Meteorology
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	Department of Environment, Land, Water and Planning
DEPI	Department of Environment and Primary Industries
DSE	Department of Sustainability and Environment (Now DEPI in 2013)
ETAC	Environmental Technical Advisory Group
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)
GL	Gigalitre (one billion litres)
GIS	Geographical Information System
GMW	Goulburn Murray Water
HRWS	High Reliability Water Share
IWC	Index of Wetland Condition
JAMBA	Japan-Australia Migratory Bird Agreement
LRWS	Low Reliability Water Share
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
RCS	Regional Catchment Strategy
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement
RWS	Regional Waterway Strategy
SWP	Seasonal Watering Proposal
TIA	Torrumbarry Irrigation Area
WetMAP	Wetlands Monitoring and Assessment Program
VEWH	Victorian Environmental Water Holder
VWMS	Victorian Waterway Management Strategy

Appendix 1. Species lists

Sources: Long 2000; McFarlane 2005; Rakali Ecological Consulting 2014; Hooper 2015.

Table A1 1: Fauna list for the Wirra-Lo Wetland Complex

Common name	Scientific name	Date of last record
Birds		
Australasian Bittern	*Botaurus poiciloptilus*	1998
Australasian Grebe	*Tachybaptus navaehollandiae*	2011
Australasian Shoveller (Blue wing)	*Anas rhynchotis*	2011
Australian Crake	*Porzana fluminea*	2011
Australian Magpie	*Cracticus tibicen*	2014
Australian Pelican	*Pelecanus conspicillatus*	2011
Australian Raven	*Corvus coronoides*	2011
Australian Reed Warbler	*Acrocephalus australis*	2000
Australian Shelduck	*Tadorna tadornoides*	1998
Australian White Ibis	*Threskiornis molucca*	2011
Australian Wood Duck	*Chenonetta jubata*	2014
Barn Owl	*Tyto alba*	1998
Black Cormorant	*Phalacrocorax carbo*	2011
Black Falcon	*Falco subniger*	2014
Black Swan	*Cygnus atratus*	2004
Black-faced Cuckoo Shrike	*Coracina novaehollandiae*	2014
Black-fronted Dotterel	*Elseyornis melanops*	2011
Black-shouldered Kite	*Elanus axillaris*	2014
Black-tailed Native Hen	*Tribonyx ventralis*	2003
Black-winged Stilt	*Himantopus himantopus*	2011
Blue-faced Honeyeater	*Entomyzon cyanotis*	1998
Brown Falcon	*Falco berigora*	2014
Brown Quail	*Coturnix ypsilophora*	2000
Brown Treecreeper	*Climacteris picumnus*	2014
Budgerigar	*Melopsittacus undulatus*	2000
Bush Stone Curlew	*Burhinus grallarius*	2005
Button Quail	*(species not known)*	2003
Chestnut Breasted Rail	*Gallirallus philippensis*	2003
Chestnut-rumped Thornbill	*Acanthiza uropygialis*	2014
Cockateil	*Nymphicus hollandicus*	2014
Collared Sparrowhawk	*Accipiter cirrocephalus*	2014
Common Bronzewing Pigeon	*Phaps chalcoptera*	2014
Crested Pigeon	*Ocyphaps lophotes*	2014
Cuckoo	*(species not known)*	2004
Dusky Moorhen	*Gallinula tenebrosa*	2000
Dusky Wood Swallow	*Artamus cyanopterus*	2006
Eastern Great Egret	*Ardea modesta*	2011

Common name	Scientific name	Date of last record
Eastern Rosella	*Platycercus eximius*	2014
Emu	*Dromaius novaehollandiae*	1996
Eurasian Coot	*Fulica atra*	1998
Galah	*Eolophus roseicapilla*	2014
Golden-headed Cisticola	*Cisticola exilis*	2003
Grey Shrike Thrush	*Colluricincla harmonica*	2014
Grey Teal	*Anas gracilis*	2014
Grey-crowned Babbler	*Pomatostomus temporalis*	2014
Hardhead	*Aythya australis*	2011
Hoary-headed Grebe	*Poliocephalus poliocephalus*	2011
Latham's Snipe	*Gallinago hardwickii*	2011
Laughing Kookaburra	*Dacelo novaeguineae*	2014
Little Black Cormorant	*Phalacrocorax sulcirostris*	2011
Little Falcon (Australian Hobby)	*Falco longipennis*	2000
Little Grassbird	*Megalurus gramineus*	2014
Little Pied Cormorant	*Microcarbo melanoleucos*	2006
Little Raven	*Corvus mellori*	2011
Magpie Goose	*Anseranas semipalmata*	1993
Magpie Lark	*Grallina cyanoleuca*	2005
Musk Duck	*Biziura lobata*	2011
Nankeen Kestrel	*Falco cenchroides*	2014
Nankeen Night Heron	*Nycticorax caledonicus*	2011
Noisy Miner*	*Manorina melanocephala*	2014
Owlet Nightjar	*Aegotheles cristatus*	2015
Pacific Black Duck	*Anas superciliosa*	2015
Peregrine Falcon	*Falco peregrinus*	2014
Pied Butcherbird	*Cracticus nigrogularis*	2014
Pied Cormorant	*Phalacrocorax varius*	2007
Pied Honeyeater	*Certhionyx variegatus*	2003
Pink Eared Duck	*Malacorhynchus membranaceus*	2011
Purple Swamphen	*Porphyrio porphyrio*	2000
Red-capped Robin	*Petroica goodenovii*	2014
Red-kneed Dotteral	*Erythrogonys cinctus*	2011
Red-rumped Parrot	*Psephotus haematonotus*	2014
Restless Flycatcher	*Myiagra inquieta*	2000
Richards Pipet	*Anthus richardi*	2007
Rufous Songlark	*Cincloramphus mathewsi*	2007
Seagull	*Larus spp.*	2011
Singing Bushlark	*Mirafra cantillans*	2007
Singing Honeyeater	*Lichenostomus virescens*	2005
Southern Boobook Owl	*Ninox boobook*	2005
Southern Whiteface	*Aphelocephala leucopsis*	2005
Spotless Crake	*Porzana tabuensis*	2011
Spotted Harrier	*Circus assimilis*	2000

Common name	Scientific name	Date of last record
Spur-winged Plover	*Vanellus miles*	2000
Straw-necked Ibis	*Threskiornis spinicollis*	2014
Striated Pardalote	*Pardalotus striatus*	2014
Stubble Quail	*Coturnix pectoralis*	2007
Sulphur-crested Cockatoo	*Cacatua galerita*	2014
Superb Fairy-wren	*Malurus cyaneus*	2014
Tawny Frogmouth	*Podargus strigoides*	1998
Variegated Fairy Wren	*Malurus lamberti)*	2014
Wedge-tailed Eagle	*Aquila audax*	2014
Weebill	*Smicrornis brevirostris*	2014
Welcome Swallow	*Hirundo neoxena*	2005
Whistling Kite	*Haliastur sphenurus*	2011
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	2015
White-browed Woodswallow	*Artamus superciliosus*	2014
White-faced Heron	*Egretta novaehollandiae*	2011
White-fronted Chat	*Epthianura albifrons*	2014
White-necked Heron	*Ardea pacifica*	2011
White-plumed Honeyeater	*Lichenostomus penicillatus*	2015
White-winged Chough	*Corcorax melanoramphos*	2015
Willie Wagtail	*Rhipidura leucophrys*	2014
Yellow-billed Spoonbill	*Platalea flavipes*	2000
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	2014
Zebra Finch	*Taeniopygia guttata*	2014
Frogs		
Common Froglet	*Crinia signifera*	2014
Plains Froglet	*Crinia parinsignifera*	2014
Barking Marsh Frog	*Limnodynastes fletcheri*	2014
Eastern Banjo Frog	*Limnodynastes dumerilli*	2014
Perons Tree Frog	*Litoria peroni*	2014
Growling Grass Frog	*Litoria raniformis*	2003
Mammals		
Swamp Wallaby	*Wallabia bicolor*	1998
Eastern Grey Kangaroo	*Macropus giganteus*	2014
Brown Hare*	*Lepus capenis*	2014
European Fox	*Vulpus vulpus*	2014
Reptiles		
Boulengers Skink	*Morethia boulengeri*	2014
Tiger snake	*Notechis scutatus*	2014
Brown Snake	*Pseudonaja textilis*	2014
Bearded Dragon	*Pogona barbata*	2014
Lace Monitor	*Varanus varius*	2010

Table A1 2: Flora list for the Wirra-Lo Wetland Complex

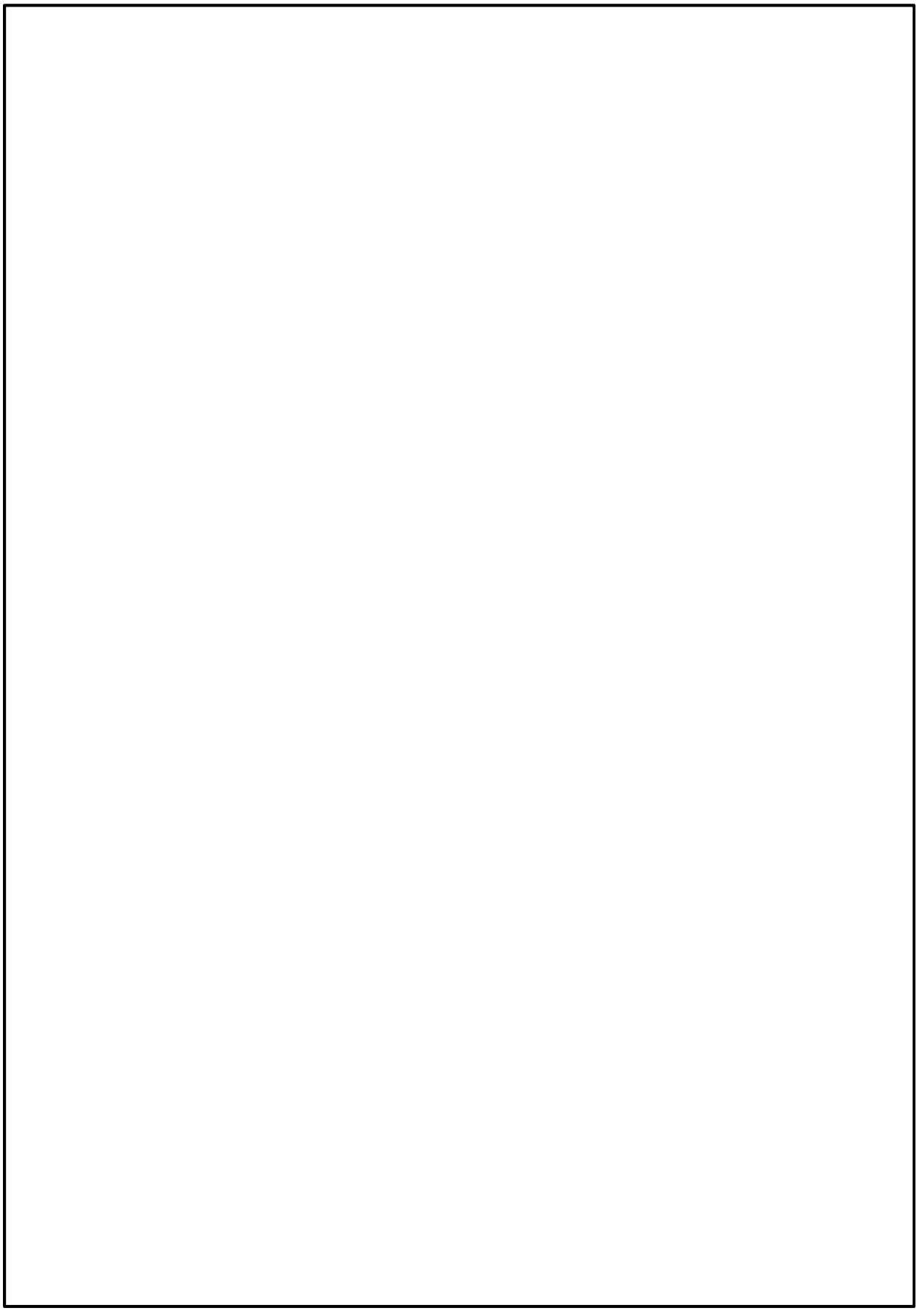
Common Name	Scientific Name	Date of last record
Water dependent native		
Austral Water-mat	*Lepilaena australis*	2014
Common Duckweed	*Lemna disperma*	2014
Pacific Azolla	*Azolla filiculoides*	2014
Thin Duckweed	*Landoltia punctata*	2014
Austral Mudwort	*Limosella australis*	2014
Black Box	*Eucalyptus largiflorens*	2014
Blackseed Glasswort	*Tecticornia pergranulata*	2014
Brown-back Wallaby-grass	*Rytidosperma duttonianum*	2014
Bulrush	*Typha spp.*	2014
Common Blown-grass	*Lachnagrostis filiformis s.l.*	2014
Common Nardoo	*Marsilea drummondii*	2014
Common Spike-sedge	*Eleocharis acuta*	2014
Common Swamp Wallaby-grass	*Amphibromus nervosus*	2014
Eumong	*Acacia stenophylla*	2014
Furrowed Pondweed	*Potamogeton sulcatus*	2014
Gold Rush	*Juncus flavidus*	2014
Grey Germander	*Teucrium racemosum s.l.*	2014
Large Mudwort	*Limosella curdieana*	2014
Lesser Joyweed	*Alternanthera denticulata s.l.*	2014
Narrow-leaf Dock	*Rumex tenax*	2014
Narrow-leaf Nardoo	*Marsilea costulifera*	2014
Nitre Goosefoot	*Chenopodium nitrariaceum*	2014
Northern Water-ribbons	*Cycnogeton multifructum*	2014
Pale Goodenia	*Goodenia glauca*	2014
Poison Pratia	*Lobelia concolor*	2014
Red Pondweed	*Potamogeton cheesemanii*	2014
Red Water-milfoil	*Myriophyllum verrucosum*	2014
Rigid Panic	*Walwhalleya proluta*	2014
River Bluebell	*Wahlenbergia fluminalis*	2014
River Red-gum	*Eucalyptus camaldulensis*	2014
Robust Water-milfoil	*Myriophyllum papillosum*	2014
Small Loosestrife	*Lythrum hyssopifolia*	2014
Spiny Lignum	***Duma horrida subsp. horrida***	2014
Spotted Emu-bush	***Eremophila maculata subsp. maculata***	2014
Spreading Emu-bush	***Eremophila divaricata subsp. divaricata***	2014

Common Name	Scientific Name	Date of last record
Stalked Plover-daisy	*Leiocarpa websteri*	2014
Star Bluebush	*Stelligera endecaspinis*	2014
Star Fruit	*Damasonium minus*	2014
Tall Fireweed	*Senecio runcinifolius*	2014
Tangled Lignum	*Duma florulenta*	2014
Tussock Rush	*Juncus aridicola*	2014
Waterwort	*Elatine gratioloides*	2014
Winged Water-starwort	***Callitriche umbonata***	2014
Clammy Goosefoot	*Dysphania pumilio*	2014
Pale Beauty-heads	*Calocephalus sonderi*	2014
Pale Knotweed	*Persicaria lapathifolia*	2014
Slender Groundsel	*Senecio glossanthus s.l.*	2014
Slender-fruit Saltbush	*Atriplex leptocarpa*	2014
Sprawling Saltbush	*Atriplex suberecta*	2014
Terrestrial native		
Berry Saltbush	*Atriplex semibaccata*	2014
Black Cotton-bush	*Maireana decalvans s.s.*	2014
Branching Groundsel	***Senecio cunninghamii var. cunninghamii***	2014
Bristly Wallaby-grass	*Rytidosperma setaceum*	2014
Clay Plantain	*Plantago cunninghamii*	2014
Common Wallaby-grass	*Rytidosperma caespitosum*	2014
Corky Saltbush	*Atriplex lindleyi subsp. inflata*	2014
Cotton Fireweed	*Senecio quadridentatus*	2014
Dark Roly-poly	***Sclerolaena muricata var. semiglabra***	2014
Dense Crassula	*Crassula colorata*	2014
Fuzzy New Holland Daisy	*Vittadinia cuneata var. cuneata*	2014
Fuzzy New Holland Daisy	***Vittadinia cuneata var. morrisii***	2014
Grassland Wood-sorrel	*Oxalis perennans*	2014
Grey Copperburr	*Sclerolaena diacantha*	2014
Grey Roly-poly	*Sclerolaena muricata var. villosa*	2014
Hedge Saltbush	*Rhagodia spinescens*	2014
Jersey Cudweed	*Helichrysum luteoalbum*	2014
Knotty Spear-grass	*Austrostipa nodosa*	2014
Nodding Saltbush	*Einadia nutans*	2014
Old-man Saltbush	*Atriplex nummularia subsp. nummularia*	2014
Paper Sunray	*Rhodanthe corymbiflora*	2014
Prickly Saltwort	*Salsola tragus subsp. tragus*	2014
Rough Spear-grass	*Austrostipa scabra subsp. falcata*	2014
Ruby Saltbush	*Enchylaena tomentosa var. tomentosa*	2014
Salt Sea-spurrey	*Spergularia brevifolia*	2014
Short-leaf Bluebush	*Maireana brevifolia*	2014

Common Name	Scientific Name	Date of last record
Short-wing Saltbush	*Sclerochlamys brachyptera*	2014
Spider Grass	*Enteropogon acicularis*	2014
Woolly New Holland Daisy	*Vittadinia gracilis*	2014
Introduced		
African Box-thorn	*Lycium ferocissimum*	2014
Annual Beard-grass	*Polypogon monspeliensis*	2014
Annual White Clover	*Trifolium michelianum var. michelianum*	2014
Aster-weed	*Aster subulatus*	2014
Barley-grass	*Hordeum murinum s.l.*	2014
Bearded Oat	*Avena barbata*	2014
Black Nightshade	*Solanum nigrum s.l.*	2014
Burr Medic	*Medicago polymorpha*	2014
Celery Buttercup	*Ranunculus sceleratus subsp. sceleratus*	2014
Cluster Clover	*Trifolium glomeratum*	2014
Common Peppercress	*Lepidium africanum*	2014
Common Sow-thistle	*Sonchus oleraceus*	2014
Common Vetch	*Vicia sativa subsp. sativa*	2014
Curled Dock	*Rumex crispus*	2014
Drain Flat-sedge	*Cyperus eragrostis*	2014
Ferny Cotula	*Cotula bipinnata*	2014
Golden Thistle	*Scolymus hispanicus*	2014
Great Brome	*Bromus diandrus*	2014
Hare's-foot Clover	*Trifolium arvense var. arvense*	2014
Lesser Canary-grass	*Phalaris minor*	2014
Marsh Fox-tail	*Alopecurus geniculatus*	2014
Ox-tongue	*Helminthotheca echioides*	2014
Paradoxical Canary-grass	*Phalaris paradoxa*	2014
Paspalum	*Paspalum dilatatum*	2014
Prickly Lettuce	*Lactuca serriola*	2014
Prostrate Knotweed	*Polygonum aviculare s.l.*	2014
Ribwort	*Plantago lanceolata*	2014
Rough Sow-thistle	*Sonchus asper s.l.*	2014
Scorzonera	*Scorzonera laciniata*	2014
Small Ice-plant	*Mesembryanthemum nodiflorum*	2014
Smooth Mustard	*Sisymbrium erysimoides*	2014
Soft Brome	*Bromus hordeaceus subsp. hordeaceus*	2014
Spear Thistle	*Cirsium vulgare*	2014
Strawberry Clover	*Trifolium fragiferum var. fragiferum*	2014
Subterranean Clover	*Trifolium subterraneum*	2014
Sweet Briar	*Rosa rubiginosa*	2014
Variegated Thistle	*Silybum marianum*	2014

Common Name	Scientific Name	Date of last record
Wall Fescue	*Vulpia muralis*	2014
Water Couch	*Paspalum distichum*	2014
Water Crassula	*Crassula natans var. minus*	2014
Wimmera Rye-grass	*Lolium rigidum*	2014
Woolly Clover	*Trifolium tomentosum var. tomentosum*	2014

Appendix 2. Bathymetry mapping for Wirra-Lo Wetland Complex



Source: Northern Land Solutions 2014.

Appendix 3. EVC mapping for Wirra-Lo Wetland Complex

Source: Rakali Ecological Consulting 2015.

Appendix 4. Alignment with Schedule 9 of the Basin Plan – Ecosystem Function

Item	Criteria	Meets criteria	Description for Wirra-Lo Wetland Complex
Criterion 1: The ecosystem function supports the creation and maintenance of vital habitats and populations			
1	**Assessment indicator:** An ecosystem function requires environmental watering to sustain it if it provides vital habitat including:		
	(a) a refugium for native water-dependent biota during dry periods and drought; or	✓	Prior to the drought the Wirra-Lo Wetland Complex provided permanent refuge for EPBC- listed Growling Grass Frog to recolonise the Benjeroop/Murrabit West floodplain after dry periods or droughts.
	(b) pathways for the dispersal, migration and movement of native water-dependent biota; or	✓	Wirra-Lo Wetland Complex is located on the floodplain of three waterways (Barr Creek, Loddon River and Murray River) and provides a stepping stone for biota moving between these waterways.
	(c) a diversity of important feeding, breeding and nursery sites for native water-dependent biota; or	✓	Feeding habitat for a high diversity of waterbirds, breeding habitat for frogs and possible waterbirds (knowledge gap).
	(d) a diversity of aquatic environments including pools, rifle and run environments; or	✓	The Wirra-Lo Wetland Complex provides a diversity of habitat types including deep open water areas, freshwater meadows, marshes and swamps and associated mudflats.
	(e) a vital habitat that is essential for preventing the decline of native water-dependent biota.	✓	Wirra-Lo Wetland Complex provides vital habitat for EPBC- listed Growling Grass Frog,
Criterion 2: The ecosystem function supports the transportation and dilution of nutrients, organic matter and sediment			
2	**Assessment indicator:** An ecosystem function requires environmental watering to sustain it if it provides for the transportation and dilution of nutrients, organic matter and sediment, including:		
	(a) pathways for the dispersal and movement of organic and inorganic sediment, delivery to downstream reaches and to the ocean, and to and from the floodplain; or	O	Wirra-Lo Wetland Complex has the potential to be an important component in the dispersal of organic and inorganic sediments and through reconnection of drainage lines from the wetlands to the Loddon River..
	(b) the dilution of carbon and nutrients from the floodplain to the river systems.	X	

Item	Criteria	Meets criteria	Description for Wirra-Lo Wetland Complex
Criterion 3: The ecosystem function provides connections along a watercourse (longitudinal connections)			
3	**Assessment indicator:** An ecosystem function requires environmental watering to sustain it if it provides connections along a watercourse or to the ocean, including longitudinal connections:		
	(a) for dispersal and re-colonisation of native water-dependent communities; or	X	
	(b) for migration to fulfil requirements of life history stages; or	X	
	(c) For in-stream primary production.	X	
Criterion 4: The ecosystem function provides connections across floodplains, adjacent wetlands and billabongs (lateral connections)			
4	**Assessment indicator:** An ecosystem function requires environmental watering to sustain it if it provides connections across floodplains, adjacent wetlands and billabongs, including:		
	(a) lateral connections for foraging, migration and re-colonisation of native water-dependent species and communities; or	X	
	(b) lateral connections for off-stream primary production.	X	

Appendix 5. Alignment with Schedule 8 of the Basin Plan

Item	Criteria	Meets criteria	Justification
Criterion 1: The water-dependent ecosystem is formally recognised in international agreements or, with environmental watering, is capable of supporting species listed in those agreements			
1	Assessment indicator: A water-dependent ecosystem is an environmental asset that requires environmental watering if it is:		
	(a) a declared Ramsar wetland; or		
	(b) with environmental watering, capable of supporting a species listed in or under the JAMBA, CAMBA, ROKAMBA or the Bonn Convention.	✓	Eastern Great (JAMBA/CAMBA listed) and Latham's Snipe (JAMBA/CAMBA/ROKAMBA) have been recorded at Wirra-lo Wetland Complex.
Criterion 2: The water-dependent ecosystem is natural or near-natural, rare or unique			
2	Assessment indicator: A water-dependent ecosystem is an environmental asset that requires environmental watering if it:		
	(a) represents a natural or near-natural example of a particular type of water-dependent ecosystem as evidenced by a relative lack of post-1788 human induced hydrologic disturbance or adverse impacts on ecological character; or		
	(b) represents the only example of a particular type of water-dependent ecosystem in the Murray-Darling Basin; or		
	(c) represents a rare example of a particular type of water-dependent ecosystem in the Murray-Darling Basin.		
Criterion 3: The water-dependent ecosystem provides vital habitat			
3	Assessment indicator: A water-dependent ecosystem is an environmental asset that requires environmental watering if it:		
	(a) provides vital habitat, including: (i) a refuge for native water-dependent biota during dry spells and drought; or		
	(ii) pathways for the dispersal, migration and movements of native water-dependent biota; or		
	(iii) important feeding, breeding and nursery sites for native water-dependent biota; or	✓	The Wirra-lo Wetland Complex provides a number of areas suitable for waterbird breeding. The nationally threatened Growling Grass Frog has been known to breed at the complex up to at least 2006.
	(b) is essential for maintaining, and preventing declines of, native water-	✓	With the removal of irrigation infrastructure throughout the area the Wirra-lo

Item	Criteria	Meets criteria	Justification
	dependent biota.		wetland complex is critically important for water dependent fauna in the area, particularly frogs.
Criterion 4: Water-dependent ecosystems that support Commonwealth, State or Territory listed threatened species or communities			
4	Assessment indicator: A water-dependent ecosystem is an environmental asset that requires environmental watering if it:		
	(a) supports a listed threatened ecological community or listed threatened species; or Note: See the definitions of ***listed threatened ecological community*** and ***listed threatened species*** in section 1.07. (Listed under the EPBC Act 1999)	✓	The Wirra-lo Wetland Complex has been known to support two nationally threatened species intermittently up to at least 2005, being: • Growling Grass Frog • Australasian Bittern
	(b) supports water-dependent ecosystems treated as threatened or endangered (however described) under State or Territory law; or	✓	Subject to further investigation, the Wirra-lo Wetland Complex supports one endangered and four vulnerable EVCs within the Murray Fans Bioregion. Plant taxa that belong to the EVC Red Gum Swamp (EVC 292) are also protected under the FFG Act (DEPI, 2014c).
	(c) supports one or more native water-dependent species treated as threatened or endangered (however described) under State or Territory law.	✓	Other than the nationally threatened species listed above the Wirra-lo Wetland Complex supports an additional two state listed fauna species.
Criterion 5: The water-dependent ecosystem supports, or with environmental watering is capable of supporting, significant biodiversity			
5	Assessment indicator: A water-dependent ecosystem is an environmental asset that requires environmental watering if it supports, or with environmental watering is capable of supporting, significant biological diversity. This includes a water-dependent ecosystem that:		
	(a) supports, or with environmental watering is capable of supporting, significant numbers of individuals of native water-dependent species; or		To be confirmed but likely
	(b) supports, or with environmental watering is capable of supporting, significant levels of native biodiversity at the genus or family taxonomic level, or at the ecological community level.		

Appendix 6. Outcomes of Scientific peer review (Butcher et al. 2015)

A61. Wirra-Lo Complex

The Wirra-Lo Complex is located on an active floodplain area between the lower Loddon River and the Murray River. The wetland complex is privately owned and has undergone considerable change in landuse since 1992 when the current landholder purchased the property. The widespread flooding that occurred in 2010 and 2011 also had significant impacts on the wetland complex as the flooding was rapid and extensive, having severe impacts on ground dwelling invertebrates, reptiles and aquatic biota.

Retirement of irrigation licences means that Goulburn-Murray Water is rationalising irrigation water delivery in the area; this has implications for water delivery to the wetland complex (e.g. alternative routes and additional infrastructure will be required to maintain environmental watering across the wetland complex).

Environmental values at the site include the presence of the EPBC-listed Growling Grass Frog (*Litoria raniformis*) and Australian Bittern (*Botaurus poiciloptilus*), and FFG-listed Eastern Great Egret (*Ardea modesta*). Threatened plant species are present locally, but are outside the site boundaries.

The wetland complex can be considered as four water management units:

1. Duck Creek South
2. Duck Creek North
3. Red Gum Swamp
4. Lignum Swamp

Alternate management of water in Duck Lake South and Duck Lake North, in particular, is considered a key management tool. For example, being able to dry either Duck Lake South or Duck Lake North will be advantageous to minimise the threat associated with fish predation on Growling Grass Frog populations. An increase in River Red Gum canopy cover is also proposed as a key management objective, as adult Growling Grass Frogs also utilise woodlands when foraging.

A61.1. General observations

The local groundwater table is thought to have dropped in recent times (i.e. over the Millennium Drought); however, current depth to groundwater and changes in response to the 2010-11 floods is unknown. There was little evidence of salinity issues across the site when visited in March 2015. There is no active groundwater monitoring within 1 km of the site and the lack of such groundwater information prohibits a valuable monitoring benchmark of local groundwater level and salinity prior to wetland watering. Available time-series of groundwater level monitoring data and known regional (as opposed to local) water level data suggests the depth to water table can be in the range of 2-4 m and that groundwater is highly saline (i.e. > 50,000 EC).

It is recommended that the North Central CMA establish groundwater monitoring at Wirra-Lo to include:

- Utilisation of an existing nearby groundwater level monitoring bore in the Parilla Sand Aquifer to provide long-term aquifer characteristics.
- Establish a groundwater level monitoring bore and a surface water monitoring site at the Northern extent of the Duck Creek wetland.

Groundwater and surface water level and quality information would be monitored to 1) assist management of surface water level and salinity; and 2) understand any changes to the groundwater system which may be caused by the proposed environmental watering regimes. Surface and groundwater water quality should be monitored weekly for the first 2 years, and then reviewed.

Overall wetland condition was reported by Rakali Consulting (2015) as poor, although there was considerable variability across the complex, with areas of Lignum Swampy Woodland and Intermittent Swamp Woodland being in good and moderate condition (respectively). Poor conditions were considered by Rakali Consulting to be influenced by factors such as poor catchment condition, altered hydrology, the presence of weeds and poor tree condition.

A61.2. Overarching objectives

The objectives and EWRs considered at the workshop by North Central CMA staff and the scientific panel initially focussed on Duck Creek South; the insights gained and overall approach developed for Duck Creek South were then applied (with modifications) to Duck Creek North, Red Gum Swamp and Lignum Swamp. The development of an over-arching management goal set for the entire wetland complex was considered appropriate (see text box below).

Wirra-Lo Wetland Complex water management goal

To provide vital habitat including the provision of refuge and suitable breeding conditions for Growling Grass Frog (*Litoria raniformis*), and to provide high quality feeding and breeding habitat for a large diversity of waterbirds by rehabilitating the River Red Gum (*Eucalyptus camaldulensis*) woodland and aquatic vegetation communities.

Overall, the frequency of watering at the complex scale is envisaged as 1 in 2 years, although the frequency and extent and/or depth may vary between and within the four wetland units.

A61.3. Duck Creek (South and North)

A61.3.1. Objectives

The intention, within a 10-year management cycle, is to fill the main channels and inundate the floodplain in winter-spring. The floodplain is then expected to dry over the next 3-6 months (i.e. over summer), whilst the channel will dry at a slower rate (8-10 months) but can be topped up to maintain depth at 0.3-0.5 m to preserve Growling Grass Frog habitat.

Objectives for Duck Creek South are included in **Error! Reference source not found.**. Proposed amendments include:

- Objective 1.1 – Maintain the objective, although the associated tolerance limits for the environmental watering regime were considered NA.
- Objective 1.2 – Maintain the objective but was reworded to confirm that 'extent' related to longitudinal extent along Duck Creek. The intention is that the inundation extent be maintained over time. The increased inundation duration in the creek was noted in terms of the potential threat of excessive encroachment by *Typha*. It was recommended that a management response be prepared to address *Typha* encroachment should it occur. For example, if *Typha* encroachment exceeds 10% of the channel, then it should be dried in summer-autumn for 2 years. Such an approach is possible with the infrastructure proposed for the wetland complex and the ability to isolate Duck Creek South from Duck Creek North. The scientific panel recommended that watering of Duck Creek South should initially commence in spring (rather than summer) so that the response of *Typha* can be evaluated.

- Objective 1.3 – Maintain the objective, as for 1.1 and 1.2. The scientific panel recommended that River Red Gum response be monitored in the first year to provide information on whether or not watering is required in subsequent years. For example, if there is a large germination event, then consideration can be given to a longer wetting cycle in year 2, so that regeneration is not excessive. This will need to be managed carefully if some regeneration is desirable (note that two consecutive years of watering is typically recommended, the second year of a shorter duration, to aid River Red Gum saplings to establish – see Roberts and Marston 2011).
- Objectives 1.4 and 1.5 – The scientific panel recommended that these objectives be omitted, as the priority objective is to promote habitat for Growling Grass Frog and River Red Gum.
- Objective 2.1 – Maintain the objective, although the watering regime is likely to be met by that of the preceding vegetation objectives.
- Objective 3.1 – Maintain the objective.
- Objective 3.2 – The scientific panel recommended that this objective be moved to the justification associated with River Red Gum objective, rather than stand in its own right.

A61.3.2. Environmental watering requirements

The watering regime to meet River Red Gum requirements (**Error! Reference source not found.**) is based on information contained in Roberts and Marston (2011) and Rakali (2014), and was considered by the scientific panel to be appropriate. The watering regime proposed includes full watering (channel and floodplain) in spring, supplemented with autumn watering of the channel so that frog habitat persists.

The conceptual underpinning of environmental watering at Duck Creek South is summarised in **Error! Reference source not found.**. The conceptual model illustrates the pathway and processes associated with delivery of environmental water for provision of vital habitat to support Growling Grass Frog. Controlling variables beyond the influence of environmental water delivery that may affect the outcome for this species include the size of the regional population and factors affecting dispersal of adults to Wirra-Lo, as well as food resources for the adult frogs at Wirra-Lo. Growling Grass Frog adults select habitat based on terrestrial woodland and grassland characteristics and feed on terrestrial invertebrates. The landholder of Wirra-Lo has noted the impacts of the 2011 floods, one of which was to wipe out much of the ground dwelling invertebrates (K. Hooper, pers. comm., March 2015). During the site visit, ants were observed to be present and Mr Hooper commented that this was a relatively recent occurrence. The dispersal conditions and food resources at Wirra-Lo are covariates that may affect the success of returning Growling Grass Frog adults to the site, but at present these remain a knowledge gap.

The delivery of environmental water is expected to lead to the germination of seeds from different functional guilds of plants (emergent, amphibious and aquatic) within each of the four wetland units at Wirra-Lo, with the watering regime designed to promote gains in diversity and regeneration. Invertebrates will emerge from the sediments on wetting of previously dry soils, and as an important part of the food chain will in turn support fish and waterbirds. Establishment of near permanent water at the site potentially dense stands of aquatic vegetation will provide vital breeding habitat for the Growling Grass Frog as well as other frog species.

It is likely that fish will arrive with the environmental water, including carp and Eastern gambusia. The management of the watering regime in Duck Creek North and South will be to occasionally dry one area to cracking soils, so as to reduce fish predation on Growling Grass Frog tadpoles. The frequency and duration of these drying events are at present a knowledge gap.

Delivery of water to improve River Red Gum and Black Box (*Eucalyptus largiflorens*) recruitment will increase woodland complexity and promote resilience in the populations. Lignum habitat and

inundated floodplain will provide vital habitat as important feeding and breeding areas for waterbirds, while the woodland can also support terrestrial threatened species such as the Grey-Crowned Babbler (*Pomatostomus temporalis*).

Figure A6 1: Conceptual model of environmental watering outcomes at Duck Creek South.

Table A6 1: Environmental watering requirements for Wirra-Lo Wetland Complex - Duck Creek South (FP = floodplain; Ch = channel)

Ecological Objectives	Water management area	Environmental watering requirements											
		Recommended number of events in 10 years			Tolerable interval between events once wetland is dry (months)			Duration of ponding (months)			Preferred timing of inflows	Volume to fill to target supply level (ML)	Depth (m)
		Min	Opt	Max	Min	Opt	Max	Min	Opt	Max			
1. Habitat Objectives													
1.1 To increase the extent of floating, submerged and emergent aquatic vegetation associated with Aquatic Herbland (e.g. *Triglochin* spp., *Potamogeton* spp.)	Bed and fringe	5	6-8	8	NA			4	3-6 (FP) 8-10 (Ch)	12	Autumn/ Spring	Depends on wetland area	0.3 – 1.0 (~0.8 initial)
1.2 To increase the longitudinal extent of emergent aquatic vegetation along Duck Creek associated with Tall Marsh (including *Typha* spp., *Juncus* spp. and *Eleocharis* spp.)	Fringe	5	6-8	8	12		60	4	8	12	Winter/ Spring		0.2 – 1.0
1.3 To maintain/ rehabilitate the health of adult River Red Gum (*Eucalyptus camaldulensis*) trees recruitment (Intermittent Swampy Woodland).	Fringe	2	3-6	7	6	18-30	54	2	4	18	Winter/ Spring		Not critical

Ecological Objectives	Water management area	Environmental watering requirements											
		Recommended number of events in 10 years			Tolerable interval between events once wetland is dry (months)			Duration of ponding (months)			Preferred timing of inflows	Volume to fill to target supply level (ML)	Depth (m)
		Min	Opt	Max	Min	Opt	Max	Min	Opt	Max			
2. Species Objectives													
2.1 To provide refuge and suitable breeding conditions for EPBC-listed Growling Grass Frog (*Litoria raniformis*) in Duck Creek North and Duck Creek South.	Bed and fringe	7	8	10	Unknown, prefers seasonal to permanent water bodies			5	7	-	Spring/ Summer	Depends on wetland area	N/A
3. Process objectives													
3.1 Maintain/rehabilitate appropriate seasonality and duration of wetting and drying	Complex	Dependent on implementing the above objectives											

A61.4. Red Gum Swamp

A61.4.1. Objectives

It was agreed at the workshop that the main objective for environmental watering in the Red Gum Swamp unit would be to rehabilitate the health of existing River Red Gum and promote regeneration (i.e. Objective 1.3. (**Error! Reference source not found.**)). Objectives 1.1-1.2 and 1.4-1.6 are to be removed.

Watering in this unit of the complex will be undertaken within the context of being a 5-year rehabilitation of River Red Gum within the Intermittent Swampy Woodland and Lignum Swampy Woodland EVCs. However, the aim of River Red Gum regeneration should not be a barrier to achieving gains elsewhere, such as in the Emu Creek area.

A61.4.2. Environmental watering regime

The proposed environmental watering requirements (based on the needs of River Red Gum) were taken from Roberts and Marston (2011) and were considered by the scientific panel to be appropriate. The scientific panel recommends that monitoring of River Red Gum response occurs in the first three years and then reviewed to allow for adjustments of the watering regime, as necessary.

A61.5. Lignum Swamp

A61.5.1. Objectives

It was agreed at the workshop that the approach developed for Duck Creek South (floodplain component) will also be applied to the Lignum Swamp unit. The intent is to rehabilitate River Red Gum condition, with the expectation that aquatic and amphibious species will also benefit.

A61.5.2. Environmental watering regime

The watering regime will aim to fill the wetland to 71.6 m AHD 4-6 years in 10. To promote River Red Gum regeneration and establishment, watering will include watering in two consecutive years, followed by a gap (drying), then watering for another two consecutive years. Watering in an individual year can also be included over the 10-year period of the EWMP.

Watering will also be managed to ensure that any opportunistic water bird breeding event of note continues until fledging.

Table A6 2: Environmental watering requirements for Wirra-Lo Wetland Complex - Red Gum Swamp

Ecological Objectives	Water management area	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	Volume to fill to target supply level (ML)	Depth (m)
		Min	Opt	Max	Min	Opt	Max	Min	Opt	Max			
1. Habitat Objectives													
1.3 To rehabilitate the health of adult River Red Gum (*Eucalyptus camaldulensis*) trees (Intermittent Swampy Woodland).	Bed and fringe	2	4	5	12	48	84	2	4	18	Winter - Spring	Depends on wetland area	Not critical
1.3 To facilitate recruitment of River Red Gum (*Eucalyptus camaldulensis*) trees (Intermittent Swampy Woodland).	Bed and Fringe	2*	3*	5*	Follow up flooding required then as per adult			1	2	-	Late Spring – Early Summer		0.2 – 0.3

*number of desired recruitment events, follow up flooding required