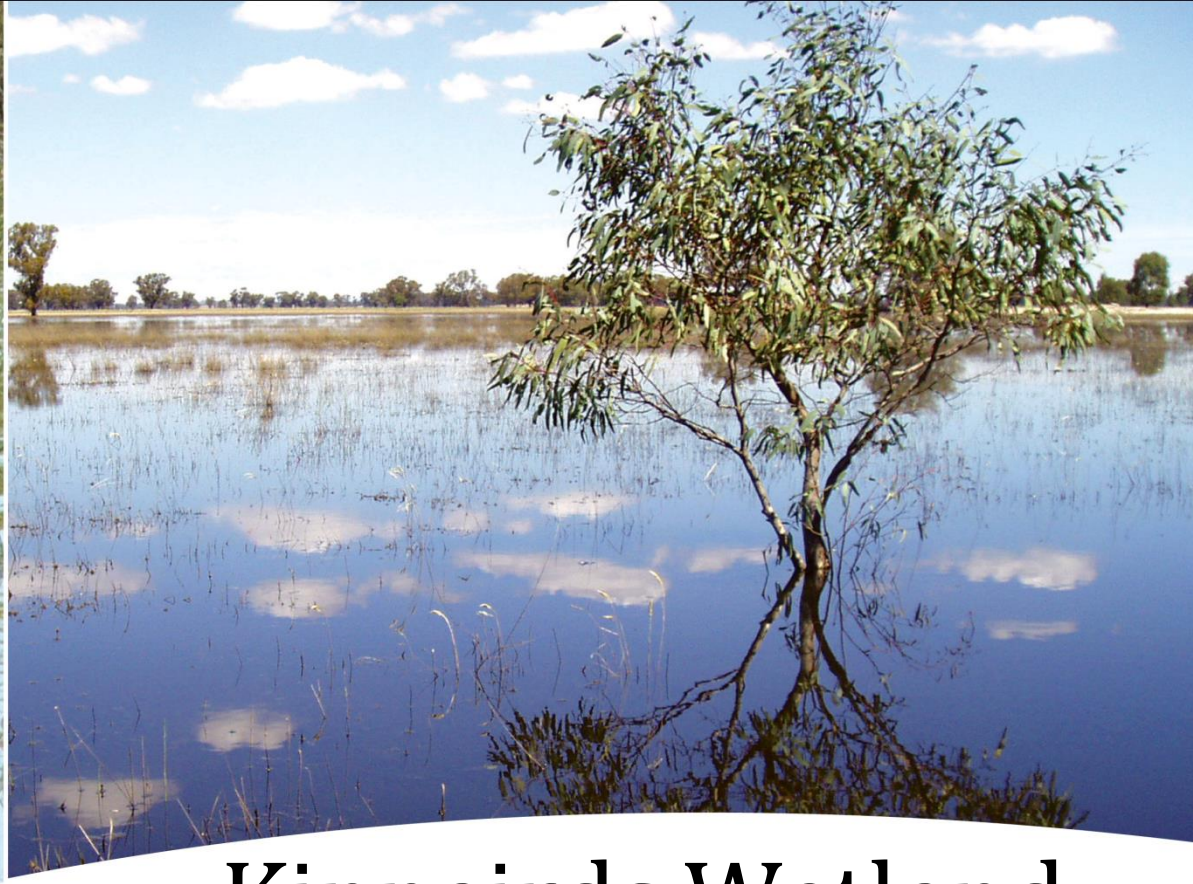

Kinnairds Wetland Environmental Water Management Plan 2011

Goulburn Broken Catchment Management Authority

GOULBURN BROKEN
CATCHMENT MANAGEMENT AUTHORITY

DOCUMENT CONTROL

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MANAGEMENT

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Date 2011

Citation GB CMA (2011) 'Kinnaird's Swamp Environmental Water Management Plan.' Goulburn Broken Catchment Management Authority, Shepparton, Victoria.

EXECUTIVE SUMMARY

This plan outlines the water regimes required to protect and enhance the water dependent environmental values for Kinnairds Swamp. This information will inform the management of the wetlands and the development of seasonal watering proposal for wetlands in the Goulburn Broken Catchment for consideration by the VEWH.

Kinnairds Swamp is a shallow and seasonal Red Gum Swamp. It is located 1 km north east of Numurkah Township in northern Victoria. The wetland provides important breeding habitat for Royal Spoonbills and contains the largest known population of the *Environment Protection Biodiversity Conservation Act* (1999) listed rigid water-milfoil (*Myriophyllum porcatum*) within the Goulburn Broken Catchment and Victoria. The wetland is at the terminal end of the larger Muckatah Depression. The wetland is managed by Moira Shire and Goulburn-Murray Water. It is valued for its rarity, species diversity and waterbird habitat.

In the plan the following four ecological objectives have been established for the wetland:

- Improve the diversity of native wetland flora species to be consistent with EVC benchmarks;
- reduce the cover and diversity of exotic flora species;
- maintain populations of rigid water-milfoil and slender water-milfoil;
- maintain or increase the diversity and abundance of frog species supported by the wetland during flood events;
- provide opportunities for waterbird breeding; and
- provide feeding habitat for significant waterbird species.

To achieve these ecological objectives minimum, optimum and maximum watering regimes are recommended. These are summarised in the table below. The ecological objectives and watering regimes were developed by a Scientific Technical Committee.

Watering Regime for Kinnairds Swamp

Minimum – *Provide two flooding events in ten years, filling the wetland to variable depths to maintain EVCs with minimum water requirements to allow survival of existing vegetation.*

Optimum – *Provide five to seven flooding events in ten years, filling the wetland to variable depths to provide EVCs with appropriate watering requirements, allow the regeneration and recruitment of species within the wetland body and encourage breeding opportunities for aquatic fauna.*

Maximum – *Provide an annual flooding event over a ten year period, filling the wetland to variable depths to encourage growth of EVCs or breeding opportunities for aquatic biota.*

The plan also details potential risks associated with the delivery of environmental water to the wetland, opportunities to improve the environmental water delivery efficiency to the wetland, and key environmental water management knowledge gaps including the flood regime tolerances of aquatic dependent ecological vegetation classes and their associated flora species such as rigid water-milfoil.

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ACKNOWLEDGEMENTS

This report could not have been developed without the assistance and patience of many individuals. Acknowledgement goes to the team at Australian Ecosystems for their consistent data collection within the Goulburn Broken Catchment wetlands and reports developed.

Members of the Scientific Technical Group which comprised Keith Ward (Goulburn Broken Catchment Management Authority), Rolf Weber (Department of Sustainability and Environment), Gary Deayton (Moira Shire), Sam Green (Goulburn-Murray Water), Damien Cook (Australian Ecosystems) and Doug Frood (Pathways Bushland and Environment Consultant) for their input and development into the watering plans. Lisa Deayton for her research on the history of Kinnairds Swamp. Jane Roberts and Terry Hillman for their scientific review and valuable insights into writing an Environmental Water Management Plan.

ABBREVIATIONS

CAMBA	China Australia Migratory Bird Agreement
CEWH	Commonwealth Environmental Water Holder
CMA	Catchment Management Authorities
DSE	Department of Sustainability and Environment
EC	Electrical Conductivity
EPBC	*Environment Protection Biodiversity Conservation Act 1999*
EVC	Ecological vegetation community
EWA	Environmental Water Allocation
EWMP	Environmental Water Management Plan
EWR	Environmental water reserve
FFG	*Flora and Fauna Guarantee Act 1988*
GB CMA	Goulburn Broken Catchment Management Authority
GIS	Geographic Information System
GL	Gigalitre (one billion litres)
GMID	Goulburn-Murray Irrigation District
G-MW	Goulburn-Murray Water
IWC	Index of Wetland Condition
JAMBA	Japan Australia Migratory Birds Agreement
ML	Megalitre (one million litres)
NVIRP	Northern Victoria Irrigation Renewal Project
ROKAMBA	Republic of Korea Australia Migratory Bird Agreement
SKM	Sinclair Knight Mertz
VEWH	Victorian Environmental Water Holder

1. INTRODUCTION

1.1 BACKGROUND

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

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

1.2 PURPOSE

The Victorian Catchment Management Authorities (CMAs), Department of Sustainability and Environment (DSE) and the Victorian Environmental Water Holder (VEWH) are working together to develop new Environmental Water Management Plans for both current and future environmental watering sites throughout northern Victoria. The primary purpose of the plans is to provide a consistent set of documents that support Seasonal Watering Proposals to be submitted by CMAs to the Victorian Environmental Water Holder annually (section 6.3 – Implementation: Seasonally Adaptive Approach). The supporting information will include:

- lead management agencies and their management responsibilities;
- the water dependant environmental, social and economic values of the site;
- the sites environmental conditions and threats;
- hydrological and ecological objectives;
- opportunities for improved water delivery, efficiency or capacity through structural works or other measures; and
- scientific knowledge gaps and recommendations for future work.

This document is the Environmental Water Management Plan for Kinnairds Swamp in the Goulburn Broken Catchment Management region. This watering plan is not a holistic management plan for the site it is limited to issues related to the management of water dependent values and environmental water.

1.3 REGION

The Goulburn Broken Catchment comprises the catchments of the Goulburn and Broken River. The catchment covers a total of 2,391,544 hectares or 10.5 per cent of Victoria's total land area (Figure 1) and approximately two per cent of the Murray Darling Basins total land area (DNRE, 2002). Despite its small contribution to the total land area of the Murray Darling Basin, it generates 11 per cent of the basins water resources. Within the Goulburn Broken Catchment approximately 2,000 natural wetlands have been recorded including a number of wetlands formally recognised for their conservation significance. These include the internationally significant Barmah Forest Ramsar site, ten wetlands of national significance listed in *A Directory of Important Wetlands in Australia* (EA, 2001) and 111 wetlands of bioregional significance identified for the *National Land and Water Resource Audit* (CoA, 2002). In addition, a large number of wetlands support state and nationally threatened biota communities and birds listed on international agreements and conventions.

Kinnairds Swamp is a 96 hectare seasonal shallow freshwater marsh within the larger Goulburn Broken Catchment (Figure 1). The swamp is situated within the localised Muckatah catchment (section 2.1 – catchment history) north-east of the Numurkah township (Figure 2). Kinnairds Swamp is managed both publically and privately (section 2.3 – wetland characteristics, Figure 3). This plan focuses on the public planning area only.

Prior to European settlement, Kinnairds Swamp was a seasonal open River Red Gum Swamp filling on a near annual basis in winter-spring from rainfall and run-off from the surrounding catchment and drying out in the summer-autumn (DPI, 2003). Post-European settlement saw Kinnairds Swamp partially cleared in the 1840s for pig and sheep farming and cropping (Bossence, 1979) . The name Kinnairds comes from a land owner that had property surrounding the current swamp area. The property flooded in May 1889 and Bossence (1979) states "*an immense sheet of water spread over the land….water flowed over the top fence wires on Mr Alan Kinnairds Farm*."

Irrigated agriculture was introduced into the Numurkah area post World War II (section 2.1 - Catchment history) with Kinnairds Swamp being used for grazing and cropping oats (DPI, 2003) however, irrigation run-off caused prolonged flooding along the Muckatah Depression and into Kinnairds Swamp. Between the 1950s and the 1970s a variety of attempts were made to control or eliminate the flooding of the wetland with drains and banks being constructed from the Broken Creek to the upper reaches of the wetland. However, this was to no avail and prolonged flooding caused changes to vegetation characteristics by drowning trees and creating open areas dominated by sedges, rushes and other species adapted to prolonged inundation.

Cropping of the Swamp was abandoned in the early 1980s and the drought of the 1980s saw a change of focus to harvesting water from Kinnairds Swamp, creating a new network of dams, banks and drains at the swamp. The annual drying frequency and duration reduced as the swamp remained wet through summer and into autumn. As a result of prolonged inundation, thickets of river red gums (*Eucalyptus camaldulensis*) formed at the southern end of the swamp.

In 1999, the Muckatah Depression Main Drain was constructed to provide drainage to ~60,000 hectares of the Muckatah catchment above Kinnairds Swamp. Part of the design included constructing the Drain to flow through the eastern section of Kinnairds Swamp (Figure 3 & 4). This created a wetland area to provide flood retardation, nutrient and sediment reduction and control discharge rates from the catchment into the Broken Creek and to create an open herbaceous swampland allowing retention of the swamps natural wetland function (section 4 - Hydrology and Systems Operations; Figure 4). It also provided the capacity to manage the flooding regime of the western section of Kinnairds Swamp (Figure 3).

Figure 1: Location of Kinnairds Swamp within the Goulburn Broken Catchment

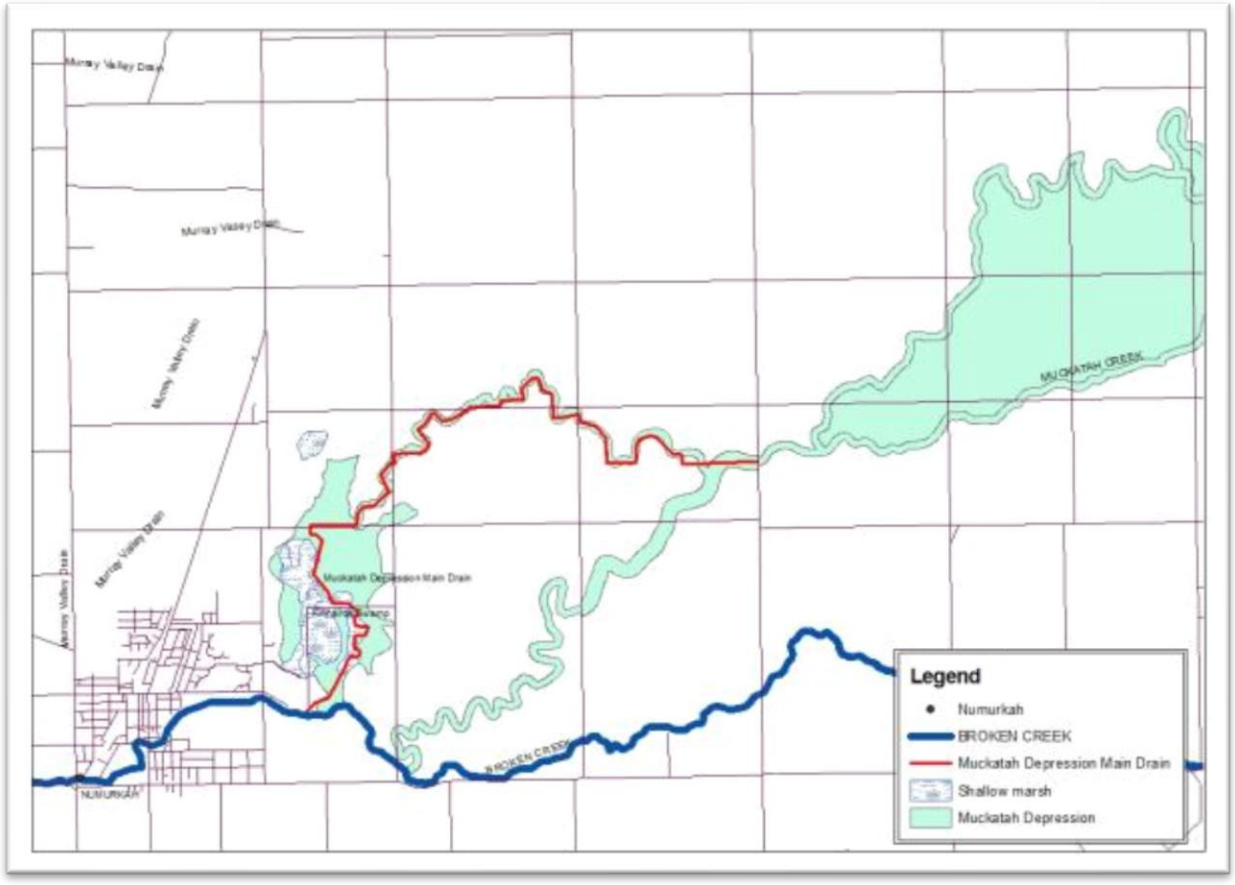

Figure 2: Location of Kinnairds Swamp in relation to the Muckatah Depression

1.4 CONSULTATION

This plan was prepared by the Goulburn Broken Catchment Management Authority with input from a Scientific Technical Committee. The Scientific Technical Committee developed ecological and hydrological goals for Kinnairds Swamp at a workshop based on the local history of the swamp, knowledge of past and present watering regimes, the water requirements to support existing ecological values and the current condition of the swamp (Appendix 1). Members of the Scientific Technical Committee included Keith Ward (Goulburn Broken CMA), Sam Green (Goulburn-Murray Water), Damien Cook (Australian Ecosystems), Doug Frood (Pathways Bushland and Environment), Rolf Weber (Department of Sustainability and Environment), Gary Deayton (Moira Shire), Jo Wood (Goulburn Broken CMA) and Simon Casanelia (Goulburn Broken CMA). Draft plans of this report were submitted to members of the Goulburn Broken Wetland Management Group and the Kinnairds Swamp Advisory Group for comment. In addition, Jane Roberts and Terry Hillman provided a scientific review of the draft plan.

1.5 INFORMATION SOURCES

Information used in the development of this Plan was compiled from various sources including:

- Goulburn Broken Regional River Health Strategy (GBCMA, 2005).
- Kinnairds Swamp Environmental Management Plan (DPI, 2003).
- Ecological Monitoring of flora and fauna response to environmental water delivery in 2008 and 2010 (Cook et al., 2009, Jolly and Osler, 2011).
- Workshop booklet from the Scientific Committee Technical Workshop (Committee, 2011).

This information was supplemented by discussions with people with an intimate knowledge of the swamp area, its environmental values, and the management and operation of Kinnairds Swamp.

In addition, a number of state-wide data sets and digital mapping layers were used including the:

- Flora Information System of Victoria (DSE, 2005a);
- Atlas of Victorian Wildlife (DSE, 2007a);
- Bioregional Conservation Status of Ecological Vegetation Classes;
- Wetland environments and extent up to 1994; and
- Moira Shire Aerial photography (2007 layer).

1.6 LIMITATIONS

The information sources used in the development of this report have a number of limitations. These limitations include the data contained in the Flora Information System and the Atlas of Victorian Wildlife comes from a combination of incidental records and systematic surveys. The data varies in accuracy and reliability due to the distribution and intensity of survey efforts. In addition, the lack of knowledge about the distribution and characteristics of invertebrates and non-vascular plant species means the data is weighted towards the less cryptic elements of flora and fauna, i.e. vascular flora and vertebrates. The water regime for Kinnairds Swamp discussed in this Plan was developed using local knowledge, technical experts, field observations and scientific literature on the water requirements of relevant aquatic flora and fauna where available.

This report also draws on material collated from management plans, research documents and published literature. These sources vary in their age and hence the degree to which they reflect the current situation. However, the Plan intends to be a live document and will be amended as new information becomes available.

2. SITE OVERVIEW

2.1 CATCHMENT HISTORY

The Muckatah catchment is situated in the Victorian Riverina which is characterised by flat to gently undulating landscape on recent unconsolidated sediments with evidence of former stream channels and wide floodplain areas associated with major river systems and prior steams. Alluvium deposits from the Cainozoic period gave rise to the red brown earths and texture contrast soils which dominate the Riverine Plain (DSE, 2011). The catchment is however, characterised by the shallow meandering ancestral watercourse known as the Muckatah Depression in which Kinnairds Swamp is part. The Muckatah Depression is a prior stream depression and fed from a 600km^2 catchment beginning near Yarrawonga on the Warby Ranges and outfalls into the Broken Creek downstream of Kinnairds Swamp (DPI, 2003, G-MW, 1999). The depression and its anabranches traverse the catchment for over 100 kilometres, forming at times a continuous series of freshwater meadows and marshes. These depression wetlands cover an area of approximately 2,000 hectares when flooded (O'Connor, 1995). Kinnairds Swamp is located on the floodplain of the lower Broken Creek at the terminal end of the Muckatah Depression.

Native vegetation in the Muckatah catchment has been extensively cleared for agriculture since European settlement in 1840s. The idea of irrigated agriculture was proposed in 1881, however the land was deemed unsuitable by Irrigation specialists the Chaffey brothers and farmers had to rely on rainfall for farming activities. In 1939 the Yarrawonga Main Channel began carrying water towards Numurkah, but work was delayed by World War II. Resumption of Irrigation works coincided with soldier settlement after the war and in 1946 as land holdings were acquired for subdivision into orchards and dairy farms with irrigation and drainage being constructed (Bossence, 1979). The current primary activities of the Muckatah catchment include intensive horticulture, dairy, and livestock production.

2.2 LAND STATUS AND MANAGEMENT

Kinnairds Swamp is managed by Goulburn-Murray Water, Moira Shire and a private landowner (section 2.3 – Wetland characteristics, Figure 3). A range of management agencies are also responsible for ensuring that management of the study area complies with a broad range of legislative requirements. Lead management agencies and their key responsibilities are summarised in Table 1. The broader community including adjacent landholders, Yorta Yorta Peoples (section 3.4.1 - Cultural heritage), Landcare, Trust for Nature and recreational users also have an interest and role in the management of the planning area. The successful management of the study area therefore relies on effective cooperation and partnership between the government agencies and the broader community.

Table 1: Lead government agencies and their key study area responsibilities

Agency	Responsibility
Aboriginal Affairs Victoria	Promote knowledge and understanding within the wider community of the study area's Aboriginal people and their history. Administer legislation protecting Aboriginal heritage sites within the study area (*State Aboriginal Heritage Act 2006* and Part IIA of the Commonwealth *Aboriginal Torres Strait Islander Heritage Protection Act 1984*).
Department of Primary Industries	Provide technical and extension support for the sustainable management of fisheries, agriculture, minerals and petroleum.
Department of Sustainability and Environment	Provide financial, policy and strategic support for the management of public and private land. Management of flora and fauna, State Forest and public Land Water Frontage. Management of hunting and domestic stock licensing on public land.
Environmental Protection Authority	Protect, restore and enhance air, land and water quality and control of unwanted noise.
Goulburn Broken Catchment Management Authority	Implementation of the Goulburn Broken Regional Catchment Strategy. Works on waterways, regional drainage and floodplain management, and co-ordinating Commonwealth and State natural resource management investment. Determining the environmental water requirements of swamps and streams, developing and submitting annual water proposals to DSE for consideration, and managing the delivery of environmental water in accordance with DSE's watering plan.
Goulburn-Murray Water	Part managers of Kinnairds Swamp. Assist with upgrades of Muckatah Surface Water Management System and implement on ground works to allow Environmental Water delivery to the Swamp.
Kinnairds Swamp Management Group	Assist with the implementation of Management Actions that have arisen from the Kinnairds Swamp Management Plan.
Murray-Darling Basin Authority	The Murray-Darling Basin Authority's principal aim is to manage the Basin's water resources in the national interest.
Moira Shire	Part managers of Kinnairds Swamp. Regulate local development through the planning scheme, on-ground works, and management of local roads and urban drainage.
Victorian Environmental Water Holder	Management of environmental water entitlements on behalf of the Minister for Environment as of July 2011.

2.3 WETLAND CHARACTERISTICS

Wetlands in Victoria are currently classified using a system developed by Corrick and Norman (1980, Appendix 2) which includes information on water depth, permanency and salinity (Corrick and Norman, 1980). Wetlands through Victoria were mapped and classified between 1975 and 1994 and developed into spatial layers (DSE, 2007b).

Kinnairds Swamp is classified as a shallow freshwater marsh in the Department of Sustainability and Environment wetlands 1994 layer. Kinnairds Swamp has a mean depth of 0.5m and has a calculated capacity of approximately 482.5 ML[1].

The wetland is located within the Victorian Riverina bioregion within the Muckatah Depression (Table 2 and Figures 2 & 3). Approximately 18 ha of the swamp is owned by Goulburn-Murray Water and 78.5 ha is owned by the Moira Shire (Figure 3). Kinnairds Swamp is surrounded by urban development on its south west margin, irrigation along the north margin and cropping and pastures along the eastern margin and the Broken Creek crown frontage on the south eastern margin (Figure 3).

Environmental water can currently be delivered to Kinnairds Swamp via the Muckatah Depression Drain. Due to delivery constraints and transmission losses from this delivery method, a scoping study has been undertaken to determine a more efficient delivery method. The study recommended environmental water should be delivered via Murray Valley 4 channel at Hendy Road (section 8.3 - Infrastructure recommendations; Paynter 2010, Figure 15). This would allow small volumes of water to be delivered directly to the eastern side of the wetland

[1] Environmental water allocation volumes will vary corresponding with ecological and hydrological targets that need to be met at the time of delivery.

Table 2: Summary of site characteristics

Characteristics	Description
Name	Kinnairds Swamp
Mapping Id	7925619057
Area (ha)	96.5
Bioregion	Victorian Riverina
Conservation Status	None
Land Status	Public and Private
Land Manager	Goulburn-Murray Water, Moira Shire, Private
Surrounding Land Use	Irrigated Agriculture, Residential and Public Land Conservation
Water Supply	Muckatah Depression and Lower Broken Creek
1788 Wetland Category	Shallow Freshwater Marsh
1994 Wetland Category	Shallow Marsh
Wetland Capacity (ML)	482.5
Mean wetland depth at Capacity (m)	0.5m*

*Note: filling Kinnairds wetland to 0.5m will not occur during every environmental watering event. Filling the wetland to variable depths will promote an increased plant species community and drawing down the wetland slowly will allow the habitat to change in its natural state, resulting in different vegetation communities establishing within the wetland body.

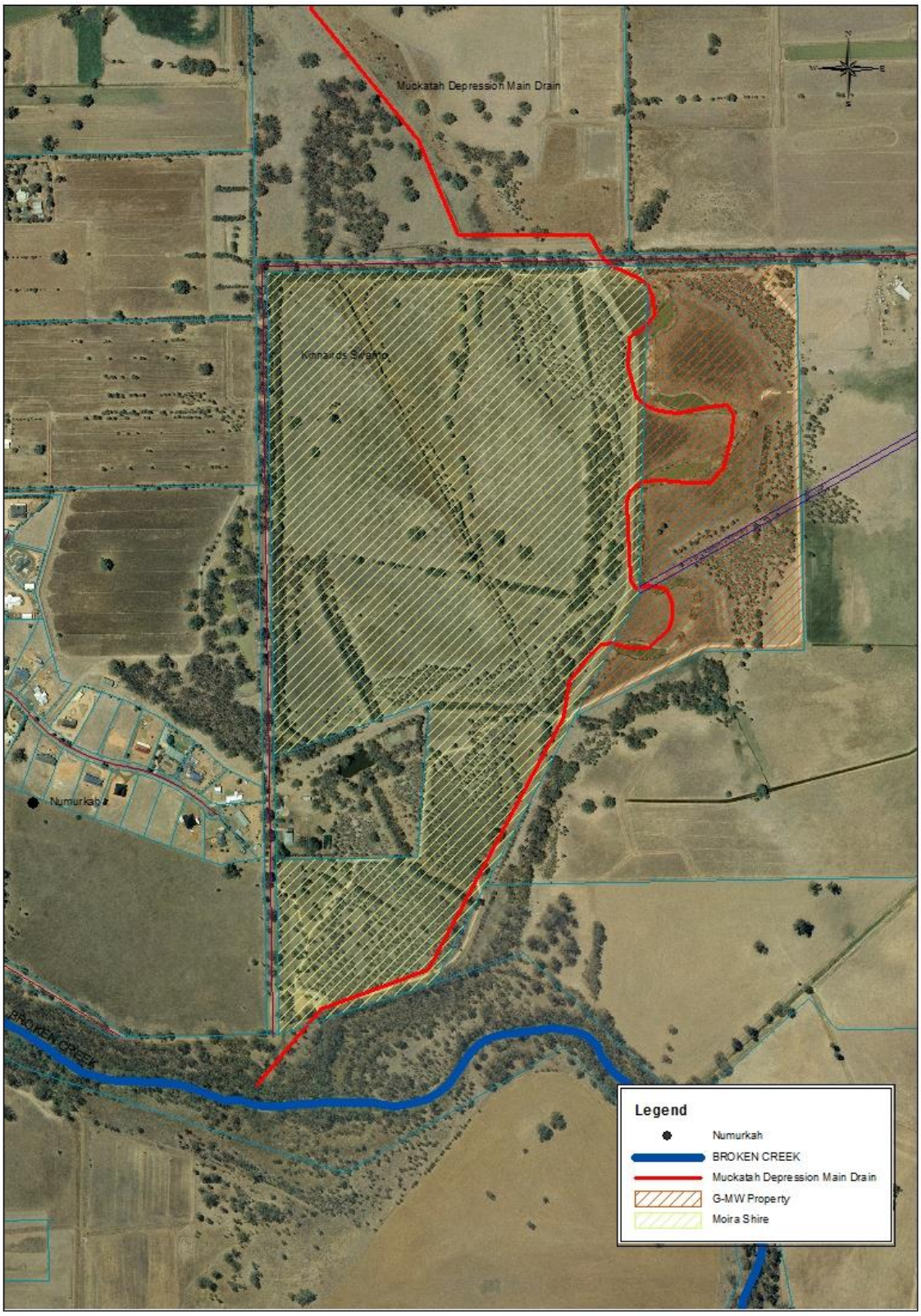

Figure 3: Wetland property boundaries (unthatched areas are private land not included in this plan).

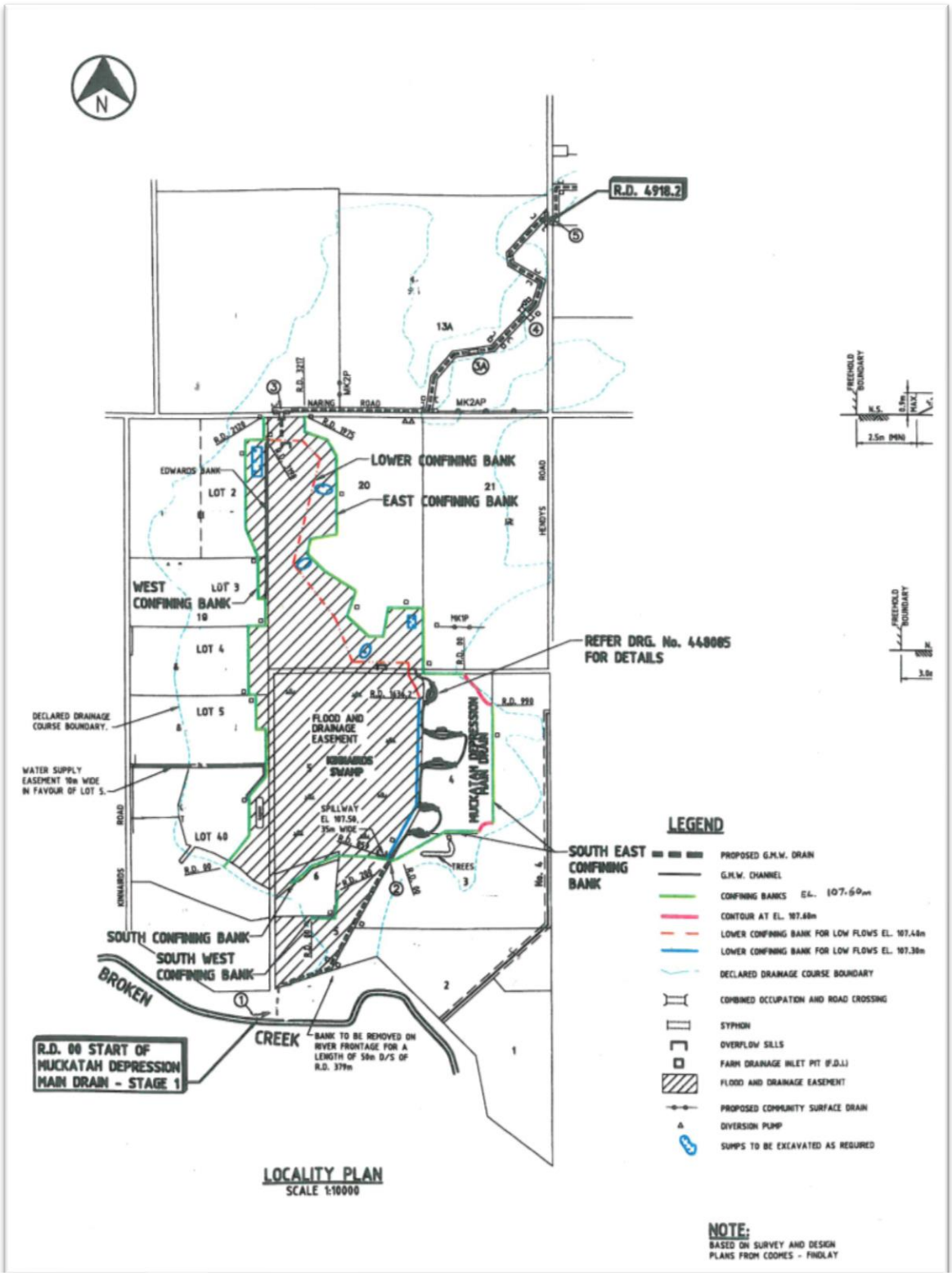

Figure 4: Location of levees and banks within Kinnairds Swamp

2.4 ENVIRONMENTAL WATER SOURCES

The Environmental Water Reserve is the legally recognised amount of water set aside to meet environmental needs. The reserve includes minimum river flows, unregulated flows and specific environmental entitlements. Environmental entitlements are held in storage and if available and required can be delivered to wetlands or streams to protect their environmental values and health. Environmental entitlements are held by the Victorian Environmental Water Holder.

Environmental water for Kinnairds Swamp can be sourced from the Victorian River Murray Flora and Fauna Bulk Entitlement. This bulk entitlement has a source volume of 27,600ML and is managed by the Victorian Environmental Water Holder.

Future water reserves that may also be used in Kinnairds Swamp include water savings from the Northern Victoria Irrigation Renewal Project (NVIRP) and environmental water held by the Commonwealth Environmental Water Holder (CEWH) (Appendix 3).

2.5 LEGISLATIVE AND POLICY FRAMEWORK

There is a range of international treaties, conventions and initiatives, as well as National and State Legislation, policies and strategies that direct management of the study area. Those with particular relevance to the study area and the management of its environmental and cultural values are listed below. For the functions and major elements of each refer to Appendix 4.

International treaties, conventions and initiatives:

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

Commonwealth legislation and policy:

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

Victorian legislation:

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

Victorian policy, codes of practice, charters and strategies:

- Goulburn Broken Catchment Regional Catchment Strategy (GBCMA, 2003).
- Our Water Our Future (DSE, 2004).
- Northern Region Sustainable Water Strategy (DSE, 2009c).
- Lower Broken Creek and Nine Mile Creek Environmental Watering Plan (GBCMA, 2010).
- Biodiversity Strategy for the Goulburn Broken Catchment, Victoria 2010-2015 (Miles et al., 2010).

2.6 RELATED PLANS AND ACTIVITIES

A number of key management documents have been written that directly or indirectly assist with management of the site. These include:

1. Kinnairds Swamp Environmental Management Plan (DPI, 2003). This management plan presents the geo-morphological, biological, utilisation history, management history and current stakeholder's requirements. It focuses on the values as a breeding and feeding site for significant species, as a public amenity and as a flow retarding and nutrient assimilating wetland.

2. Trust for Nature Draft Management Plan for the Covenant of Kinnairds Wetland (Williams, 2010). This plan was developed to guide the appropriate management of Kinnairds Swamp subject to the covenant to protect and enhance its conservation values. The principles behind the conservation efforts are to encourage the conservation of all biodiversity values in the swamp and to manage the swamp for its more significant biodiversity values.

These plans make a number of recommendations, some of which have been implemented and have assisted with the protection and enhancement of Kinnairds Swamp natural values including:

1. Revegetation of the degraded areas in the swamp and surrounding terrestrial zone.
2. Pest plant and animal control.
3. Construction of the Muckatah Primary Surface Water Management System, including a constructed wetland on the eastern side of the swamp (Figure 3 G-MW property). This includes water management structures within the swamp linking the constructed area to the natural (western) swamp area.
4. Environmental Water Delivery for drought refuge in 2008 and 2010 (section 4.1.4 – Environmental Water).
5. Ecological monitoring of environmental water delivery in 2008/09 and 2010/11 (Cook et al., 2009, Cook et al., 2010)
6. Fencing around the swamp boundary to control stock and vehicle access.
7. Constuction of walking tracks and bird hides within the swamp to promote tourism and deter disturbance of fauna and flora.

3. WATER DEPENDENT VALUES

3.1 ENVIRONMENTAL - FAUNA

3.1.1 FAUNA LISTINGS AND SIGNIFICANCE

Kinnairds Swamp provides habitat for a wide variety of water dependent and terrestrial fauna species. To date 194 species have been recorded at the swamp (Appendix 5). These include 150 bird species (96 non-wetland species and 54 wetland species), 20 aquatic macro invertebrate species, seven frog species, three reptile species and 14 species of mammal and 1 native fish. Of these, two are listed under the *Convention on the Conservation of Migratory Species* (*Bonn*) (Figure 5), six are listed under the *Flora and Fauna Guarantee Act* (FFG 1988), two are listed under the *Environmental Protection Biodiversity Conservation Act* (EPBC 1999), 20 are considered endangered, vulnerable or near threatened on the *DSE Advisory list of threatened vertebrate fauna in Victoria* (2007) (Table 3 for wetland species and Appendix 5 for all species). Four birds are listed under the Japan Australia Migratory Bird Agreement (JAMBA), seven birds are listed under China Australia Migratory Bird Agreement (CAMBA) (Figure 5) and two birds are listed under Republic of Korea Australia Migratory Bird Agreement (ROKAMBA). Brolga (*Grus rubicunda*) were observed at Kinnairds Swamp for the first time in 50 years in 2008 (Figure 6)(O'Connor, 2011).

Many water birds such as herons, pelicans, spoonbills, cormorants, darters, ibis and ducks utilise the swamp as a breeding and feeding ground. Little Pied Cormorants (*Microcarbo melanoleuos*), Eurasian Coot (*Fulica atra*), Black Swan (*Cygnus atratus*), Pacific Black Duck (*Anas superciliosa*), and Grey Teal (*Anas gibberifrons*) are common species that have been known to breed and feed in the wetland. During a flooding event in 1992, the wetland also played host to approximately 1500 Pink-eared Ducks (*Malachorhynchus membranaceus*) (O'Connor *pers. comm.* 2000 cited in DPI, 2003). The vulnerable Royal Spoonbill (*Platalea regia*) and Australasian Shovelers (*Anas rhynchotus*) utilise the swamp as a breeding site (section 3.1.2 - Significant Fauna).

There are accounts of Water-rats (*Hydromys chrysogaster*) living in the wetland area (Walsh 1997 cited in DPI, 2003). Although Water-rats may have dense populations in some irrigated areas, particularly in drainage wetlands, wetland reduction and flood mitigation has removed much of the Water-rats habitat (Strahan, 1995) and hence wetlands such as Kinnairds Wetland are an increasingly important habitat (DPI, 2003).

Amphibians thrive at Kinnairds swamp when it holds water due to the variety of available aquatic habitat. The EPBC listed Growling Grass Frog (*Litoria raniformis*) was recorded at the Swamp in 2005 but has not been recorded since and may no longer be present.

Figure 5: Bonn Convention listed Glossy Ibis photographed at Kinnairds Swamp following the delivery of environmental water in 2008.

Photo: Paul O'Connor, DSE 2008

Table 3: Conservation status of fauna species recorded at Kinnairds Swamp

.	Scientific Name	Type	International agreements	EPBCA Status	FFG	DSE Status
Australasian Bittern	*Botaurus poiciloptilus*	B			L	End
Australasian Shoveler	*Anas rhynchotus*	B				Vul
Ballion's Crake	*Porzana pusilla palustris*	B			L	Vul
Brolga	*Grus rubicundas*	B			L	Vul
Cattle Egret	*Ardea ibis*	B	J, C			
Eastern Great Egret	*Ardea modesta*	B	J,C,B		L	Vul
Fork-tailed Swift	*Apus pacificus*	B	J, C			
Glossy Ibis	*Plegadis falcinellus*	B	C, B			NT
Growling Grass Frog	*Litoria raniformis*	A		Vu	L	End
Hardhead	*Aythya australis*	B				Vul
Latham's Snipe	*Gallinago hardwickii*	B	J, C, R,B			NT
Magpie Goose	*Anseranus semipalmata*	B				Vul
Nankeen Night Heron	*Nycticorax caledonicus*	B				NT
Pied Cormorant	*Phalacrocorax varius*	B				NT
Royal Spoonbill	*Platalea regia*	B				Vul
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	B	C		L	Vul

Legend

Type: (Bird (B)

International: CAMBA (C), JAMBA (J), ROKAMBA (R), Bonn (B)

EPBC Status: Vulnerable (Vu)

FFG Status: Listed as threatened (L)

DSE Status: Endangered (End), Vulnerable (Vul), Near Threatened (NT)

Figure 6: Flora and Fauna Guarantee Act (1988) listed Brolga photographed at Kinnairds Swamp following the delivery of environmental water in 2008.

Photo: Paul O'Connor, DSE 2008

3.1.2 SIGNIFICANT FAUNA

Kinnairds Swamp provides breeding habitat for the vulnerable Royal Spoonbill (*Platalea regia*), Australasian Shovelers (*Anas rhynchotis*). The protection of River Red Gums (*Eucalyptus camaldulensis*) in the swamp is required to ensure breeding habitat for the colonial Royal Spoonbills is maintained (Figure 7). They breed between October and March and usually only have one brood per season of 3-4 eggs. Lag time and breeding duration have not been fully investigated but it has been estimated that a Lag time of 1-2 months, breeding duration of 2-3 months and a flood duration of 4-5 months is required (Rogers and Ralph, 2011).

Figure 7: Royal Spoonbill with breeding plumage

Photo: Paul O'Connor DSE 2008

Australasian Shovelers have been recorded breeding and feeding at Kinnairds Swamp (Figure 8). Australasian Shovelers nest on the ground and therefore do not have a water depth requirement (Kingsford, 1991). However, they do prefer to be near deep water and breeding is stimulated by flooding or factors associated with flooding such as large rainfall events and an increasing water level (Rogers and Ralph, 2011). They breed between August and December, have a breeding duration of 3 months that requires flooding of approximately 5-6 months and can have 9-11 eggs per clutch (Rogers and Ralph, 2011). The Shovelers feed at night or at dusk in shallow water.

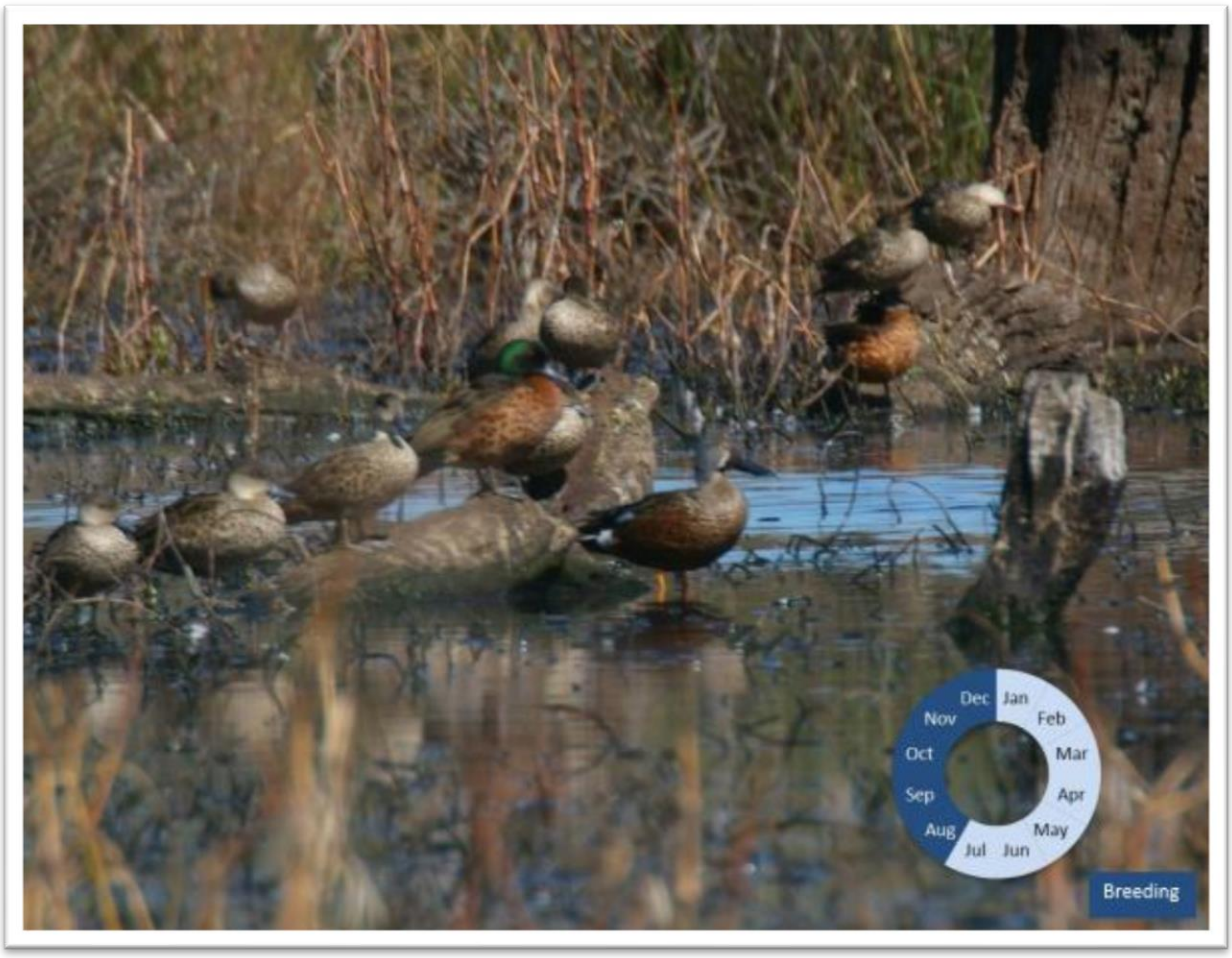

Figure 8: Australasian Shoveler (standing in water middle of picture) surrounded by Chestnut and Grey Teal.

Photo: Keith Ward, GBCMA 2008

Brolga may have been utilising the swamp as a feeding site when recorded in 2008. Brolga breeding at the site has not been recorded since the 1950s.

Hardhead (*Aythya australis*), Eastern Great Egrets (*Ardea modesta*), Magpie Geese (*Anseranus semipalmata*) and Glossy Ibis (*Plegadis falcinellus*) utilise the swamp as a feeding site when it is wet or in a period of drawdown.

At an international level, the Muckatah Depression including the Kinnairds Wetland also plays an important role in providing habitat for international migratory species such as Latham's Snipe (*Gallinago hardwickii*) seen in Figure 9. Snipe have been observed around the margins of the swamp and in its upper reaches during several flood events (O'Connor *pers. comm.* 2000 cited in DPI, 2003). Aerial species such as White-throated Needletail (*Hirundapus caudacutus*) and Fork tailed Swift (*Apus pacificus*) have also been recorded at the swamp.

Figure 9: Latham's Snipe

Photo: Jo Wood, GBCMA 2006

3.2 FLORA - VEGETATION COMMUNITIES

A hierarchical system of classification of vegetation classes has been developed in Victoria over the past decade in order to classify vegetation into units that are both ecologically meaningful and useful for vegetation managers. The classification that has been adopted in Victoria is Ecological Vegetation Classes (EVCs), which are defined by a combination of floristics, lifeform, position in the landscape and an inferred fidelity to particular environments. Each EVC includes a collection of floristic communities that occur across a biogeographic range and although differing in species, have similar habitat and ecological processes operating. Approximately 300 EVCs have been described for Victoria.

Kinnairds swamp is dominated by a mosaic of Red Gum Swamp and Plains Grassy Wetland EVCs with smaller occurrences of Plains Rushy Wetland, Tall Marsh and Riverine Swampy woodland (Cook et al., 2009, Jolly and Osler, 2011). Table 4 shows the conservation status of these EVCs. The Red Gum Swamp EVC is dominated by an open canopy of river red gum (*Eucalyptus camaldulensis*) over a diverse community of semi-aquatic grasses, sedges and herbs (section 3.2.1 – Flora – Species listing and significance). Plains Grassy Wetland EVC is species rich with a diverse community of semi-aquatic grasses, sedges and verges of herbs (DSE, 2009b).

Following the delivery of environmental water in 2008, the nationally threatened species rigid water-milfoil (*Myriophyllum porcatum*) and the state threatened slender water-milfoil (*Myriophyllum gracile var.lineare*) were recorded in the Red Gum Swamp and Plains Grassy Wetland EVCs (Figures 10 & 11). These populations are the largest known populations in Victoria.

Table 4: Conservation status of water-dependent Ecological Vegetation classes recorded at Kinnairds Swamp

EVC C number	EVC Name	Bioregional Conservation Status
292	Red Gum Swamp	Vu
125	Plains Grassy Wetland	En
961	Plains Rushy Wetland	Vu
821	Tall Marsh	De
815	Riverine Swampy Woodland	Vu

Legend (Wierzbowski et al., 2002)

En = Endangered. Meaning the EVC is on the verge of extinction with 90% or more cleared since European settlement (1750).

Vu = Vulnerable. Meaning the EVC is moving towards extinction with 70% or more of these areas having been cleared since European settlement (1750).

De = Depleted. Meaning the EVC is likely to become threatened if clearing or threatening processes continue and that 50-70% of this EVC has already been cleared since European settlement (1750).

3.2.1 FLORA – SPECIES LISTING AND SIGNIFICANCE

A total of 181 native flora species have been recorded at Kinnairds Swamp including 70 water dependent species (Appendix 7). Of these species five are considered rare, threatened, endangered or depleted in Victoria and rigid water-milfoil is considered to be vulnerable within Australia (Table 5, Figures 10 and 11).

Table 5: Listed water-dependent flora species recorded at Kinnairds Swamp

Common Name	Scientific Name	EPBCA Status	FFG Status	DSE Status
Riverina Bitter-cress	*Cardamine moirensis*			r
Rigid Water-milfoil	*Myriophyllum porcatum*	V	L	v
Slender Water-milfoil	*Myriophyllum gracile var. lineare*		L	en
Spoon-leaf Mud-mat	*Glossostigma cleistanthum*			v
Winged Water Starwort	*Callitriche umbonata*			r

Legend: EPBC Status: Vulnerable (V)**;** FFG Status: Listed as threatened (L)**:** DSE Status: Endangered (en), Vulnerable (v), Rare (r)

The most common species found within the wetland are common spike-rush (*Eleocharis acuta*), rushes (*Juncus spp*.), water-milfoils (*Myriophyllum spp*.), docks (*Rumex spp*.), Pacific azolla (*Azolla filiculoides*) and river red gums (DPI, 2003).

The River Red Gum EVC is dominated by the nationally vulnerable rigid water-milfoil (Figure 10), common spike-rush , common swamp Wallaby-grass (*Amphibromus nervosus*), moira grass (*Pseudoraphis spinescens)*, tussock rush (*Juncus aridicola*) and slender water-milfoil (Cook et al., 2009). Riverine bitter-cress (*Cardamine moirensis*), common blown-grass (*Lachnagrostis filiformis var.1*) and ferny small-flower buttercup (*Ranunculus pumilio var. pumilio*) were also present. In 2010, gold rush (*Juncus flavidis*) and short-fruit nardoo (*Marsilea hirsuta*) were recorded for the first time in this EVC.

Plains Grassy Wetland EVC is dominated by the endangered slender Water-milfoil (Figure 11), common spike-rush, common nardoo (*Marsilea drummondii*), narrow-leaf nardoo (*Marsilea costulifera*) and common swamp Wallaby-grass (Cook et al., 2009). Winged-water starwort (*Callitriche umbonata*), spoon-leaf mud-mat (*Glossostigma cleistanthum*) and bluish raspwort (*Haloragis glauca*) are also present. In 2010 gold rush was recorded for the first time in this EVC.

Individual terrestrial species of significance around Kinnairds Swamp include the vulnerable yellow-tongue daisy (*Brachyscome chryoglossa*) and some rare species that have not been recorded anywhere else in Victoria such as spiny-fruit saltbush (*Atriplex spinibractea*) and coolibah grass (*Panicum queenslandicum*) (DPI, 2003) (Appendix 7).

3.2.2 FLORA - SIGNIFICANCE

Kinnairds Swamp is of high conservation significance as it contains the largest known populations of the *Environmental Protection Biodiversity Conservation Act* (1999) listed rigid water-milfoil (*Myriophyllum porcatum*) and the *Flora and Fauna Guarantee Act* (1988) listed slender water-milfoil (*Myriophyllum gracile var.lineare*) in Victoria (Figure 10).

Myriophyllum porcatum (rigid water-milfoil) is an annual aquatic herb that occurs in shallow, ephemeral wetlands. It was recorded for the first time at Kinnairds Swamp in 2008 following the delivery of environmental water in autumn after a prolonged dry period (Figure 10). Little is known about the ecology of this species other than that it is found in ephemeral and seasonal wetlands and seed apparently persist in sediment when the wetland dries out. Plants have been observed flowering in September to October and fruiting from October to November (Orchard, 1985). Its habitat has been significantly reduced as a result of hydrological alteration such as wetland drainage and channelisation, increased nutrient loads from rural and urban catchments and the introduction of exotic species (DSE, 2005b, Bunn et al., 1997, Murphy, 2006).

Figure 10: The EPBC listed rigid water-milfoil (*Myriophyllum porcatum*) growing at Kinnairds Swamp.

Photo: Damien Cook, Australian Ecosystems 2008

Myriophyllum gracile var. lineare (slender water-milfoil) was recorded at Kinnairds Swamp during in 2008 and 2010 following the delivery of environmental water and had been recorded at the swamp previously in small numbers (Figure 11). Population counts in 2008 determined that approximately 1000 plants were present making it the largest known population of this species in Victoria. Little is known about the ecology and biology of this perennial aquatic species, however it has been found in boggy swamps, shallow still waters and water from 1-2 metres deep in NSW (Orchard, 1985). Flowering begins around August and fruiting continues until March (Orchard, 1985).

The lack of knowledge on the ecological requirements of both these water-milfoil species is a significant knowledge gap.

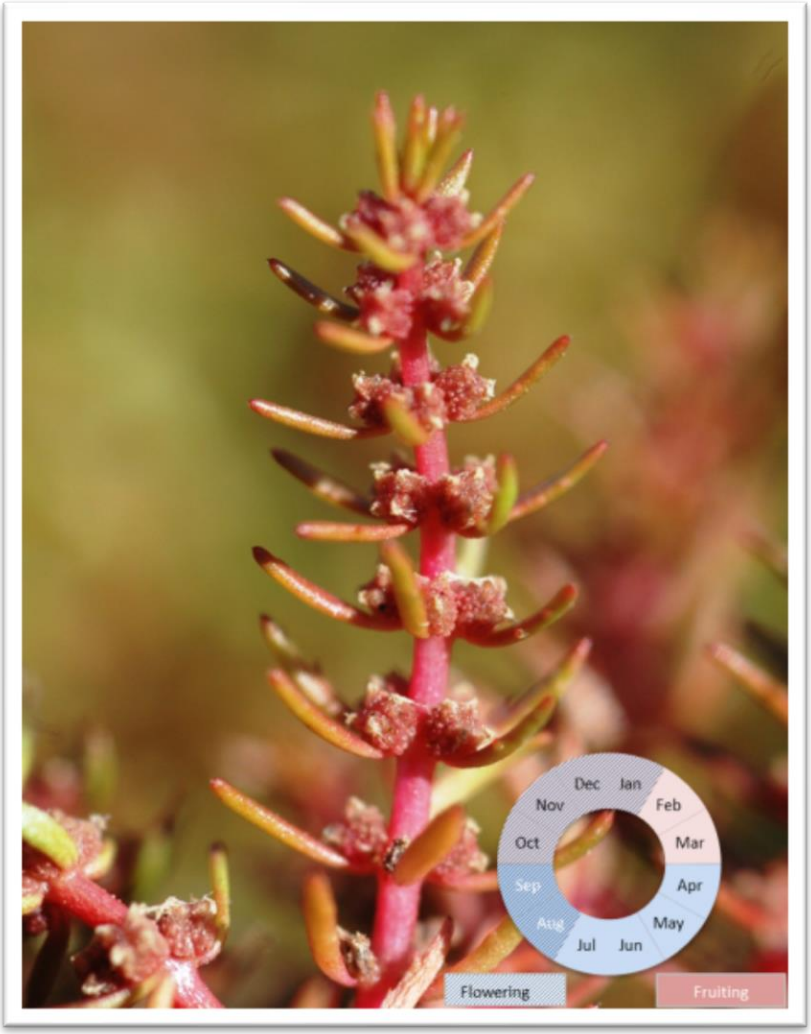

Figure 11: Slender Water-milfoil (*Myriophyllum gracile var. lineare*) growing at Kinnairds Swamp.

Photo: Damien Cook, Australian Ecosystems 2008

3.3 WETLAND DEPLETION AND RARITY

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

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

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

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

Comparison between the wetland layers has demonstrated the impact of European settlement and development on Victorian wetlands. This has been severe, with approximately one-third of the state's wetlands being lost since European settlement; many of those remaining are threatened by continuing degradation from salinity, drainage and agricultural practices (EA, 2001). Across the state, the greatest losses of original wetland area have been in the freshwater meadow (43%), shallow freshwater marsh (60%) and deep freshwater marsh (70%) categories (DNRE, 1997).

Kinnairds Swamp is classified as both shallow and deep freshwater marsh. Over 70 per cent of deep freshwater marsh area has been lost since settlement (EA, 2001). Within the Goulburn Broken Catchment shallow freshwater marshes have declined by 40 per cent and deep freshwater marshes have declined by 60 per cent in area since settlement (GBCMA, 2006).

The conservation and protection of these areas is imperative for the flora and fauna that rely on them as breeding, feeding and roosting sites.

3.3.1 ECOSYSTEM FUNCTIONS

Wetlands are considered ecologically important due to their role in maintaining biological diversity, promoting biochemical transformation and storage and decomposition of organic materials (DSE, 2007b).

Kinnairds Swamp is a floodplain swamp. Floodplain swamps perform important functions necessary to maintain the hydrological, physical and ecological health of river systems. These functions include:

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

However, the capacity of floodplain wetlands to perform the ecological functions outlined above will depend on their condition (section 5 – Threats and Condition) and on connectedness back to the river.

3.4 SOCIAL VALUES

3.4.1 CULTURAL HERITAGE

The study area and the surrounding catchment have a long history of traditional owner occupation by the Yorta Yorta Peoples and are an important part of their cultural and spiritual heritage (Figure 12). Kinnairds Swamp would have provided the Yorta Yorta Peoples with a rich and diverse supply of plant and animal resources for food, medicines, shelter, clothing and tools (Appendix 7). Evidence of past traditional owner occupation includes scarred trees and artefact scatters recorded along the Broken Creek. There are no registered sites within 4km of Kinnairds Swamp (Sutherland, 2010). However, Kinnairds Swamp has not been extensively surveyed for Aboriginal archaeological sites and past land uses may have destroyed existing sites.

The Yorta Yorta Cooperative Management Agreement was signed in 2004. The agreement establishes a formal role for the Yorta Yorta Peoples in the management of land and water in their traditional country. The Yorta Yorta Nations in their draft Greater Regional Natural Resource Management Plan set out a number of objectives to protect the regions native ecosystems and biodiversity including:

- to restore, maintain and protect all native ecosystems; and
- to ensure the long term viability of populations and species considered rare and endangered, threatened or of special concern.

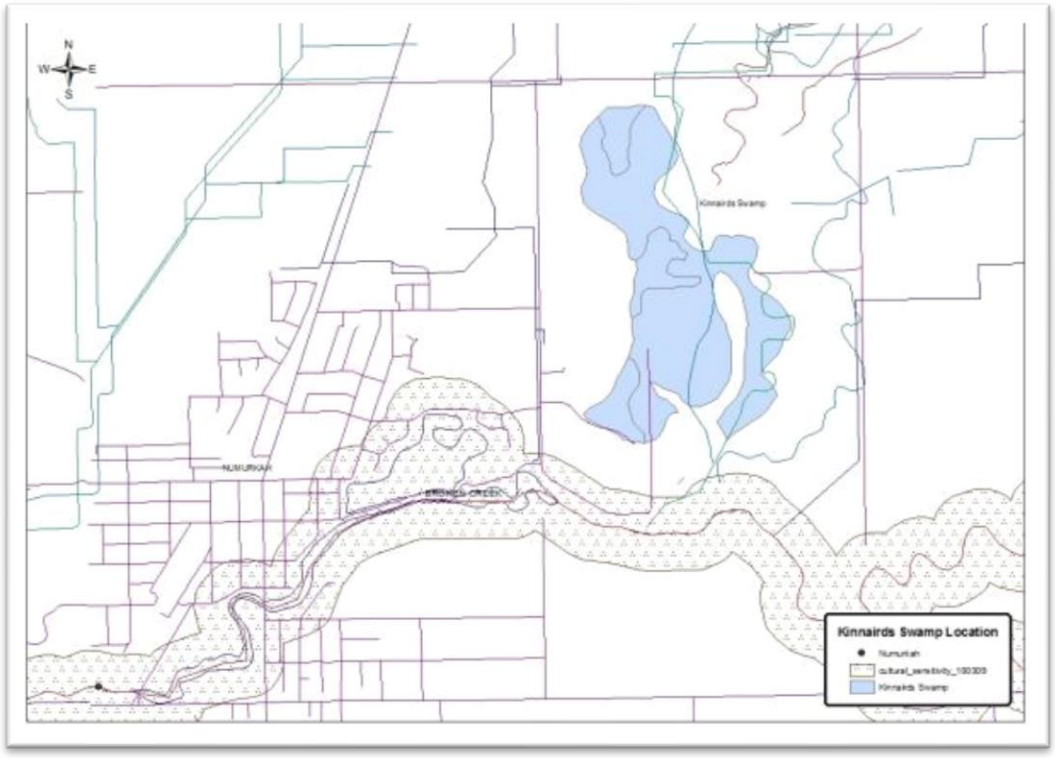

Figure 12: Cultural sensitive areas along the Broken Creek adjacent to Kinnairds Swamp

3.4.2 RECREATION

Activities enjoyed by visitors to the swamp include bird watching, picnicking, bike riding and walking. None of these activities are directly dependent on wetland flooding. However, wetland flooding can enhance the enjoyment of visitor's activities by providing more diverse habitat and fauna experiences.

3.5 ECONOMIC

Wetlands provide both direct and indirect economic values to Goulburn Broken Catchment (Cork et al., 2001) . The direct economic values that Kinnairds Swamp provides to the Goulburn Broken Catchment include non-consumptive uses such as tourism and recreation. Indirect economic values that Kinnairds Swamp provides to the Goulburn Broken Catchment include water filtration, flood protection, water storage, groundwater recharge, nutrient discharge, carbon storage and habitat for threatened flora and fauna species.

4. HYDROLOGY AND SYSTEM OPERATIONS

Wetland hydrology is the most important determinant in the establishment and maintenance of wetland types and processes. It affects the chemical and physical aspects of the wetland which in turn affects the type of flora and fauna that the wetland supports (DSE, 2007b). A wetland's hydrology is determined by surface and groundwater inflows and outflows in addition to precipitation and evapotranspiration (DSE, 2007b). Duration, frequency and seasonality (timing) are the main components of a wetland's hydrological regime.

4.1 WATER MANAGEMENT AND DELIVERY

4.1.1 PRE-REGULATION

Under natural conditions, Kinnairds Swamp would have received water from run-off within the Muckatah Depression or in high flood events from the Broken Creek. When the swamp filled it spilled into the Broken Creek and would have flooded most years during winter and spring and dried out in summer and autumn, i.e. had a seasonal wet-dry water regime.

4.1.2 POST-REGULATION

Settlement in the Muckatah Catchment occurred around the 1840s. At this time Kinnairds Swamp was cleared for grazing and cropping. Irrigation was introduced to the area post World War II and it has since experienced prolonged flooding.

In 1999, the Muckatah Primary Surface Water Management System to provide drainage to ~60,000 hectares of the catchment above Kinnairds Swamp began. Stage One of the Muckatah Surface Water Management System constructed an artificial wetland on the eastern side of the wetland with a set of low-level confining banks around the wetland margin to retard the one in two year flow events. The purpose of constructing this wetland is to be used as a retardation basin to aid in flood retention, filtering sediments and nutrients and minimising discharge into the Broken Creek. It also provides the ability to manage the flooding regime of the natural section of Kinnairds Swamp.

4.1.3 WETLAND VOLUME

Based on field measurements taken by the GBCMA in 2010, the study area is 96.5 hectares in size and has an average depth of approximately 0.5m. Therefore, the volume of the swamp equates to approximately 482.5 ML. When dry the amount of water required to inundate the swamp to the desired depth may be twice its volume (965 ML) due to delivery losses and the water required to saturate the soil profile of the swamp.

4.1.4 ENVIRONMENTAL WATER

In April 2008, an Environmental Water Allocation of 413ML was delivered to Kinnairds Swamp from Murray Valley Channel 5/3 (MV 5/3) via the Muckatah Depression Main Drain. This flooded the 18 hectare eastern section and part of the western 78.5 hectare section of Kinnairds Swamp before the swamp dried in the spring of 2008. This triggered a response from flora including the nationally threatened rigid water-milfoil (which had never previously been recorded at the site) and state threatened slender water-milfoil. In addition, resting, breeding and feeding habitat was provided for a wide range of wetland dependant fauna including the international migratory species Latham's Snipe.

Between the 12th April and 26th May 2010, 400ML of Environmental Water was delivered to Kinnairds Swamp. The cover of native wetland flora species increased markedly following the watering event. Rainfall from September 2010 to March 2011 has kept the wetland water levels high (Figure 13).

Although the Muckatah Depression Main Drain is designed to spill into the body of the swamp it has high transmission losses, losses to the drainage sump and poor capacity to deliver to the core areas of the wetland making it an inefficient delivery method. The Murray Valley 4 channel is the preferred option (Figure 15) but would need reconfiguration to be able to deliver the high flow rates required (Paynter, 2010).

The delivery of these environmental water allocations has increased the abundance, distribution and diversity of native aquatic dependent species in the swamp.

Figure 13: Flood water from the Muckatah Depression (top of picture) entering Kinnairds Swamp in February 2011 and flowing into the Broken Creek (bottom of picture).

Photo: K. Ward (GB CMA 2011).

5. THREATS AND CONDITION

5.1 WATER DEPENDENT THREATS

The key threats to the values of Kinnairds Swamp are outlined below. These threats result from activities in the wetland, on adjoining land and in the surrounding catchment. To address these threats and the impacts an integrated approach is therefore required.

Altered water regime – Hydrology is the most important component of wetland ecosystems. It drives the physical and chemical properties of a wetland, and the biota it supports. As described in section 4 – Hydrology, the natural hydrological regime of Kinnairds Swamp has been significantly altered by the introduction of irrigated agriculture post World War II causing changes to the hydrological regime of the Muckatah Depression, and in the 1980s when channel and levee construction occurred within Kinnairds Swamp causing prolonged flooding, water logging and stress to River Red Gums and wetland biodiversity. However, a more natural hydrological regime is being reinstated through the delivery and management of environmental water.

Altered physical form – Physical form means the area and bathymetry of a wetland. The area of Kinnairds Swamp has been reduced by drainage and excavation beginning in the late 1940s (post world war II) and continuing up until the late 1990s with the construction of the Muckatah Depression Drain and the construction of a channel within the eastern margin of the swamp and levees to both the east and western margins of the swamp. Future impacts on the physical form of the swamp are unlikely to occur due to the protection provided by its current landholders.

Poor water quality – Poor water quality including low dissolved oxygen may reduce habitat available for native aquatic biota, reducing its diversity and abundance. The water quality in Kinnairds Swamp may be impacted by:

- Carp (*Cyprinus carpio*) feeding in sediment which can increase turbidity.
- Run-off containing high nutrient loads entering Kinnairds Swamp from surrounding agricultural land.
- Pollutants entering Muckatah Depression from urban, irrigation and dryland drainage.

Degraded habitats (Soil disturbance) –Wetland soils provide the physical substrate which aquatic vegetation requires to establish, and provides habitat for benthic invertebrates and microorganisms. Threatening processes that can lead to poor wetland soils within Kinnairds Swamp include:

- Human visitation (walking off designated tracks into the wetland body)
- Carp disturbance in high flood events when the wetland connects with the Broken Creek allowing Carp to move into the wetland.

Exotic flora and fauna – The invasion of native vegetation by pest plants is listed as a potentially threatening process under schedule 3 of Victoria's *Flora and Fauna Guarantee Act* (1988) and is considered to be one of the major threats to the conservation of biological diversity in Victoria (PV, 2003). The growth of pest plants can be sufficiently vigorous to reduce or prevent the regeneration or establishment of native plant species, altering the composition and structure of native communities. Modifications to the composition and structure of native vegetation as a result of pest plant invasion can modify the abundance of native fauna, geomorphological process, the nutrient content of soil and disturbance regimes including fire, grazing and insect activity (PV, 2003).

A total of 69 environmental weeds have been recorded at the site comprising nine wetland species (Jolly and Osler, 2011). Of these species, Aster- weed (*Aster subulatus*) listed on the *DSE advisory list of Environmental Weeds* (DSE, 2009a) and Arrowhead (*Sagittaria platyphylla*) pose the greatest risk to the site due to their ability to outcompete native flora species. The native Water Couch (*Paspalum distichum*) also poses a threat to the wetland due to its ability to outcompete other native flora.

Pest animals threaten the ecological values of wetlands by predating native species, transmitting diseases, and competing for food and habitat and feeding on native fauna. Pest animals recorded at Kinnairds Swamp include:

- Foxes (*Vulpes vulpes*) - Fox predation is listed as a threatening process under the *Environmental Protection Biodiversity Conservation Act* (1999) and Schedule 3 of the *Flora and Fauna Guarantee Act* (1988).
- Carp, Goldfish and Gambusia.

5.2 CURRENT CONDITION

The condition of Kinnairds Swamp was assessed in December 2010 using a method developed by DSE called the Index of Wetland Condition (IWC). The IWC defines wetland condition as the state of the biological, physical, and chemical components of the wetland ecosystem and their interactions (DSE, 2007b).

The IWC has six subindices based on the catchment of the wetland and its fundamental characteristics: physical form, hydrology, water properties, soils and biota (Appendix 8). Each subindex is given a score between 0 and 20 based on the assessment of a number of measures (Appendix 8). The overall IWC score is not a simple summation of the subindex scores. A formula is used that weights each subindex according to the contribution it makes to the overall condition of the wetland. The wetland hydrology subindex for example contributes more to the overall score than the soils subindex. Further information on the method can be found on the IWC website: **www.dse.vic.gov.au/iwc**.

The overall IWC score for Kinnairds Swamp in December 2010 was six out of ten, which is considered to be moderate (Table 6). Of note, the subindices hydrology and wetland catchment were considered to be in very poor and poor condition respectively. Hydrology was considered to be very poor due to the impacts of irrigation development and the construction of levees on the natural wetting and drying regime. Wetland catchment was considered poor as 75 per cent of the land surrounding Kinnairds Swamp is used for high or medium intensity land uses such as urban development, irrigated agriculture and cropping.

Table 6: Kinnairds Swamp IWC subindex score, overall score and associated condition categories

IWC subindex	Score	Condition category
Wetland catchment	7/20	Poor
Physical form	16/20	Good
Hydrology	0/20	Very poor
Water properties	17/20	Excellent
Soils	18/20	Excellent
Biota	14/20	Moderate
Overall IWC Score	**6/10**	**Moderate**

5.3 CONDITION TRAJECTORY

Ongoing management including the delivery of environmental water and continued monitoring of Kinnairds Swamp is critical to protecting the ecological values at Kinnairds Swamp. If no intervention occurs, Kinnairds Swamp will only receive water via the Muckatah Depression Main Drain, which, with an increasingly dry climate, may occur less frequently than suits the swamp vegetation and dependant aquatic fauna. Shifts in climate such as an increase in summer storm events may also impact the wetland. This may increase flooding duration over summer and possibly cause loss of species diversity and terrestrialisation of vegetation within the wetland area.

6. MANAGEMENT OBJECTIVES AND ADAPTIVE APPROACHES

6.1 MANAGEMENT GOAL

The water management goal of Kinnairds Swamp is derived from sources including information from the Kinnairds Swamp Environmental Wetland Management Plan (DPI, 2003), local expertise and knowledge. The goal considers the overall values the swamp supports. This includes consideration of the aquatic dependent values the swamp has historically supported and the likely aquatic dependent values it could support into the future considering climate change.

Kinnairds Swamp water management goal

"To provide a more natural hydrological regime that supports Red Gum Swamp and Plains Grassy Wetland EVCs and habitat for significant waterbird and flora species"

The goal for Kinnairds Swamp is to deliver a hydrological regime that is closer to natural than it has been.

6.2 ECOLOGICAL AND HYDROLOGICAL OBJECTIVES

6.2.1 ECOLOGICAL OBJECTIVES

Ecological objectives are the desired ecological outcomes of the site. In line with the draft policy Victorian Strategy for Healthy Rivers, Estuaries and Wetlands (VSHREW), the ecological objectives are based on the key values of the site (section 3 – Water dependent values). The ecological objectives are expressed as the target condition or functionality for each key value and are expressed as one of the following trajectories for each key value:

- Protect – retain the value at an existing stage of succession.
- Improve – improve the condition of the value while allowing natural processes of regeneration, disturbance and succession to occur.
- Maintain – maintain the current condition of the value while allowing natural processes of regeneration, disturbance and succession to occur.
- Reinstate – reintroduce natural values that can no longer be found in the area.

The ecological objectives for Kinnairds Swamp are based on values that the wetland provides for the larger Muckatah Catchment and on a local scale for its waterbird carrying capacity, ability to support species listed under the *Environmental Protection Biodiversity Conservation Act* (1999) and the *Flora and Fauna Guarantee Act* (1988) and its ability to support frog and waterbird breeding. The ecological objectives for Kinnairds Swamp are:

- Improve the diversity of native wetland flora species to be consistent with Red Gum Swamp and Plains Grassy Wetland EVC benchmarks.
- Reduce the cover and diversity of exotic flora species.
- Maintain populations of rigid water-milfoil and slender water-milfoil.
- Maintain or increase the diversity and abundance of frog species supported by the wetland during flood events.
- Provide breeding habitat for significant waterbird species including Royal Spoonbills and Australasian Shoveler during flooding events.
- Provide feeding habitat for significant waterbird species such as Eastern Great Egret, Magpie Goose, Brolga, Glossy Ibis, Latham's Snipe and Whiskered Tern during flood events.

Justification for these ecological requirements is given in Table 7 below.

Table 7: Ecological requirements for Kinnairds Swamp

Ecological Objective	Justification (Value based)
Improve the diversity of native wetland flora species to be consistent with Red Gum Swamp and Plains Grassy Wetland EVC benchmarks*.	Increase habitat and food sources for native fauna. Increase biodiversity.
Reduce the cover and diversity of exotic and/ or highly invasive native flora species.	Exotic plant species present at Kinnairds Swamp notably Aster Weed and the highly invasive native Water couch, are believed to be outcompeting native wetland plants.
Maintain populations of rigid water-milfoil and slender water-milfoil#	Kinnairds Swamp has the largest recorded populations of the nationally threatened rigid water-milfoil and slender water-milfoil.
Maintain or increase the diversity and abundance of frog species supported by the wetland during flood events^.	Kinnairds Swamp is relatively rich in frog species as seven have been recorded (Appendix 5).
Provide opportunities for waterbird breeding especially Royal Spoonbills and Australasian Shoveler during flood events.	Kinnairds Swamp has supported breeding populations of Royal Spoonbills and Australasian Shoveler, two species that are listed.
Provide feeding habitat for significant waterbird species such as the Eastern Great Egret, Magpie Goose, Brolga, Glossy Ibis, Latham's Snipe and Whiskered Tern.	Mudflats are feeding areas for Glossy Ibis and shallow freshwater marsh is a feeding area for Eastern Great Egrets.

*Refer to Appendix 9. # This objective is included although watering regimes and ecological information for both species is not known well enough to include specific requirements. ^ Refer to appendix 10

6.2.2 HYDROLOGICAL OBJECTIVES

Consistent with the management goal and the ecological objectives above, the water regime for Kinnairds Swamp is for flooding to occur 5 in 10 years to 7 in 10 years, in late Autumn-spring, and drying out within a year (Table 8). In the long term, reinstating a more natural hydrological regime will encourage the restoration of the original Red Gum Swamp and Plains Grassy Wetland EVCs, and reduce the abundance and distribution of aquatic weeds. Red Gums grow more if flooded in spring – summer (Roberts and Marston, 2011). This coincides with both Royal Spoonbill and Australasian Shoveler breeding, hence water delivery may need to be extended into summer in order to avoid birds abandoning nests and drawdown should be slow [2]. Royal Spoonbills prefer to nest in trees over a water depth of 0.5-1.5m and breeding is stimulated by flooding and seasons. A correlation between flooding and flood duration for breeding indicates that Royal Spoonbills prefer a slow drawdown period (Rogers and Ralph, 2011). Monitoring will be needed in order to determine how long water should be held within the swamp. Soil should be kept moist for a duration of 12-18 months if establishment of river red gum seedlings is desired (Committee, 2011). Watering the wetland every 5 in 10 to 7 in 10 years will allow submerged aquatic species to germinate, grow and reseed.

To possibly promote growth of the nationally threatened rigid water-milfoil and state threatened slender water-milfoil environmental water delivery should coincide with watering river red gum and plains grassy wetland EVCs. Due to the lack of research and literature on these species it is difficult to determine a singular watering regime for these water-milfoil species. Increased research and monitoring of these species should occur to better understand their lifecycle, preferred watering regime and tolerance to flooding duration (Section 9 –Knowledge Gaps and Recommendations).

[2] Note: Table 8 discusses water regimes for “colonial” nesters and the Australasian Shoveler should be included in this for this watering plan.

Table 8: Hydrological and ecological requirements for Kinnairds 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 (mm)
		Min	Opt	Max	Min	Opt	Max	Min	Opt	Max			
Improve the diversity of native wetland flora species to be consistent with Red Gum Swamp EVC benchmarks #.	Wetland body and riparian zone	2	5-7	10	3	6	54	2	6	18[1]	Late Autumn – Spring or spring summer for more growth[2]	482.5	Variable to 500mm
Improve the diversity of native wetland flora species to be consistent with Plains Grassy Wetland EVC benchmarks.	Wetland body and riparian zone	3	5-7	10	6	6	42	3	6	9	Late Autumn – Spring	482.5	Variable to 500mm
Maintain populations of rigid water-milfoil and slender water-milfoil.	Floodway and Wetland body	NA	NA	NA	NA	NA	12[3]	NA	NA	NA	Late Autumn	482.5	Variable to 500mm
Provide opportunities for waterbird breeding especially Royal Spoonbills and Australasian	Wetland body	3	10	10	6	9	12	6	8	NA	Spring [4]	482.5[5]	Maximum of 500mm[6]
Maintain or increase the diversity and abundance of frog species supported by the wetland during flood events.	Wetland fringe and body	NA	NA	NA	NA	NA	12[7]	2	2-6[8]	NA	Spring-Summer	482.5	Variable to 500mm

1. Red Gums have been used as the main indicator plant for this watering regime. Red Gums should not be wet for more than two consecutive summers (Barlow, 2011).
2. More growth achieved for Red Gums if flooded during spring-summer (Roberts and Marston, 2011).

3. *Myriophyllum porcatum* may need dry period of at least 12 months (STC, 2011).
4. (Rogers and Ralph, 2011, Young, 2003).
5. Filling wetland based on monitoring of past environmental water deliveries to Kinnairds Swamp.
6. Water depth should be kept fairly constant if waterbirds are nesting/ breeding to avoid nests being abandoned (Young 2003).
7. This is estimation only as research on frog survival in dry wetlands for extended periods is limited.
8. (ARC, 2010); Appendix 9.

6.2.3 WATERING REGIME

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

The optimal, minimum and maximum watering regimes are described below; however the duration of watering may vary between these hydrological regimes. Due to the inter-annual variability of these estimates (particularly the climatic conditions), determination of the predicted volume requirements in any given year will need to be undertaken by the environmental water manager when watering is planned.

Minimum watering regime

Provide two flooding events in ten years. Fill wetland to variable depths to provide River Red Gum and Plains Grassy Wetland EVCs with minimum water requirements to allow survival of existing vegetation.

Optimum watering regime

Provide five -seven flooding events in ten years. Fill wetland to variable depths to provide River Red Gum and Plains Grassy Wetland EVCs with appropriate watering requirement, allow regeneration and recruitment of species within the wetland body and encourage breeding opportunities for aquatic biota.

Maximum watering regime

Provide ten flooding events in ten years. Fill wetland to variable depths to encourage growth of specific River Red Gum and Plains Grassy Wetland EVCs vegetation or encourage breeding opportunities for aquatic biota.

Filling the wetland to full supply level is not always desired. Flooding Kinnairds Swamp to variable depths will promote increased plant diversity and drawing down the wetland slowly will allow the habitat to change, resulting in different vegetation communities establishing within the wetland body. This will assist in meeting the EVC benchmarks required to restore Kinnairds Swamp. Wherever possible, this managed hydrological regime should be aligned with local climatic conditions. The little that is known of the water requirements for the two milfoil species is consistent with the optimum watering regime described above.

6.3 IMPLEMENTATION: SEASONALLY ADAPTIVE APPROACH

Each year CMAs prepare **seasonal watering proposals** for wetlands and rivers. The proposals identify the environmental water requirements of wetlands and rivers in the Goulburn Broken Catchment in the coming year. The proposals are informed by the Environmental Water Management Plans, scientific studies and reports that identify the flood or flow regimes required to meet the ecological objectives of each site or system. **Seasonal Watering Proposals** are developed using the "seasonally adaptive" approach, originally developed through the Northern Regional Sustainable Water Strategy and now incorporated in the Victorian Strategy for Healthy Rivers, Estuaries and Wetlands.

The seasonally adaptive approach identifies the priorities for environmental watering, works and complementary measures, depending on the amount of water available in a given year or prevailing climatic conditions. It is a flexible way to deal with short-term climatic variability and helps guide annual priorities and manage drought. This approach is outlined in Table 9.

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

The proposals are prepared in consultation with key stakeholders and partners and are approved by CMA boards. The proposals are submitted to the Victorian Environmental Water Holder (VEWH) for consideration. The VEWH then prepares **seasonal watering plans** based on the CMAs seasonal watering proposals. The plans describe the desired environmental water use for rivers and wetlands across Victoria in the coming year. To help facilitate the desired environmental water use outlined in these plans, the VEWH negotiates access to environmental water managed by the Commonwealth Environmental Water Holder (CEWH) and the Murray Darling Basin Authority (MDBA). The VEWH then prepares **seasonal watering statements** that authorise CMAs to undertake the agreed watering activities, including the use of CEWH and MDBA water. As more environmental water becomes available during the season the VEWH may prepare additional seasonal watering statements. Where possible, the VEWH, CEWH and the MDBA seek to coordinate the delivery and management of environmental water to maximise ecological benefits (Figure 14).

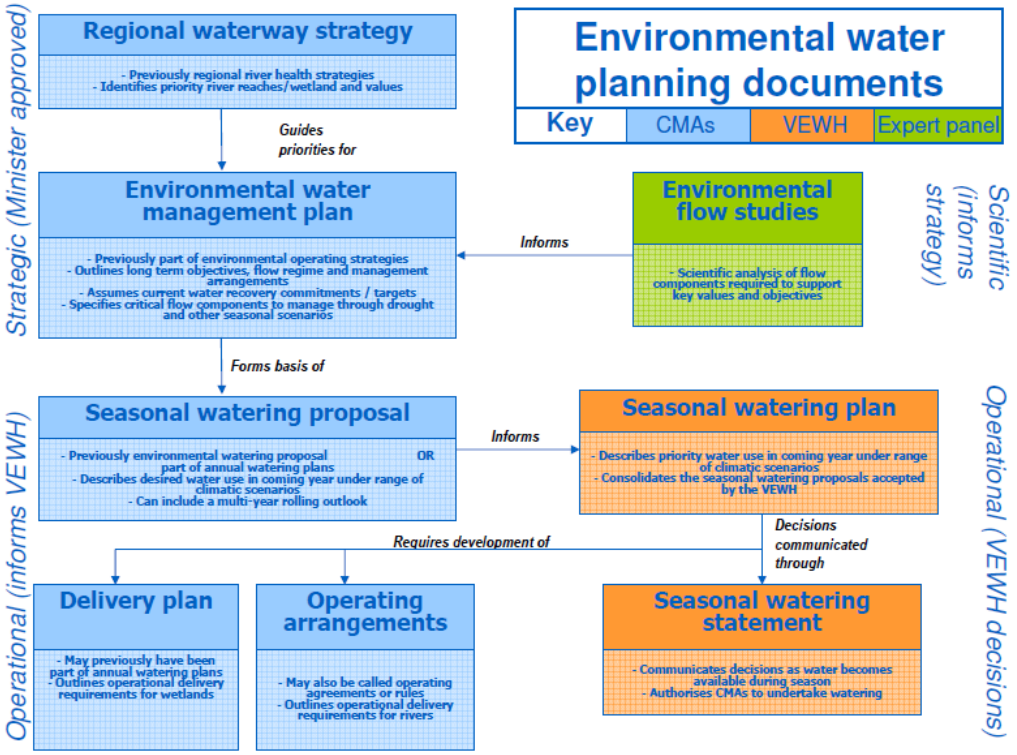

Figure 14: Flow chart for Environmental water planning

Table 9: The seasonally adaptive approach to river and wetland management

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

7. POTENTIAL RISKS AND MITIGATION MEASURES

Potential risks associated with impacts from the application of environmental water to Kinnairds Swamp are listed in Table 10. In addition, a detailed risk assessment process will be developed prior to delivering environmental water in any give season and will be provided in the site watering proposal. Mitigation measures will also occur during environmental water delivery and thereafter to assist with lessening any potential risks.

Potential risks of environmental water delivery to Kinnairds Swamp include:

- Flood duration is too long or short. If duration is too short, waterbirds may abandon nests, frogs may not complete all stages in life-cycle and aquatic flora may not set-seed. If duration is too long, vegetation composition may be lost or become less diverse due to waterlogging.
- Flood timing is too late or early. Environmental water can only be delivered during the irrigation season when there is capacity in the channel system and the Muckatah Depression Drain, which may not coincide with the desired timing.
- Flood depth is too shallow or deep. Shallow flooding may occur if environmental water allocations cannot be achieved due to delivery constraints, or deep flooding may occur if a high rainfall event occurs after delivery.
- Flood frequency is too frequent or infrequent. This may occur if a significant rainfall event occurs after an environmental water delivery, or water cannot be delivered within a sufficient time frame.
- Poor water quality. Water in the Muckatah Depression Drain or the channel system may have low dissolved oxygen, high turbidity, increased salinity and nutrient levels when adding environmental water to Kinnairds Swamp. Flooding wetlands that have accumulated large amounts of organic material can also lead to low dissolved oxygen.
- Pest plant and animal invasion. Aquatic pest plants such as Arrowhead and pest animals such as Carp can be introduced via environmental water delivery. Flooding can also stimulate the growth of pest plants and animals if it is the wrong time or duration.
- Impacts to social and economic values such as reduced public access if flooding is too high, or the accidental degradation of cultural heritage sites.

Table 10: Potential risks associated with environmental water delivery to Kinnairds Swamp

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

		Flood frequency		✓	✓	✓	✓	✓			Prioritise water requirements of wetlands in seasonal watering proposals according to their required water regimes and inundation history Monitor the condition of the wetland Monitor the ecological response of the wetland to flooding
2	Poor water quality	Low dissolved oxygen	✓	✓			✓				Monitor dissolved oxygen levels and the ecological response of the wetland to flooding Add or drawdown water where appropriate or practical
		High turbidity	✓				✓				Monitor turbidity levels and the ecological response of the wetland to flooding Add or drawdown water where appropriate or practical
		High water temperature	✓				✓				Monitor water temperature and the ecological response of the wetland to flooding Add or drawdown water where appropriate or practical
		Increased salinity levels	✓		✓	✓	✓				Monitor salinity levels and the ecological response of the wetland to flooding Add or drawdown water where appropriate or practical
		Increased nutrient levels									Monitor nutrient and Blue Green Algae levels, and the ecological response of the wetland to flooding Place public warning signs at the wetland if BGA levels are a public health risk
		Increased organic matter	✓				✓				Implement the required water regime
3	Pest aquatic plant and animal invasion	Introduction of pest fish	✓		✓	✓	✓				Monitor the ecological response of the wetland to flooding Install a carp screen Implement an appropriate drying regime

		Growth and establishment of aquatic pest plants	✓	✓	✓	✓	✓				Monitor the abundance of native and pest aquatic plants Control pest plants in connected waterways Spray or mechanically remove pest plants Implement an appropriate drying regime

8. ENVIRONMENTAL WATER DELIVERY INFRASTRUCTURE

8.1 CONSTRAINTS

Environmental water can be delivered to Kinnairds Swamp via channels entering the Muckatah Depression (section 8.3 – Infrastructure recommendations). Constraints posed by the existing arrangements at the Swamp include:

- Flow volume – Possibility of flooding neighbouring properties on delivery of water via the Muckatah Surface Water Management System.
- Flow duration - Timing of flows and if the surface water management system can be run high enough for time allocated to fill swamp.
- Irrigation demands –Kinnairds Swamp does not have a delivery share, therefore environmental water can only be delivered when there is spare capacity to carry water in the irrigation channels and the Muckatah Depression.

The option of delivering water to specific parts of Kinnairds Swamp using the Muckatah Depression Main Drain is not recommended. It is less efficient in the use of water due to transit losses, losses to the drainage sump and poor targeting of the core components of the wetland.

8.2 IRRIGATION MODERNISATION

The Northern Victoria Irrigation Renewal Project (NVIRP) is a $2 billion works program to upgrade ageing irrigation infrastructure across the Goulburn-Murray Irrigation District and to save water lost through leakage, evaporation and system inefficiencies. Works will include lining and automating channels, building pipelines and installing new, modern metering technology.

A watering plan for the Lower Broken Creek and Nine Mile Creek has been written for Goulburn Broken CMA on behalf of the Northern Victorian Irrigation Renewal Program (NVIRP). The potential for NVIRP impact on Kinnairds Swamp is predicted as a minor reduction in flows is not likely to impact on the capacity to delivery environmental water to this area (GBCMA, 2010).

8.3 INFRASTRUCTURE RECOMMENDATIONS

The following infrastructure recommendations are procured from Goulburn-Murray Water *"Scoping Infrastructure Works for Priority Wetlands in the Shepparton Irrigation Region – Kinnairds Swamp"* (Paynter 2010).

The most effective method for delivering environmental water is via Hendy Road. This is via delivery from the Murray Valley 4 channel at Hendy Road leaving the channel upstream of the Murray Valley 276 outfall regulator and following an existing internal fence line through private property. Works would include:

- New outlet from the channel;
- 250m of channel;
- Occupation crossing;
- Pipe through the confining bank with flap gate or isolation gate; and
- Inlet cutting to the constructed wetland.

This would allow relatively small volumes to be delivered directly to the eastern side of the wetland which is necessary to maintain the nutrient stripping facility in a healthy condition. By careful placement of the isolation structure it would also allow water to be diverted to selected areas within Kinnairds Swamp to be either topped up or filled, without filling the whole of Kinnairds Swamp and without loss of water to the Muckatah Depression Main Drain. The Murray Valley 4 channel would need reconfiguration to be able to pass the higher flow rates required by this option. The main negative to this approach is the need to acquire land which may be difficult on this property.

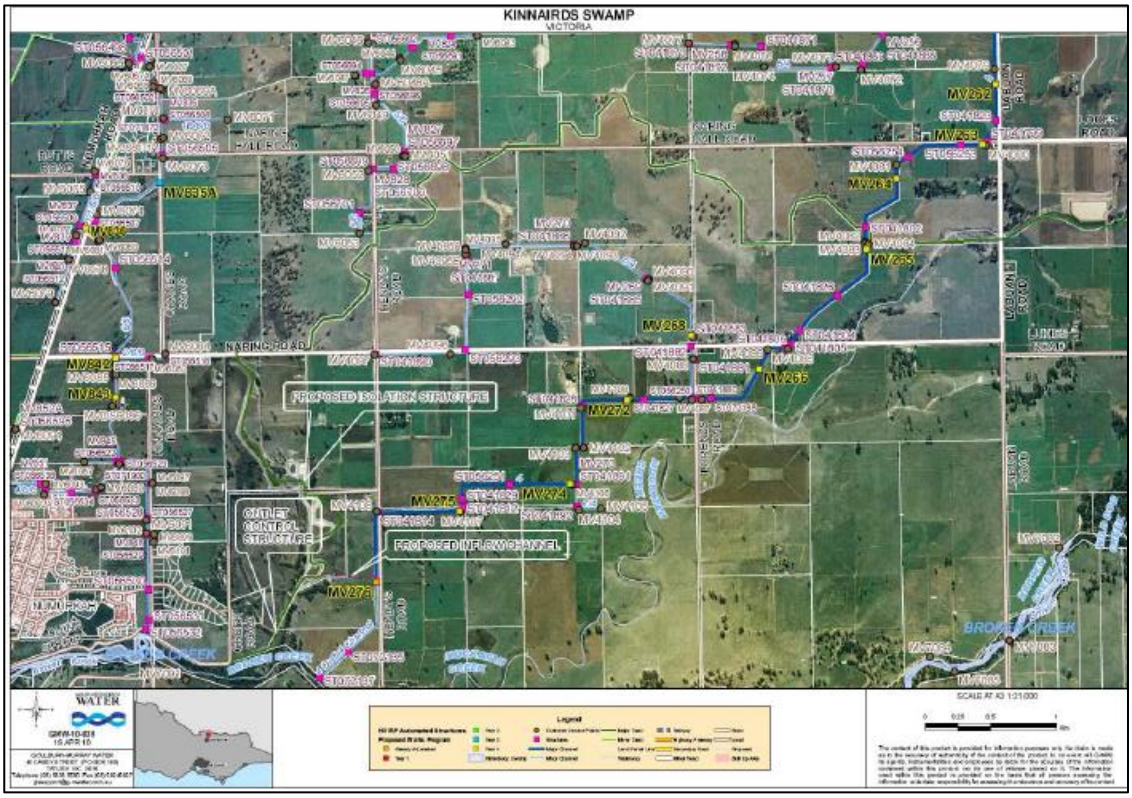

Figure 15: Proposed structures for environmental water delivery to Kinnairds Swamp

Map image taken from Scoping study report (Paynter 2010).

9. KNOWLEDGE GAPS AND RECOMMENDATIONS

There are currently a number of knowledge gaps in relation to environmental water management at Kinnairds Swamp. While most of these do not impact the ability to provide water to the wetland and generate ecological benefit, addressing these would significantly improve the accuracy of environmental water bids, and provide long-term ecological understanding of the site.

The following list describes recognised knowledge gaps that may assist with more efficient environmental water delivery to Kinnairds Swamp.

1. Research the ecology and water requirements of rigid water-milfoil and slender water-milfoil. Monitoring of these species is imperative to preserve the populations in Kinnairds Swamp.
2. Monitoring of the sites environmental conditions and issues that may pose threats. This includes monitoring species such as the native water couch and exotic species such as arrowhead and aster weed when conditions are deemed favourable for their prolific growth and collection of water quality data from Goulburn-Murray Water regarding Muckatah Depression Drain inflows into Kinnairds Swamp. This monitoring should continue on a long-term basis ensuring control of these plants. Pest animals should be monitored and prevention/eradication should occur where possible. Investigation of management options for exotic fish species entering Kinnairds Swamp should occur.
3. Simulating the natural hydrological regime to provide ecological benefits by delivering environmental water on average five –seven years in ten years if conditions prevail.
4. Monitoring water quality in Kinnairds Swamp during environmental water delivery to ensure nutrient loads do not reach critical levels.
5. Undertaking a risk management matrix before delivering environmental water to Kinnairds Swamp.
6. Observing scientific knowledge gaps and working toward filling these gaps. This includes modelling of flows within the wetland if infrastructure upgrades are proposed and continuation of monitoring of the wetland during an environmental water delivery and thereafter.

10. GLOSSARY

Complex

A conceptual whole made up of complicated and related parts.

Depression

A sunken or depressed geological formation within the landscape.

Ephemeral

Wetland alternates between holding water and being completely dry, with the dry phase being the usual state; flooding occurs rarely and irregularly; surface water persists only very briefly, days to a few weeks.

Seasonal

Wetland alternates between holding water and being completely dry, in nearly all years, except possibly extremely wet and extremely dry years, and on a fairly predictable seasonal pattern; surface water persists for months (Brock et al., 2003, Roberts and Marston, 2011).

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12. APPENDICES

APPENDIX 1: WORKSHOP NOTES

Participants were given a booklet with wetland characteristics, maps and site information to discuss (all found in relevant sections of this plan). Ecological and hydrological requirements were determined by J. Wood and S. Casanelia before the Scientific Committee met and were discussed and changed where relevant and are now in section 6 – Management Goal.

APPENDIX 2: CORRICK AND NORMAN CLASSIFICATION OF WETLAND CATEGORIES

A system of wetland classification developed by Corrick and Norman (1980) is used to describe wetlands in Victoria. Under this system six naturally occurring wetland types are described based upon water depth, frequency of inundation, salinity and dominant vegetation.

Freshwater meadow

These include shallow (up to 0.3m) and temporary (less than four months duration) surface water, although soils are generally waterlogged throughout winter.

Shallow freshwater marsh

Wetlands that are usually dry by mid-summer and fill again with the onset of winter rains. Soils are waterlogged throughout the year and surface water up to 0.5m deep may be present for as long as eight months.

Deep freshwater marsh

Wetlands that are generally inundated to a depth of 1-2m throughout the year.

Permanent open freshwater

Wetlands that are usually more than 1m deep. They can be natural or artificial. Wetlands are described as permanent if they retain water for longer than 12 months, however they can have periods of drying.

Semi-permanent saline

These wetlands may be inundated to a depth of 2m for as long as eight months each year. Saline wetlands are those in which salinity exceeds 3,000mg/L throughout the whole year.

Permanent saline

These wetlands include coastal wetlands and part of intertidal zones. Saline wetlands are those in which salinity exceeds 3,000mg/L throughout the whole year.

APPENDIX 3: ENVIRONMENTAL WATER SOURCES

Victorian River Murray Flora and Fauna Bulk Entitlement – Deployed along the length of the Murray River in Victoria. This has been used in the past to supply water to Barmah Forest and wetlands connected to the supply networks of the Goulburn River and lower Broken Creek Systems.

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

- The Victorian River Murray Flora and Fauna Bulk Entitlement; and
- Future Northern Victorian Irrigation Renewal Project (NVIRP) Environmental Entitlement.

In 1987 an annual allocation of 27,600ML of high security water was committed to flora and fauna conservation in Victorian Murray Wetlands. In 1999, this became a defined entitlement for the environment called the Victorian River Murray Flora and Fauna Bulk Entitlement.

Future NVRIP Environmental Water Entitlements - One third of water savings from Stage 1 of the NVIRP project will be used for the environment, some of which will be stored in Lake Eildon. This water will be released into stressed rivers and streams when required. The NVIRP water savings are predicted to provide up to 75GL as a statutory environmental entitlement, which will be used to help improve the health of priority stressed rivers and wetlands in northern Victoria. The entitlement will have priorities which enable the water to be used at multiple locations as the water travels downstream (provided losses and water quality issues are accounted for); meaning that the water can be called out of storage at desired times to meet specific environmental needs.

The environment's share of water savings will be over and above The Living Murray and Snowy commitments and will primarily target the use of environmental water for priority Victorian wetlands and tributaries.

This will also have flow on benefits when the water enters the River Murray, which can then be reused to meet the needs of the Murray and its floodplains and wetlands, including Kerang Lakes, Barmah Forest, Gunbower Forest, Hattah Lakes, Lindsay-Wallpolla Island and various other sites along the River Murray.

Stage 2 is expected to deliver a further 200 billion litres of water savings a year, which will be shared equally between irrigators and the environment.

Commonwealth Environmental Water Holder (CEWH) – The *Water Act 2007* established the Commonwealth Environmental Water Holder to manage the water entitlements that the Commonwealth acquires. These water entitlements will be used to protect or restore environmental assets such as wetlands and streams.

69 GL of environmental water will be available for the Lower Goulburn between February and July 2011. Commonwealth environmental water is available to avoid the critical loss of threatened species. It is also available to avoid irretrievable damage or catastrophic events and to maintain key refuges to allow re-colonisation when conditions improve.

APPENDIX 4: LEGISLATIVE FRAMEWORK

Acts, Agreements and Conventions

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

Bilateral Migratory Bird Agreements

Japan Australia Migratory Bird Agreement 1974 - Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment.

China Australia Migratory Bird Agreement 1986 - Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment.

These agreements require that the parties protect migratory birds by:

- Limiting the circumstances under which migratory birds are taken or traded;
- Protecting and conserving important habitats;
- Exchanging information; and
- Building cooperative relationships.

Convention of Migratory Species (Bonn Convention) 1979 - The Convention on the Conservation of Migratory Species of Wild Animals (also known as CMS or Bonn Convention) aims to conserve terrestrial, marine and avian migratory species throughout their range. It is an **intergovernmental treaty**, concluded under the aegis of the United Nations Environment Programme, concerned with the conservation of wildlife and habitats on a global scale. Since the Convention's entry into force, its membership has grown steadily to include 114 (as of 1 October 2010) Parties from Africa, Central and South America, Asia, Europe and Oceania.

Republic of Korea Australia Migratory Bird Agreement 2009 – Agreement between the Government of Australia and the Government of the Republic of Korea on the protection of Migratory birds.

ACTS (NATIONAL)

Australian Heritage Commission Act 1975 - An Act to establish an Australian Heritage Commission.

Aboriginal and Torres Strait Islander Heritage Protection Act 1984 - An Act to preserve and protect places, areas and objects of particular significance to Aboriginals, and for related purposes.

Native Title Act 1993 – Legislation to protect any native title that has survived 200 years of colonisation.

Environmental Protection Biodiversity Conservation Act 1999 - The Australian Government's central piece of environmental legislation. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places — defined in the Act as matters of national environmental significance.

Water Act 2007 - An Act to make provision for the management of the water resources of the Murray-Darling Basin, and to make provision for other matters of national interest in relation to water and water information, and for related purposes.

Water Amendment Act 2008 - An Act to amend the Water Act 2007, and for related purposes.

ACTS (VICTORIA)

Environmental Effects Act 1978 – Potential environmental impacts of a proposed development are subject to assessment and approval under this Act. A structural works program and any associated environmental impacts would be subject to assessment and approval under this Act.

Planning and Environment Act 1987 – Controls the removal or disturbance to native vegetation within Victoria by implementation of a three-step process of avoidance, minimisation and offsetting.

Flora and Fauna Guarantee Act 1988 - The key piece of Victorian legislation for the conservation of threatened species and communities and for the management of potentially threatening processes.

Water Act 1989 (Victorian) - The legislation that governs the way water entitlements are issued and allocated in Victoria. It defines water entitlements and establishes the mechanisms for managing Victoria's water resources.

Catchment and Land Protection Act 1994 - has an objective of establishing a framework for the integrated and coordinated management of catchments which will;

- maintain and enhance long-term land productivity while also conserving the environment, and
- aim to ensure that the quality of the State's land and water resources and their associated plant and animal life are maintained and enhanced.

The Act established ten Catchment and Land Protection Boards, nine of which have since expanded their roles to become Catchment Management Authorities. The *Catchment and Land Protection Act* (1994) provides for the development of Regional Catchment Strategies which, among other things, must assess the nature, causes, extent and severity of land degradation of the catchments in the region and identify areas for priority attention. Local Planning schemes must have regard for the Regional Catchment Strategies.

Aboriginal Heritage Act 2006 - The main purpose of this Act is to provide for the protection of Aboriginal cultural heritage in Victoria. The objectives of this Act are-

(a) to recognise, protect and conserve Aboriginal cultural heritage in Victoria in ways that are based on respect for Aboriginal knowledge and cultural and traditional practices;

(b) to recognise Aboriginal people as the primary guardians, keepers and knowledge holders of Aboriginal cultural heritage;

(c) to accord appropriate status to Aboriginal people with traditional o familial links with Aboriginal cultural heritage in protecting that heritage;

(d) to promote the management of Aboriginal cultural heritage as an integral part of land and natural resource management;

(e) to promote public awareness and understanding of Aboriginal cultural heritage in Victoria;

(f) to establish an Aboriginal cultural heritage register to record Aboriginal cultural heritage;

(g) to establish processes for the timely and efficient assessment of activities that have the potential to harm Aboriginal cultural heritage;

(h) to promote the use of agreements that provide for the management and protection of Aboriginal cultural heritage;

(i) to establish mechanisms that enable the resolution of dispute relating to the protection of Aboriginal cultural heritage;

(j) to provide appropriate sanctions and penalties to prevent harm to Aboriginal cultural heritage.

Advisory lists of rare and threatened species in Victoria (DSE) – Three advisory lists are maintained by DSE for use in a range of planning processes and in setting priorities for actions to conserve biodiversity. Unlike other threatened species lists, there are no legal requirements or consequences that flow from inclusion of a species on an advisory list. The advisory list comprises:

- Advisory list of Rare and Threatened Plants in Victoria – 2005
- Advisory list of Threatened Vertebrate Fauna in Victoria – 2007
- Advisory list of Threatened Invertebrate Fauna in Victoria - 2009

Policy and Frameworks

Wetland Policy of the Commonwealth Government of Australia 1997 - On 2 February 1997, the inaugural World Wetlands Day, the Commonwealth Government released the Wetlands Policy of the Commonwealth Government of Australia. The Wetlands Policy aims to promote the conservation, repair, and wise use of wetlands and - within the broader context of environmental management - incorporate the conservation of wetlands into the daily business of the Commonwealth Government.

Framework for Determining Commonwealth Environmental Watering Actions 2009 - The purpose of this paper is to outline a framework for determining Commonwealth environmental watering actions in the Murray-Darling Basin. The framework will be developed and implemented over the period 2009-2011, prior to the development of the Environmental Watering Plan (EWP) by the Murray Darling Basin Authority, and be adapted in accordance with the EWP once that is available.

Policy and Frameworks (Victoria)

The State Environment Protection Policy (Waters of Victoria) 2003 - Sets the framework for government agencies, businesses and the community to work together, to protect and rehabilitate Victoria's surface water environments.

Northern Region Sustainable Water Strategy 2009 - The Northern Region Sustainable Water Strategy has been released by the Victorian Government to secure the water future for urban, industrial, agricultural and environmental water users for the next 50 years.

Reports Applicable to the Environmental Watering Plan

Goulburn Broken Catchment Regional Catchment Strategy 2003 – A strategy that sets the framework for Natural Resource Management and the context for sub-strategies and action plans within the Goulburn Broken Catchment.

Our Water Our Future 2004 - Sets out 110 actions for sustainable water management aimed at every sector of the community, seeking to secure water supplies and sustain growth over the next 50 years. The 110 actions aim to:

- Repair rivers and groundwater systems – the natural source of all our fresh water – by giving them legal water rights and conducting restoration works;
- Price water to encourage people to use it more wisely;
- Permanently save water in our towns and cities, through common sense water saving and recycling measures;
- Secure water for farms through pioneering water allocation and trading systems; and
- Manage water allocation to find the right balance between economic, environmental and social values.

Biodiversity strategy for Goulburn Broken Catchment 2009 - This Strategy follows implementation of Goulburn Broken CMAs Native Vegetation Management Strategy (developed in 2000) and from the Fringe to mainstream – a Strategic Plan for Integrating Native Biodiversity (developed in 2004). The Strategy provides a regional perspective for implementing Victoria's White Paper for Land and Biodiversity at a time of Climate Change (released December 2009).

Lower Broken Creek and Nine Mile Creek EWP 2010 - This Environmental Watering Plan assesses the hydrologic impact of the NVIRP on the creek system downstream of Katamatite and reviews the likely impact of the hydrologic modification on the high value environmental assets.

APPENDIX 5: FAUNA SPECIES LIST

Fauna list of Kinnairds Swamp – taken from Victorian Fauna Database 2010, G. Deayton 2005-2007 counts, P. O'Connor 2008-2009 counts and D. Cook 2008-2009 counts.

E – Listed as endangered under the *Environmental Protection Biodiversity Conservation Act (1999)*

L = listed as threatened under the *Flora and Fauna Guarantee Act (1988)*

vu = Listed as vulnerable on the DSE Advisory list of threatened vertebrate fauna (2007)

en = Listed as endangered on the DSE Advisory list of threatened vertebrate fauna (2007)

nt = Listed as near threatened on the DSE Advisory list of threatened vertebrate fauna (2007)

dd = Listed as data deficient on the DSE Advisory list of threatened vertebrate fauna (2007)

cr = Listed as critically endangered on the DSE Advisory list of threatened vertebrate fauna (2007)

w Water dependant species or Waterbirds

b Observed breeding at the Swamp

Common Name	Scientific Name	EPBC	FFG	VROTS	Origin and guild
BIRDS					
Australasian Bittern	*Botaurus poiciloptilus*	En	L	en	w
Australasian Darter	*Anhinga novaehollandiae*				w
Australasian Grebe	*Tachybaptus novaehollandiae*				w
Australasian Pipit	*Anthus novaeseelandiae*				
Australasian Shoveler	*Anas rhynchotis*			vu	w b
Australian Hobby	*Falco longipennis*				
Australian Magpie	*Gymnorhina tibicen*				
Australian Pelican	*Pelecanus conspicillatus*				w
Australian Raven	*Corvus coronoides*				
Australian Reed-Warbler	*Acrocephalus stentoreus*				w
Australian Shelduck	*Tadorna tadornoides*				w b
Australian Spotted Crake	*Porzana fluminea*				w
Australian White Ibis	*Threskiornis molucca*				w
Australian Wood Duck	*Chenonetta jubata*				w
Baillon's Crake	*Porzana pusilla palustris*		L	vu	w
Black Falcon	*Falco subniger*			vu	
Black Kite	*Milvus migrans*				
Black Swan	*Cygnus atratus*				w
Black-chinned Honeyeater	*Melithreptus gularis*			nt	
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*				
Black-fronted Dotterel	*Elseyornis melanops*				w
Black-shouldered Kite	*Elanus axillaris*				
Black-tailed Native-hen	*Gallinula ventralis*				w
Black-winged Stilt	*Himantopus himantopus*				w
Blue-billed Duck	*Oxyura australis*				
Blue-faced Honeyeater	*Entomyzon cyanotis*				
Brolga	*Grus rubicunda*			vu	w
Brown Falcon	*Falco berigora*				

Brown Goshawk	*Accipiter fasciatus*				
Brown Quail	*Coturnix ypsilophora australis*			nt	b
Brown Songlark	*Cincloramphus cruralis*				
Brown Treecreeper (south-eastern ssp.)	*Climacteris picumnus victoriae*			nt	
Brown-headed Honeyeater	*Melithreptus brevirostris*				
Buff-banded Rail	*Gallirallus philippensis*				w
Buff-rumped Thornbill	*Acanthiza reguloides*				
Cattle Egret	*Ardea ibis*				w
Chestnut Teal	*Anas castanea*				w
Cockatiel	*Nymphicus hollandicus*				
Collared Sparrowhawk	*Accipiter cirrhocephalus*				
Common Bronzewing	*Phaps chalcoptera*				
Crested Pigeon	*Ocyphaps lophotes*				
Crested Shrike-tit	*Falcunculus frontatus*				
Crimson Rosella	*Platycercus elegans*				
Crimson Rosella (Yellow form)	*Platycercus elegans*				
Dusky Moorhen	*Gallinula tenebrosa*				w
Dusky Woodswallow	*Artamus cyanopterus*				
Eastern Barn Owl	*Tyto alba*				
Eastern Great Egret	*Ardea modesta*		L	vu	w
Eastern Rosella	*Platycercus eximius*				
Eurasian Coot	*Fulica atra*				w
European Goldfinch	*Carduelis carduelis*				
Fairy Martin	*Hirundo ariel*				
Fan-tailed Cuckoo	*Cacomantis flabelliformis*				
Flame Robin	*Petroica phoenicea*				
Fork-tailed Swift	*Apus pacificus*				w
Freckled Duck	*Stictonetta naevosa*				w
Fuscous Honeyeater	*Lichenostomus fuscus*				
Galah	*Eolophus roseicapilla*				
Glossy Ibis	*Plegadis falcinellus*			nt	w
Golden Whistler	*Pachycephala pectoralis*				
Golden-headed Cisticola	*Cisticola exilis*				
Great Cormorant	*Phalacrocorax carbo*				w
Grey Fantail	*Rhipidura albiscarpa*				
Grey Shrike-thrush	*Colluricincla harmonica*				
Grey Teal	*Anas gracilis*				w
Hardhead	*Aythya australis*			vu	w
Hoary-headed Grebe	*Poliocephalus poliocephalus*				w
Intermediate Egret	*Ardea intermedia*				w
Jacky Winter	*Microeca fascinans*				
Latham's Snipe	*Gallinago hardwickii*			nt	w
Laughing Kookaburra	*Dacelo novaeguineae*				
Little Black Cormorant	*Phalacrocorax sulcirostris*				w
Little Corella	*Cacatua sanguinea*				
Little Eagle	*Hieraaetus morphnoides*				

Little Egret	*Egretta garzetta*		L	en	
Little Friarbird	*Philemon citreogularis*				
Little Grassbird	*Megalurus gramineus*				w
Little Lorikeet	*Glossopsitta pusilla*				
Little Pied Cormorant	*Microcarbo melanoleucos*				w
Little Raven	*Corvus mellori*				
Little Wattlebird	*Anthochaera chrysoptera*				
Long-billed Corella	*Cacatua tenuirostris*				
Magpie Goose	*Anseranus semipalmata*			vu	w
Magpie-lark	*Grallina cyanoleuca*				
Masked Lapwing	*Vanellus miles*				w
Masked Woodswallow	*Artamus personatus*				
Musk Lorikeet	*Glossopsitta concinna*				
Nankeen Kestrel	*Falco cenchroides*				
Nankeen Night Heron	*Nycticorax caledonicus*			nt	w
Noisy Friarbird	*Philemon corniculatus*				
Noisy Miner	*Manorina melanocephala*				
Olive-backed Oriole	*Oriolus sagittatus*				
Pacific Barn Owl	*Tyto javanica*				
Pacific Black Duck	*Anas superciliosa*				w b
Pallid Cuckoo	*Cuculus pallidus*				
Peaceful Dove	*Geopelia striata*				
Peregrine Falcon	*Falco peregrinus*				b
Pied Butcherbird	*Cracticus nigrogularis*				
Pied Cormorant	*Phalacrocorax varius*			nt	w
Pied Currawong	*Strepera graculina*				
Pink-eared Duck	*Malacorhynchus membranaceus*				w
Plumed Whistling-Duck	*Dendrocygna eytoni*				w
Purple Swamphen	*Porphyrio porphyrio*				w
Purple-crowned Lorikeet	*Glossopsitta porphyrocephala*				
Rainbow Bee-eater	*Merops ornatus*				
Red Wattlebird	*Anthochaera carunculata*				
Red-capped Robin	*Petroica goodenovii*				
Red-kneed Dotterel	*Erythrogonys cinctus*				w
Red-rumped Parrot	*Psephotus haematonotus*				
Restless Flycatcher	*Myiagra inquieta*				
Royal Spoonbill	*Platalea regia*			vu	w b
Rufous Songlark	*Cincloramphus mathewsi*				
Rufous Whistler	*Pachycephala rufiventris*				
Sacred Kingfisher	*Todiramphus sanctus*				
Scarlet Robin	*Petroica boodang*				
Silver Gull	*Chroicocephalus novaehollandiae*				w
Silvereye	*Zosterops lateralis*				
Southern Boobook	*Ninox novaeseelandiae*				
Spotless Crake	*Porzana tabuensis*				w
Spotted Pardelote	*Pardalotus punctatus*				

Straw-necked Ibis	*Threskiornis spinicollis*				w
Striated Pardalote	*Pardalotus striatus*				
Stubble Quail	*Coturnix pectoralis*				
Sulphur-crested Cockatoo	*Cacatua galerita*				
Superb Fairy Wren	*Malurus cyaneas*				
Swamp Harrier	*Circus approximans*				w
Swift Parrot	*Lathamus discolor*	E	L	en	
Tawny Frog Mouth	*Podargus strigoides*				
Tree Martin	*Hirundo nigricans*				
Varied Sittella	*Daphoenositta chrysoptera*				
Wedge-tailed Eagle	*Aquila audax*				
Weebill	*Smicrornis brevirostris*				
Welcome Swallow	*Hirundo neoxena*				
Western Gerygone	*Gerygone fusca*				
Whiskered Tern	*Childonias hybridus*				
Whistling Kite	*Haliastur sphenurus*				b
White-bellied Cuckoo-shrike	*Coracina papuensis*				
White-bellied Sea-Eagle	*Haliaeetus leucogaster*		L	vu	w
White-breasted Woodswallow	*Artamus leucorynchus*				
White-browed Woodswallow	*Artamus superciliosus*				
White-faced Heron	*Egretta novaehollandiae*				w
White-necked Heron	*Ardea pacifica*				w
White-plumed Honeyeater	*Lichenostomus penicillatus*				
White-throated Gerygone	*Gerygone olivacea*				
White-throated Needletail	*Hirundapus caudactus*				w
White-throated Treecreeper	*Cormobates leucophaea*				
White-winged Chough	*Corcorax melanorhamphos*				
White-winged Triller	*Lalage sueurii*				
Willie Wagtail	*Rhipidura leucophrys*				
Yellow Thornbill	*Acanthiza nana*				
Yellow-billed Spoonbill	*Platalea flavipes*				w
Yellow-faced Honeyeater	*Lichenostomus chrysops*				
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*				
Zebra Finch	*Taeniopygia guttata*				
AQUATIC INVERTEBRATES					
Aquatic caterpillar	Family Crambidae				w
Backswimmer	Family Notonectidae				w
Beetle	Family Hydraenidae				w
Beetle	Family Hydrochidae				w
Beetle	Family Ceratopogonidae				w
Biting Midge	Family Ceratopogonidae				w
Caddis Fly	Family Leptoceridae				w
Creeping water bugs	Family Naucoridae				w
Damselfly	Family Aeshnidae				w
Damselfly	Family Zygoptera				w
Dragonfly	Family Coenagrionidae				w

Dragonfly	Family Hemicorduliidae				w
Dragonfly	Family Lestidae				w
Giant water bug	Family Belostomatidae				w
Mayfly	Family Baetidae				w
Non-biting Midge	Family Chironomidae				w
Predacious diving beetle	Family Dytiscidae				w
Pygmy back swimmer	Family Pleidae				w
Timber weevil	Family Nanophyidae				w
Water boatman	Family Coroxidae				w
NATIVE FISH					
Freshwater Catfish	*Tandanus tandanus*				w
FROGS					
Barking Marsh Frog	*Limnodynastes fletcheri*				Banks of lakes or rivers
Common Froglet	*Crinia signifera*				Moist depressions
Peron's Tree Frog	*Litoria peronii*				Wet and Dry areas
Growling Grass Frog	*Litoria raniformis*	Vu	L	En	Permanent – seasonally wet areas
Plains Froglet	*Crinia parinsignifera*				Moist depressions
Pobblebonk	*Limnodynastes dumerilii*				Most areas except Alpine and extreme dry
Spotted Marsh Frog	*Limnodynastes tasmaniensis*				Common in farm dams and wetlands
MAMMALS					
Chocolate Wattled Bat	*Chalinobus morio*				
Common Brushtail Possum	*Trichosurus vulpecular*				
Common Ringtail Possum	*Pseudocheirus peregrinus*				
Freetail Bat (eastern form)	*Mormopterus sp*				
Gould's Long Eared Bat	*Nyctophilus gouldi*				
Gould's Wattled Bat	*Chalinobus gouldii*				
Inland Broadnose Bat	*Scotorepans balstoni*				
Lesser Long Eared Bat	*Nyctophilus geoffroyi*				
Little Forest Bat	*Vespadelus vulturnus*				
Little Red Flying-fox	*Pteropus scapulatus*				
Southern Forest Bat	*Vespadelus regulus*				
Southern Freetail Bat (long penis)	*Mormopterus sp*				
Water Rat	*Hydromys chrysogaster*				
White-striped Freetail Bat	*Tadarida australis*				
REPTILES					
Eastern Brown Snake	*Pseudonaja textilis*				
Tiger Snake	*Notechis scutatus*				
Lace Monitor	*Varanus varius*			vu	
INTRODUCED SPECIES					
Brown Hare	*Lepus capensis*				
Common Blackbird	*Turdus merula*				
Common Starling	*Sturnus vulgaris*				
Common Myna	*Sturnus tristis*				
European Carp	*Cyprinus carpio*				w

European Greenfinch	*Carduelis chloris*				
House Sparrow	*Passer domesticus*				
Northern Mallard	*Anas platyrhynchos*				
Red Fox	*Vulpes vulpes*				
Spotted Dove	*Streptopelia chinensis*				

APPENDIX 6: ECOLOGICAL VEGETATION CLASSES

The following information is taken from the Index of Wetland Condition Assessment of Wetland Vegetation Update-March 2006. Victoria's Framework for the Native Vegetation Management (DNRE 2002) utilises the notion of Ecological Vegetation Classes (EVCs). The Framework defines an EVC as follows: "An EVC is a type of native vegetation classification that is described through a combination of floristic, life form and ecological characteristics, and through an inferred fidelity to particular environmental attributes. Each EVC includes a collection of floristic communities (ie: a lower level in the classification that is based solely on groups of the same species) that occur across a biogeographic range, and although differing in species, have similar habitat and ecological processes operating".

Below is a description of the EVCs found within and surrounding Kinnairds Swamp (www.dse.gov.au).

Red Gum Swamp [EVC #292]

Woodland of swampy depressions of lowland plains, with sedgy-herbaceous understorey including aquatic species.

Tall Marsh [EVC #821]

Wetland dominated by tall emergent graminoids, typically in thick species-poor swards. Rushland, sedgeland or reedbed - locally closed or in association or fine-scale mosaic with Aquatic Herbland (e.g. along floodway lagoons). At optimum development, the vegetation is treeless, but sparse *Eucalyptus camaldulensis* (or in higher rainfall areas, *E. ovata*) are dispersed through some sites where sufficient dry periods occur to allow their survival.

Riverine Swamp Woodland [EVC #815]

Eucalypt open woodland, ground-layer grassy to sedgy to herbaceous., with species indicative of periodic water-logging (and with floristic affinities to Plains Grassy Wetland). Depleted and rare, most extensive at Barmah Forest.

Plains Grassy Wetland [EVC #125]

Grassy-herbaceous shallow seasonal wetlands of lowland plains, characteristically species-rich (at least on verges) when relatively intact. Zones interpreted as representing complexes between Plains Grassy Wetland and several other wetland EVCs are frequently present.

Plains Rushy Wetland [EVC #916]

Rush-dominated wetland with floristic affinities to Plains Grassy Wetland. Occurs as a shallow wetland on drier plains, only intermittently inundated and on heavy reddish brown to grey-brown or grey clay soils.

EVCs SURROUNDING KINNAIRDS SWAMP

Plains Grassy Woodland [EVC #55]

An open, eucalypt woodland occurring on a number of geologies and soil types. Occupies poorly drained,

fertile soils on flat or gently undulating plains at low elevations. The understorey consists of a few sparse shrubs over a species-rich grassy and herbaceous ground layer.

Plains Grassy Woodland/Gilgai Wetland Mosaic [EVC # 259] – No description offered

APPENDIX 7: FLORA SPECIES LIST

Flora list of Kinnairds Swamp – taken from Victorian Flora Database 2010, DPI Kinnairds Swamp Management Plan Flora list, Walsh counts 1997 and D. Cook 2008-2011 counts.

Note: EVC information is recorded only from D.Cook Surveys.

L = Listed as threatened under the Flora and Fauna Guarantee Act (1988)

E =Listed as Endangered under the Environmental Protection Biodiversity Act (1999)

e = Endangered in Victoria in DSE Advisory list of rare and threatened plants in Victoria (2005)

k = Poorly known in Victoria in DSE Advisory list of rare and threatened plants in Victoria (2005)

v = Vulnerable in Victoria in DSE Advisory list of rare and threatened plants in Victoria (2005)

r = Rare in Victoria in DSE Advisory list of rare and threatened plants in Victoria (2005)

w = Wetland species

p = Planted

= Native to Victoria but grows outside natural range

Common Name	Scientific Name	EVC 961	EVC 292	EVC 821	EVC 125	EVC 815	EPBC	FFG	VROTS	Origin	Indigenous Use
Gold-dust Wattle	*Acacia acinacea s.l.*										
Silver Wattle	*Acacia dealbata*										Wood used for handles. Gums eaten or used to make water-proof paste
Mallee Wattle	*Acacia montana*										
Golden Wattle	*Acacia pycnantha*										
Water Plantain	*Alisma plantago-aquatica*									w	
Lesser Joyweed	*Alternanthera denticulata s.l.*	✓	✓	✓	✓	✓				w	
Plains Joyweed	*Alternanthera sp.1*					✓					
Long-nosed Swamp Wallaby-grass	*Amphibromus macrorhinus*										
Common Swamp Wallaby-grass	*Amphibromus nervosus*	✓	✓		✓					w	
Brush Wire-grass	*Aristida behriana*										
Nodding Chocolate-lily	*Arthropodium fimbriatum*										Tubers eaten.
Small Vanilla-lily	*Arthropodium minus*										Tubers eaten
Lily	*Arthropodium sp.*					✓					
Chocolate Lily	*Arthropodium strictum s.l.*										Tubers eaten
Common Woodruff	*Asperula conferta*					✓					
Berry Saltbush	*Atriplex semibaccata*					✓					
Spiny-fruit Saltbush	*Atriplex spinibractea*								e		
Sprawling Saltbush	*Atriplex suberecta*									#	
Leafy Wallaby-grass	*Austrodanthonia bipartita s.l.*										
Common Wallaby-grass	*Austrodanthonia caespitosa*					✓				w	
Brown-back	*Austrodanthonia duttoniana*					✓				w	

Wallaby-grass											
Hill Wallaby-grass	*Austrodanthonia eriantha*										
Bristly Wallaby-grass	*Austrodanthonia setacea*					✓					
Plump Spear-grass	*Austrostipa aristiglumis*					✓					
Spurred Spear-grass	*Austrostipa gibbosa*								r		
Knotty Spear-grass	*Austrostipa nodosa*										
Rough Spear-grass	*Austrostipa scabra subsp. falcata*					✓					
Pacific Azolla	*Azolla filiculoides*	✓	✓	✓	✓					w	
Tah-vine	*Boerhavia dominii*									#	Tap roots eaten
Yellow-tongue Daisy	*Brachyscome chrysoglossa*							L	v		
Variable Daisy	*Brachyscome ciliaris*										
Bulbine Lily	*Bulbine bulbosa*										Tubers eaten
Milkmaids	*Burchardia umbellata*										
Sweet Bursaria	*Bursaria spinosa subsp. spinosa*										
Winged Water-starwort	*Callitriche umbonata*								r	w	
Lemon Beauty-heads	*Calocephalus citreus*										
Cut-leaf Burr-daisy	*Calotis anthemoides*										
Riverina Bitter-cress	*Cardamine moirensis*		✓		✓				r	w	
Tall Sedge	*Carex appressa*									w	Leaves used in basket making
Common Sedge/ Knob Sedge	*Carex inversa*					✓				w	
Poong'ort / Rush Sedge	*Carex tereticaulis*									w	
Drooping Cassinia	*Cassinia arcuata*										
Common Sneezeweed	*Centipeda cunninghamii*	✓	✓							w	
Flat Spurge	*Chamaesyce drummondii*									#	
Small-leaf Goosefoot	*Chenopodium desertorum ssp. microphylum*										
Clammy goosefoot	*Chenopodium pumilio*					✓					
Windmill Grass	*Chloris truncata*					✓					
Common Everlasting	*Chrysocephalum apiculatum s.l.*										
Bindweed	*Convolvulus erubescens*										
Pink Bindweed	*Convolvulus erubescens spp. agg.*					✓					Tap roots made into dough
Grass Bindweed	*Convolvulus remotus*										
Spreading Crassula	*Crassula decumbens var. decumbens*										
Purple Crassula	*Crassula peduncularis*									w	
Sieber Crassula	*Crassula sieberiana s.l.*										
Crassula	*Crassula spp.*										
Tall Flat-sedge	*Cyperus exaltatus*									w	
Star Fruit	*Damasonium minus*	✓	✓		✓					w	
Pale Flax-lily	*Dianella longifolia s.l.*										Leaves used for cord and basket making.
Black-anther Flax-lily	*Dianella revoluta s.l.*										

Scarlet Sundew	*Drosera glanduligera*										
Tall Sundew	*Drosera peltata*										
Pale Sundew	*Drosera peltata subsp. peltata*									w	
Common Barnyard Grass	*Echinochloa crus-galli*										
Yellow Twin-heads	*Eclipta platyglossa*					✓				# w	
Nodding Saltbush	*Einadia nutans subsp. nutans*										
Waterwort	*Elatine gratioloides*				✓					w	
Common Spike-sedge	*Eleocharis acuta*	✓	✓	✓	✓					w	
Variable Spike-sedge	*Eleocharis minuta*								e		
Small Spike-sedge	*Eleocharis pusilla*	✓	✓		✓					w	
Common Wheat-grass	*Elymus scaber var. scaber*					✓					
Ruby Saltbush	*Enchylaena tomentosa var. tomentosa*										Berries and leaves eaten
Spider Grass	*Enteropogon acicularis*					✓					
Variable Willow-herb	*Epilobium billardierianum subs. cinereum*	✓								w	
Blue Devil	*Eryngium ovinum*										
River Red-gum	*Eucalyptus camaldulensis*	✓	✓			✓				w	
Yellow Box	*Eucalyptus melliodora*										
Grey Box	*Eucalyptus microcarpa*										
Common Cudweed	*Euchiton involucratus sp*					✓					
Annual Cudweed	*Euchiton sphaericus*	✓	✓								
Common Eutaxia	*Eutaxia microphylla var. microphylla*										
Spoon leaf Mud-mat	*Glossostigma cleistanthum*								v	w	
Variable Glycine	*Glycine tabacina s.l.*										Tap root chewed for licorice flavour
Tiny Cudweed	*Gnaphalium indutum*										
Silky Goodenia	*Goodenia fascicularis*										
Slender Goodenia	*Goodenia gracilis*									w	
Cut-leaf Goodenia	*Goodenia pinnatifida*										
Rough Raspwort	*Haloragis aspera*					✓					
Bluish Raspwort	*Haloragis glauca*								k		
Common Heliotrope	*Heliotropium europaeum*										
Hypoxis	*Hypoxis spp.*										
Yellow Star	*Hypoxis vaginata*										
Grass Cushion	*Isoetopsis graminifolia*										
Broad-fruit Club-sedge	*Isolepis cernua var. platycarpa*										
Grassy Club-sedge	*Isolepis hookeriana*									w	
Narrow Plover-daisy	*Ixiolaena leptolepis*										
Hollow Rush	*Juncus amabilis*									w	
Tussock Rush	*Juncus aridicola*									w	
Toad Rush	*Juncus bufonius*	✓			✓					w	
Yellow Rush	*Juncus flavidus*	✓	✓		✓	✓				w	
Joint-leaf Rush	*Juncus holoschoenus*									w	
Giant Rush	*Juncus ingens*			✓						w	

Hoary Rush	*Juncus radula*										
Plains Rush	*Juncus semisolidus*	✓	✓		✓					w	
Rush	*Juncus sp*									w	
Finger Rush	*Juncus subsecundus*									w	
Billabong Rush	*Juncus usitatus*	✓								w	
Common Blown-grass	*Lachnagrostis filiformis var.1*	✓	✓	✓	✓	✓				w	
Stalked Plover-daisy	*Leiocarpa websteri*										
Common Duckweed	*Lemna disperma*	✓	✓	✓	✓					w	
Scaly Buttons	*Leptorhynchos squamatus*										
Austral Mud-mat	*Limosella australis*		✓		✓					w	
Large Mudwort	*Limosella curdieana*				✓					w	
Native Flax	*Linum marginale*										Used for fish nets and cord. Seeds eaten.
Poison Pratia	*Lobelia concolor*					✓				w	
Poison Lobelia	*Lobelia pratioides*									w	
Scented Mat-rush	*Lomandra effusa*										
Clove-strip	*Ludwigia peploides subsp. montevidensis*	✓	✓	✓						w	
Small Loosestrife	*Lythrum hyssopifolia*	✓	✓		✓					w	
Black Cotton-bush	*Maireana decalvans*										
Wingless Bluebush	*Maireana enchylaenoides*										
Dwarf Bluebush	*Maireana humillima*										
Bluebush	*Maireana spp.*										
Narrow-leaf Nardoo	*Marsilea costulifera*	✓	✓		✓					w	
Common Nardoo	*Marsilea drummondii*	✓	✓	✓	✓					w	
Rough-barked Honey-myrtle	*Melaleuca parvistaminea*									p	
Creeping mint	*Mentha satureoides*					✓					Leaves used as medicine
Yam Daisy	*Microseris scapigera spp. agg.*										Tubers eaten
Smooth Minuria	*Minuria integerrima*								r		
Tangled Lignum	*Muehlenbeckia florulenta*					✓				w	
Mouse-tails	*Myosurus minimus var. australis*									w	
Woolly-heads	*Myriocephalus rhizocephalus*										
Upright Water-milfoil	*Myriophyllum crispatum*									w	
Clustered Water-milfoil	*Myriophyllum glomeratum*									w	
Slender Water-milfoil	*Myriophyllum gracile var. lineare*	✓	✓	✓	✓			L	e	w	
Robust Water-milfoil	*Myriophyllum papillosum*									w	
Rigid Water-milfoil	*Myriophyllum porcatum*						V	L	v	w	
Water-milfoil	*Myriophyllum spp*	✓	✓		✓						
Red Water Milfoil	*Myriophyllum verucosum*									w	
Grassland Wood-sorrel	*Oxalis perennans*	✓				✓					
Panic	*Panicum sp*									w	
Slender Knotweed	*Persicaria decipiens*									w	
Pale Knotweed	*Persicaria lapathifolia*			✓						w	

Creeping Knotweed	*Persicaria prostrata*	✓	✓							w	
Austral Pillwort	*Pilularia novaehollandiae*									w	
Curved Rice-flower	*Pimelea curviflora s.s.*					✓					
Weeping Pittosporum	*Pittosporum angustifolium*										
Narrow Plantain	*Plantago gaudichaudii*										
Grey Tussock-grass	*Poa sieberiana var. sieberiana*										Used for string and making baskets
Red Pondweed	*Potamogeton cheesemanii*		✓							w	
Floating Pondweed	*Potamogeton tricarinatus*									w	
Jersey Cudweed	*Pseudognaphalium luteoalbum*		✓								
Moira Grass	*Pseudoraphis spinescens*		✓							w	
Mulla Mulla	*Ptilotus exaltatus*										
Drumsticks	*Pycnosorus globosus*									#	
River Buttercup	*Ranunculus inundatus*									w	
Ferny Small-flower Buttercup	*Ranunculus pumilio var. pumilio*	✓	✓		✓	✓				w	
Annual Buttercup	*Ranunculus sessiliflorus*					✓					
Paper Sunray	*Rhodanthe corymbiflora*										
Slender Dock	*Rumex brownii*					✓				w	
Glistening Dock	*Rumex crystallinus s.l.*										
Narrow-leaf Dock	*Rumex tenax*	✓	✓		✓					w	
Common Bog-sedge	*Schoenus apogon*									w	
Water Figwort	*Scrophularia auriculata*	✓									
Cotton Fireweed	*Senecio quadridentatus*	✓	✓								
Variable Sida	*Sida corrugata*					✓					
Quena	*Solanum esuriale*					✓					
Sand-spurrey	*Spergularia brevifolia*										
Thin Duckweed	*Spirodela oligorrhiza*									w	
Spear Grass	*Stipa sp*										
Broughton Pea	*Swainsona procumbens*										
Grey Germander	*Teucrium racemosum s.l.*					✓					
Common Sunray	*Triptilodiscus pygmaeus*										
Trithuria	*Trithuria submersa*									w	
Fairies' Aprons	*Utricularia dichotoma s.l.*									w	
Fuzzy New Holland Daisy	*Vittadinia cuneata*										
Woolly New Holland Daisy	*Vittadinia gracilis*										
River Bluebell	*Wahlenbergia fluminalis*					✓					
Annual Bluebell	*Wahlenbergia gracilenta s.l.*										
Rigid Panic	*Walwhalleya proluta*					✓				w	Seeds ground to flour.
Tiny Duckweed	*Wolffia australiana*					✓					
Broad-leaf Early Nancy	*Wurmbea latifolia subsp. vanessae*										
EXOTIC SPECIES											
Golden Wreath Wattle	*Acacia saligna*										
Creeping Knapweed	*Acroptilon repens*										

Quicksilver Grass / Small Hair-grass	*Aira cupaniana*										
Orange Fox-tail	*Alopecurus aequalis*	✓	✓		✓					w	
Pimpernel	*Anagallis arvensis*		✓								
Cape Weed	*Arctotheca calendula*					✓					
Aster-weed	*Aster subulata*	✓	✓	✓	✓					w	
Bearded Oat	*Avena barbata*					✓					
Wild Oat	*Avena fatua*										
Oat	*Avena sp*					✓					
Lesser Quaking-grass	*Briza minor*										
Great Brome	*Bromus diandrus*					✓					
Soft Brome	*Bromus hordeaceus subsp. hordeaceus*										
Thread Water Starwort	*Callitriche hamulata*	✓	✓	✓	✓					w	
Water Starwort	*Callitriche stagnalis*									w	
Thistle	*Carduus sp*										
Saffron Thistle	*Carthamus lanatus*										
Centaury	*Centaurium spp.*										
Fat Hen	*Chenopodium album*										
Square Cicendia	*Cicendia quadrangularis*										
Spear Thistle	*Cirsium vulgare*	✓	✓		✓	✓					
Fleabane	*Conyza bilbaoana*										
Ferny Cotula	*Cotula bipinnata*										
Water Crassula	*Crassula natans*		✓		✓					w	
Umbrella Sedge	*Cyperus eragrostis*									w	
Stinkwort	*Dittrichia graveolens*										
Barn-yard Grass	*Echinochloa crus-galli*		✓								
Paterson's Curse	*Echium plantagineum*	✓									
Ox-tongue	*Helminthotheca echioides*	✓	✓		✓						
Barley Grass	*Hordeum sp*					✓					
Smooth Cat's-ear	*Hypochoeris glabra*		✓			✓					
Cat's Ear	*Hypochoeris radiate*	✓			✓						
Spiny Rush	*Juncus acutus subsp. acutus*										
Capitate Rush	*Juncus capitatus*										
Sharp-leaved Fluellen	*Kickxia elatine ssp. crinata*										
Willow-leaf Lettuce	*Lactuca saligna*	✓	✓		✓	✓					
Prickly Lettuce	*Lactuca serriola*	✓	✓		✓	✓					
Hairy Hawkbit	*Leontodon taraxacoides subsp. taraxacoides*	✓	✓								
Perennial Rye-grass	*Lolium perenne*										
Wimmera Rye-grass	*Lolium rigidum*	✓	✓			✓					
Burr Medic	*Medicago polymorpha*	✓									
Medic	*Medicago spp.*										
Thread Iris	*Moraea setifolia*										
Brazilian Water Milfoil	*Myriophyllum aquaticum*										
Red Bartsia	*Parentucellia latifolia*										

Common Bartsia	*Parentucellia latifolia ssp. latifolia*										
Water Couch	*Paspalum distichum*	✓								w	
Paspalum	*Paspalum spp.*										
Paradoxical Canary-grass	*Phalaris paradoxa*	✓	✓		✓						
Sticky Ground-cherry	*Physalis viscosa*					✓					
Prostate Knotweed	*Polygonum aviculare*	✓	✓	✓	✓						
Onion Grass	*Romulea rosea*					✓					
Curled Dock	*Rumex crispus*	✓	✓		✓					w	
Scorzonaera	*Scorzonera sp*				✓						
Variegated Thistle	*Silybum marianum*										
Black Nightshade	*Solanum nigrum*										
Common Sow-thistle	*Sonchus olercea*	✓	✓			✓					
Coast Sand-spurrey	*Spergularia media*										
Narrow-leaf Clover	*Trifolium angustifolium var. angustifolium*										
Hare's-foot Clover	*Trifolium arvense var. arvense*										
Hop Clover	*Trifolium campestre var. campestre*										
Cluster Clover	*Trifolium glomeratum*										
Annual-white Clover	*Trifolium michelianum var. michelianum*		✓								
Knotted Clover	*Trifolium striatum*	✓	✓		✓						
Subterraneum Clover	*Trifolium subterraneum*	✓	✓		✓	✓					
Woolly Clover	*Trifolium tomentosum*		✓								
Wandering Speedwell	*Veronica peregrine*	✓			✓					w	
Squirrel-tail Fescue	*Vulpia bromoides*					✓					
Bathurst Burr	*Xanthium spinosum*										

APPENDIX 8: INDEX OF WETLAND CONDITION METHOD

Table 11 below shows what is assessed for each of the six subindices and how they are scored.

Table 11: IWC subindices and measures.

IWC subindex	What is measured	How it is scored
Swamp catchment	1. The intensity of the land use within 250 metres of the swamp	• The more intensive the landuse the lower the score
	2. The width of the native vegetation surrounding the swamp and whether it is a continuous zone or fragmented	• The wider the zone and more continuous the zone, the higher the score
Physical form	3. Whether the size of the swamp has been reduced from its estimated pre-European settlement size	• A reduction in area results in a lowering of the score
	4. The percentage of the swamp bed which has been excavated or filled	• The greater the percentage of swamp bed modified, the lower the score
Hydrology	5. Whether the swamp's water regime (i.e. the timing, frequency of filling and duration of flooding) has been changed by human activities	• The more severe the impacts on the water regime, the lower the score
Water properties	6. Whether activities and impacts such as grazing and fertilizer run-off that would lead to an input of nutrients to the swamp are present	• The more activities present, the lower the score
	7. Whether the swamp has become more saline or in the case of a naturally salty swamp, whether it has become more fresh	• An increase in salinity for a fresh swamp lowers the score or a decrease in salinity of a naturally salty swamp lowers the score
Soils	8. The percentage and severity of swamp soil disturbance from human, feral animals or stock activities	• The more soil disturbance and the more severe it is, the lower the score
Biota	9. The diversity, health and weediness of the native swamp vegetation	• The lower the diversity and poorer health of native swamp vegetation, the lower the score • The increased degree of weediness in the native swamp vegetation, the lower the score

Adapted from DSE letter 29 April 2010

Scoring method

Each subindex is given a score between 0 and 20 based on the assessment of a number of measures. Weightings are then applied to the scores as shown in Table 12. The maximum possible total score for a wetland is 38.4, which for ease of reporting, is scaled to 10 by dividing the total score by 38.4 and multiplying by 10. The score is then rounded to the nearest whole number.

Table 12: Weights of each subindex

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

Six wetland condition categories have been assigned to the subindex scores (Table 13) and total IWC scores (Table 14), to be consistent with the number of categories used in other condition indices such as the Victorian Index of Stream Condition. Biota score categories were determined by expert opinion and differ to those of the other subindices.

Table 13: Swamp condition categories assigned to subindex scores.

Sub-index score range (all except biota)	Biota sub-index score range	Swamp condition category
0-4	0-8	Very poor
5-8	9-13	Poor
9-12	14-16	Moderate
13-16	17-18	Good
16-20	19-20	Excellent
N/A	N/A	Insufficient data

Table 14: Swamp condition categories assigned to total IWC scores

IWC total score range	Swamp condition category
0-2	Very poor
3-4	Poor
5-6	Moderate
7-8	Good
9-10	Excellent
N/A	Insufficient data

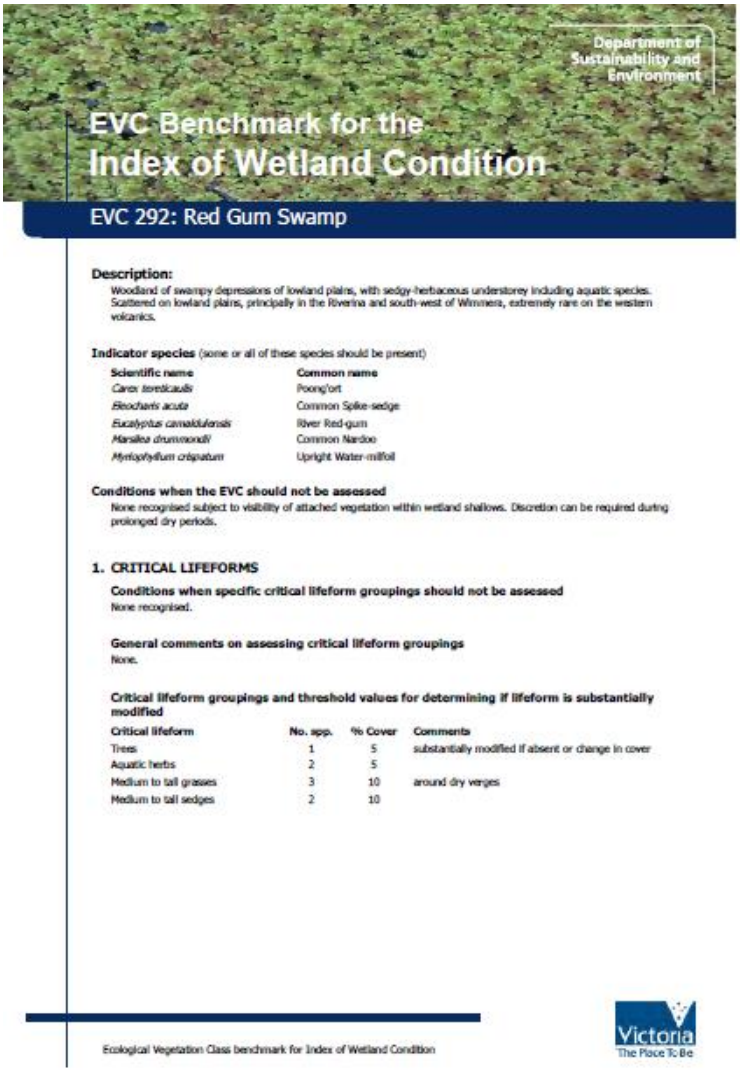
This information has been drawn from - Version 9 of the Index of wetland Condition - Methods Manual was prepared by Phil Papas, Janet Holmes and Shanaugh Lyon of the Department of Sustainability and Environment January 2010.

APPENDIX 9: EVC BENCHMARKS FOR KINNAIRDS SWAMP

EVC Benchmarks have been determined for Kinnairds Swamp by monitoring the site between 2008-2011 by Australian Ecosystems.

Benchmarks for Red Gum Swamp includes: Trees (aim to maintain 5 -10% cover); Sedges (aim to have >2 species and >10% cover); Medium to large grasses (aim to have >3 species and >10% cover around verges); Aquatic herbs (aim to have >3 species and >10% cover).

Benchmarks for Plains Grassy Wetland includes: Medium to tall herbs (aim to have 2 species, species of deep soils rather than true aquatics); Medium to tall aquatic semi-aquatic herbs (aim to have >3 species and >1% cover); Small to prostrate semi-aquatic herbs (aim to have >3 species and >5% cover); Medium to tall tufted grasses (aim to have >3 species and >15% cover, sometimes also including cane-grass); Small to medium non-tufted graminoids (aim to have >2 species and >5% cover).



Department of Sustainability and Environment

EVC Benchmark for the
Index of Wetland Condition

EVC 292: Red Gum Swamp

Description:
Woodland of swampy depressions of lowland plains, with sedgy-herbaceous understorey including aquatic species. Scattered on lowland plains, principally in the Riverina and south-west of Wimmera, extremely rare on the western volcanics.

Indicator species (some or all of these species should be present)

Scientific name	Common name
Carex tereticaulis	Poong'ort
Eleocharis acuta	Common Spike-sedge
Eucalyptus camaldulensis	River Red-gum
Marsilea drummondii	Common Nardoo
Myriophyllum crispatum	Upright Water-milfoil

Conditions when the EVC should not be assessed
None recognised subject to visibility of attached vegetation within wetland shallows. Discretion can be required during prolonged dry periods.

1. CRITICAL LIFEFORMS

Conditions when specific critical lifeform groupings should not be assessed
None recognised.

General comments on assessing critical lifeform groupings
None.

Critical lifeform groupings and threshold values for determining if lifeform is substantially modified

Critical lifeform	No. spp.	% Cover	Comments
Trees	1	5	substantially modified if absent or change in cover
Aquatic herbs	2	5	
Medium to tall grasses	3	10	around dry verges
Medium to tall sedges	2	10	

Ecological Vegetation Class benchmark for Index of Wetland Condition

Victoria
The Place To Be

EVC 292: Red Gum Swamp

2. WEEDS

High threat weed species

Scientific name	Common name
Cirsium vulgare	Spear Thistle
Holcus lanatus	Yorkshire Fog
Paspalum distichum	Water Couch
Phalaris aquatica	Toowoomba Canary-grass
Phyla canescens	Fog-fruit
Sagittaria spp.	Sagittaria

Conditions where weeds are considered to have a negligible impact

None recognised.

3. INDICATORS OF ALTERED PROCESSES

Indicator of altered process	Cover	Scale of severity
Dense River Red-gum *Eucalyptus camaldulensis* regeneration	5-10%	Minor
	10-25%	Moderate
	>25%	Severe

Circumstances where some critical lifeform groupings may not be evident

None recognised.

4. VEGETATION STRUCTURE AND HEALTH

Structural dominant	Benchmark cover
River Red-gum *Eucalyptus camaldulensis*	10%

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EVC Benchmark for the Index of Wetland Condition

EVC 125: Plains Grassy Wetland

Description:

Grassy-herbaceous shallow seasonal wetlands of lowland plains, characteristically species-rich (at least on verges) when relatively intact. Zones interpreted as representing complexes between Plains Grassy Wetland and several other wetland EVCs are frequently present. Formerly widespread in lowland plains areas.

Indicator species (some or all of these species should be present)

Scientific name	Common name
Amphibromus nervosus	Common Swamp Wallaby- grass
Amphibromus spp.	Swamp Wallaby-grass
Austrodanthonia duttoniana	Brown-back Wallaby-grass
Eleocharis acuta	Common Spike-sedge
Eleocharis pusilla	Small Spike-sedge
Eragrostis infecunda	Southern Cane-grass
Glyceria australis	Australian Sweet-grass
Lachnagrostis filiformis var. 2	Wetland Blown-grass
Poa labillardieri	Common Tussock-grass

Herbs on the verge zones of relatively intact sites

Brachyscome cardiocarpa	Swamp Daisy
Craspedia paludicola	Swamp Billy-buttons
Eryngium vesiculosum	Prickfoot
Helichrysum aff. *rutidolepis* (Lowland Swamps)	Pale Swamp Everlasting
Microseris sp. 1	Plains Yam-daisy
Neopaxia australasica	White Purslane
Potamogeton tricarinatus s.l.	Floating Pondweed
Villarsia reniformis	Running Marsh-flower

Notes on indicator species

Eragrostis infecunda occurs in drier versions (e.g. Wimmera and rainshadow basalt plains west of Melbourne).

Conditions when the EVC should not be assessed

None recognised (subject to water quality adequate to view attached vegetation in wetland shallows).

1. CRITICAL LIFEFORMS

Conditions when specific critical lifeform groupings should not be assessed

None recognised.

General comments on assessing critical lifeform groupings

None

EVC 125: Plains Grassy Wetland

Critical lifeform groupings and threshold values for determining if lifeform is substantially modified

Critical lifeform	No. spp.	% Cover	Comments
Medium to tall herbs	2	+	of fringing zone, species of deep soils rather than true aquatics
Medium to tall aquatic to semi-aquatic herbs	3	1	
Small to prostrate semi-aquatic herbs	3	5	
Medium to tall tufted grasses	3	15	sometimes also including cane grass
Small (to medium) non-tufted graminoids	2	5	

+ denotes presence

2. WEEDS

High threat weed species

Scientific name	Common name	Scientific name	Common name
Agrostis capillaris s.l.	Brown-top Bent	*Lilaea scilloides*	Lilaea
Alisma lanceolata	Water Plantain	*Mentha pulegium*	Pennyroyal
Alopecurus spp.	Fox Tail	*Nassella neesiana*	Chilean Needle-grass
Cirsium vulgare	Spear Thistle	*Paspalum* spp.	Paspalum
Cotula coronopifolia	Water Buttons	*Phalaris aquatica*	Toowoomba Canary-grass
Helminthotheca echioides	Ox-tongue	*Plantago lanceolata*	Ribwort
Holcus lanatus	Yorkshire Fog	*Rumex conglomeratus*	Clustered Dock
Juncus articulatus	Jointed Rush	*Rumex crispus*	Curled Dock
Juncus bulbosus	Bulbous Rush	*Trifolium repens* var. *repens*	White Clover
Leontodon taraxacoides subsp. *taraxacoides*	Hairy Hawkbit		

Conditions where weeds are considered to have a negligible impact

None recognised.

3. INDICATORS OF ALTERED PROCESSES

Indicator of altered process		Scale of severity
Invasion of woody species, principally tea-tree/paperbark	Incidental regeneration of shrubs within open area of wetland	Minor
	Invasion front evident around margins of open area	Moderate
	Regeneration conspicuous on wetland floor	Severe

Circumstances where some critical lifeform groupings may not be evident

None recognised.

4. VEGETATION STRUCTURE AND HEALTH

Structural dominant	Benchmark cover
Perennial native grasses, various combinations of Brown-back Wallaby-grass *Austrodanthonia duttoniana*, Wetland Wallaby-grass *Notodanthonia semiannularis*, Southern Cane-grass *Eragrostis infecunda*, Australian Sweet-grass *Glyceria australis*, Swamp Wallaby-grass *Amphibromus* spp., Common Tussock-grass *Poa labillardiere*	30%

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APPENDIX 10: FROG BREEDING EVENTS

Table extracted from Rogers and Ralph 2011.

Frog species	Preferred hydrology of breeding site (Months)			Timing of breeding				Tadpole lifespan (Months)
	< 3	3-6	Permanent	Spring	Summer	Autumn	Winter	
Common Froglet *Crinia signifera*	*	*	*	C	CM	CM	C	2-4
Plains Froglet *Crinia parasignifera*	*	*	*	C	CM	CM	C	2-4
Pobblebonk *Limnodynastes dumerili*		*	*	CT	CM	CM	C	5-6
Barking Marsh Frog *Limnodynastes fletcheri*		*	*	C	CM	M		3-4
Spotted Marsh Frog *Limnodynastes tasmaniensis*	*	*	*	C	CM	M		3-4
Perons Tree Frog *Litoria peronii*	*	*	*	C	CM	M		3-4
Growling Grass Frog *Litoria raniformis*		*	*	C	CM	M		3-5

C = Calling, M = Mating, T = Tadpoles may be present