



Moodies Swamp Environmental Water Management Plan 2012

Goulburn Broken Catchment
Management Authority



**GOULBURN
BROKEN**
CATCHMENT
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EXECUTIVE SUMMARY

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

Moodies Swamp is a 181.6 hectare seasonal shallow freshwater marsh situated in a 196 hectare reserve within the Goulburn Broken Catchment. The wetland provides important breeding habitat for Brolga and is managed by Parks Victoria. It is valued for its rarity, species diversity and waterbird habitat.

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

- Protect the diversity of native wetland flora species to be consistent with the Cane Grass wetland EVC.
- Reduce the cover and diversity of exotic flora species.
- Maintain populations of rigid water milfoil (*Myriophyllum porcatum*) and slender water-milfoil (*Myriophyllum gracile* var. *lineare*).
- Maintain or increase the diversity and abundance of frog species supported by the wetland during flood events.
- Provide opportunities for waterbird breeding especially Brolga (*Grus rubicunda*).

To achieve these ecological objectives minimum, optimum and maximum watering regimes are recommended. These are summarised in the table below and more detail can be found in section 6.2.2-hydrological objectives. These ecological objectives and watering regimes were developed by a Scientific Technical Committee.

The proposed water management goal for Moodies Swamp is:

“To provide a watering regime that supports a Cane Grass Wetland EVC and habitat for significant waterbirds especially Brolgas.”

Watering Regimes for Moodies Swamp

Minimum – Provide three flooding events every ten years filling wetlands to various depths up to 400mm to maintain EVCs and provide habitat for aquatic biota.

Optimum – Provide five flooding events every ten years filling wetlands to various depths up to 400mm to promote the regeneration and recruitment of EVCs and encourage breeding of aquatic fauna.

Maximum – Provide an annual flooding event over a ten year period, filling wetlands to various depths up to 400mm to maintain EVCs and to promote 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 tolerances of aquatic dependent ecological vegetation classes and their associated flora species such as cane-grass.



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The Goulburn Broken Wetland Management Group for proof reading and comments on the draft plan.



ABBREVIATIONS

| | |
|--------|--|
| BE | Bulk Entitlement |
| CEWH | Commonwealth Environmental Water Holder |
| DPI | Department of Primary Industries |
| DSE | Department of Sustainability and Environment |
| EPA | Environment Protection Authority |
| EVC | Ecological Vegetation Class |
| EWaMP | Environmental Water Management Plan |
| EWR | Environmental Water Reserve |
| GB CMA | Goulburn Broken Catchment Management Authority |
| GL | Gigalitre (one billion litres) |
| G-MW | Goulburn-Murray Water |
| IVT | Inter-valley transfer |
| IWC | Index of wetland condition |
| kl | Kilolitre (one thousand litres) |
| km | Kilometre |
| MDBA | Murray-Darling Basin Authority |
| ML | Megalitre (one million litres) |
| NVIRP | Northern Victoria Irrigation Renewal Project |
| SWMS | Surface Water Management System |
| 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 Moodies 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.



Figure 1: The Goulburn Broken Catchment.



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 Moodies Swamp at a workshop held at the Goulburn Broken Catchment Management Authority on March 7th 2012. The workshop was 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. Members of the Scientific Technical Committee included Sam Green (Goulburn-Murray Water), Damien Cook (Australian Ecosystems), Doug Frod (Pathways Bushland and Environment), Keith Ward, Timothy Barlow, Jo Wood and Simon Casanelia (Goulburn Broken CMA). Draft plans of this report were submitted to members of the Goulburn Broken Wetland Management Group for review.

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).
- Moodies Swamp water management recommendations (SKM, 2006).
- Moodies Swamp flood regime determination (SKM, 2007).
- Ecological response of four wetlands to the application of environmental water: Final report on monitoring from May to December 2008 (Cook et al., 2009).
- Lower Goulburn Wetlands Flora and Fauna Surveys (Cook, 2012).

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 Moodies 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 Moodies 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

Moodies Swamp is located in both the Northern Inland Slopes and Victorian Riverina Bioregion. The Northern Inland Slopes are characterised by granite metamorphic and sedimentary lower foothills to the north of the Great Dividing Range in north-eastern Victoria. The Victorian Riverina Bioregion is characterised by flat to gently undulating land on recent unconsolidated sediments with evidence of former stream channels and includes wide floodplain areas associated with the major river systems and prior streams (DSE, 2011).

Moodies Swamp is the largest individual wetland on the Broken Creek floodplain and is classified as nationally significant in *A Directory of Important Wetlands – VIC036 Broken Creek* (EA, 2001).

Over 60 per cent of the Goulburn Broken Catchment has been cleared for agriculture purposes (Miles et al., 2010). The Goulburn Broken catchment includes irrigated and dry land agriculture. Moodies Swamp is situated in the Murray Valley Irrigation District, where dairying, horticulture, cropping and livestock production occurs. Drainage, land forming and river regulation have also significantly reduced the number and area of wetland habitats. Therefore, the remnant vegetation and wetlands within the Murray Valley catchment form an important corridor in the catchment and is a stronghold for native flora and fauna, especially *Brolga (Grus rubicunda)*.

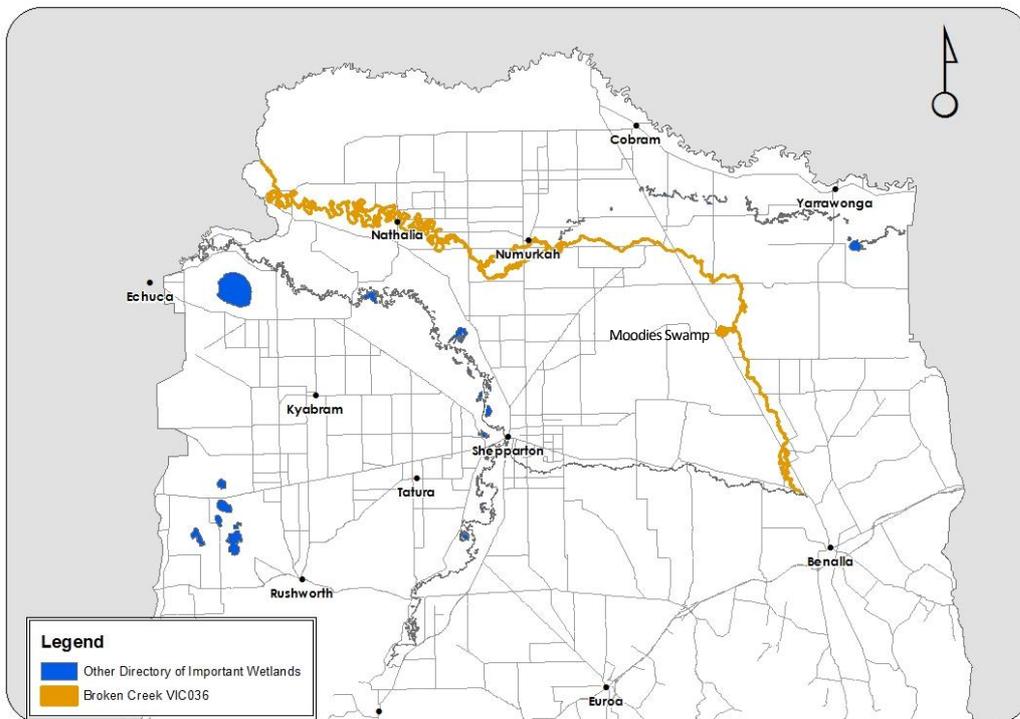


Figure 2: Moodies Swamp listed as part of the Broken Creek Directory of Important Wetlands VIC036



2.2 LAND STATUS AND MANAGEMENT

Moodies Swamp is managed by Parks Victoria. A range of management agencies are also responsible for ensuring that management of the study area complies with policy and legislation. Lead management agencies and their key responsibilities are summarised in Table 1. Adjacent landholders, Yorta Yorta Peoples, Landcare, Trust for Nature and recreational users also have an interest and role in the management of the planning area. 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.

Moodies Swamp is managed publically as a Natural Features Reserve – Wildlife Area. It is classified as part of the Broken Creek (VIC036) listed on *A Directory of Important Wetlands* (EA, 2001).

The successful management of the 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 community of the study area’s Aboriginal people and their history. Administer legislation protecting Aboriginal heritage sites within the study area (<i>State Aboriginal Heritage Act 2006</i> and Part IIA of the Commonwealth <i>Aboriginal Torres Strait Islander Heritage Protection Act 1984</i>). |
| 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 | Assisted with upgrades of Geary’s channel and implement on ground works to allow Environmental Water delivery to the Swamp in 2008. |
| Murray-Darling Basin Authority | The Murray-Darling Basin Authority’s principal aim is to manage the Basin’s water resources in the national interest. |
| Parks Victoria | Management of Moodies Swamp. |
| 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 1) 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).

Moodies Swamp is a 181.6 hectare wetland situated in a 196 hectare reserve within the Goulburn Broken Catchment (Figure 3). The swamp is adjacent to the Broken Creek and is surrounded by irrigated and dry land agriculture. The Swamp receives water from the creek via Geary and Moodies Channels (Figure 2) and from local catchment run-off (SKM, 2007). It is the largest individual wetland within the Broken Creek Floodplain (EA, 2001).

Moodies Swamp is classified as a shallow freshwater marsh in the Department of Sustainability and Environment wetlands 1994 layer, has a mean depth of 0.5m and a calculated capacity of 908 ML¹. The wetland is located within the Northern Inland Plains and Victorian Riverina Bioregion within the Broken Creek Catchment.

The Broken Creek is the primary source of water for Moodies Swamp.

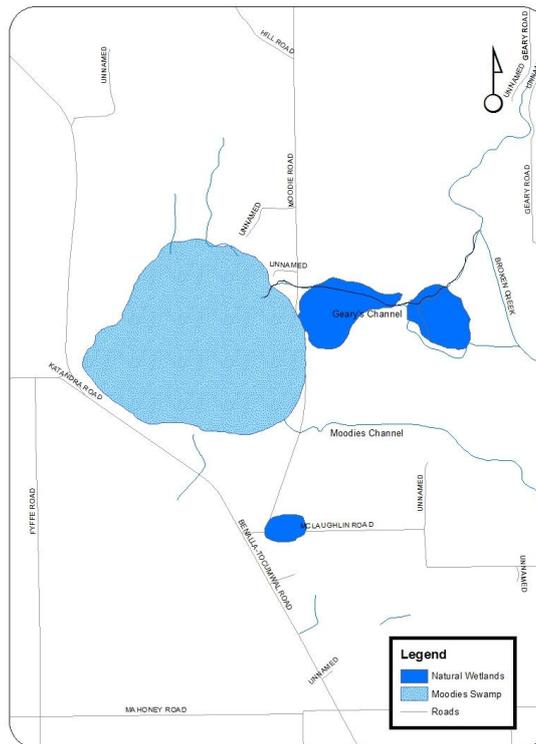


Figure 3: Moodies Swamp connection to the Broken Creek via Geary's Channel and Moodies Channel.

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 | Moodies Swamp |
| Mapping Id | 8025910900 |
| Area (ha) | 181.6 |
| Bioregion | Victorian Riverina, Northern Inland Plains |
| Conservation Status | Nationally Significant |
| Land Status | Public |
| Land Manager | Parks Victoria |
| Surrounding Land Use | Irrigated and dryland agriculture |
| Water Supply | Lower Broken Creek |
| 1788 Wetland Category | Shallow Freshwater Marsh |
| 1994 Wetland Category | Shallow Marsh |
| Wetland Capacity (ML) | 908 |
| Mean wetland depth at Capacity (m) | 0.5m |



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 Moodies Swamp can be sourced from the Commonwealth Environmental Water Share – Broken System which is a capacity of 121ML (Appendix 2).

Future water reserves that may also be used in Moodies Swamp include water savings from the Goulburn-Murray Water Connections project (previously the Northern Victoria Irrigation Renewal Project).



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 3.

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 relevant to the management of Moodies Swamp (DCE, 1991):

- *Vermin and Noxious Weeds Act 1958*.
- *Forests Act 1958*.
- *Land conservation (Vehicle control) Act 1972*.
- *Wildlife Act 1975*.
- *Crowns Land Act 1978*.
- *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, 2009b).*
- *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:

- Moodies Swamp Wildlife Reserve. Proposed Management Plan (DCE, 1991). This management plan is a basic plan dealing with the management of the area in line with the Land Conservation Council (LCC) recommendations.
- Moodies Swamp water management recommendations. Development of water management recommendations for Moodies Swamp (SKM, 2006). This plan was developed to recommend the wetting regime for Moodies Swamp based on perceived natural conditions, and the preservation of the existing vegetation within and surrounding the wetland. It also considers the water delivery system and makes recommendations regarding the most appropriate diversion techniques from the Broken Creek.
- Moodies Swamp flood regime determination (SKM, 2007). This report summarises the ecological information from the SKM 2006 report, and the Moodies Swamp Proposed Management Plan and describes the water regime considered necessary to support key ecological values. It also has updated hydraulic modelling of the current flood regime and describes differences in the current regime compared to the recommended environmental flow regime for the Broken Creek.

These plans make a number of recommendations, some of which have been implemented and have assisted with the protection and enhancement of Moodies Swamp natural values including minor earthworks along Geary's Channel for environmental water delivery in 2008.



3. WATER DEPENDENT VALUES

3.1 ENVIRONMENTAL - FAUNA

3.1.1 FAUNA LISTINGS AND SIGNIFICANCE

Moodies Swamp provides habitat for a wide variety of water dependent and terrestrial fauna species. To date 132 species have been recorded at the swamp (Appendix 4). These include 104 bird species, 4 invertebrates, 4 mammals, 6 reptiles, 6 amphibians and 8 exotic species.

Of these 47 are wetland dependent species, three are listed under the Convention of Migratory Species (Bonn), five are listed under the *Flora and Fauna Guarantee Act* (1988), eleven are considered critically endangered, vulnerable or near threatened on the DSE Advisory list of threatened vertebrate fauna in Victoria (2007) (Table 3). Three birds are listed under the Japan Australia Migratory Bird Agreement (JAMBA), five are listed under the China Australia Migratory Bird Agreement (CAMBA) and one is listed under the Republic of Korea Australia Migratory Bird Agreement (ROKAMBA).

Many waterbirds such as herons, spoonbills, cormorants, darters, egrets, ducks and grebes utilise the swamp as a breeding and feeding ground. Little Pied Cormorants (*Microcarbo melanoleuos*), Black Swan (*Cygnus atratus*) and Australasian Grebes (*Tachybaptus novaehollandiae*) are common species that have been known to breed at the swamp (Figure 4). Brolga (*Grus rubicunda*) also breed at the swamp with sometimes more than one pair having been seen breeding. Of the wetland bird species that have been recorded at the swamp, the most dominant functional feeding group is the Large Wading Birds. Marsh Sandpiper (*Tringa stagnatilis*) was recorded for the first time at the swamp in 2012.

Six amphibian species have been recorded utilising Moodies Swamp, this includes the Common Spadefoot (*Neobatrachus sudelli*) (Figure 5) and Sloanes Froglet (*Crinia sloanei*). Fish species and aquatic invertebrates have not been monitored at Moodies Swamp and records cited are only incidental. Future monitoring projects could include these components of the food chain to determine what is utilising the wetland and give a more complete picture of Moodies Swamp food web.

The Moodies Swamp Wildlife Reserve Proposed Management Plan (DCE, 1991) recommends using Brolga as a flagship species by which to manage the hydrological regime of the swamp. This plan follows this recommendation (Section 3.1.2 - Significant fauna).

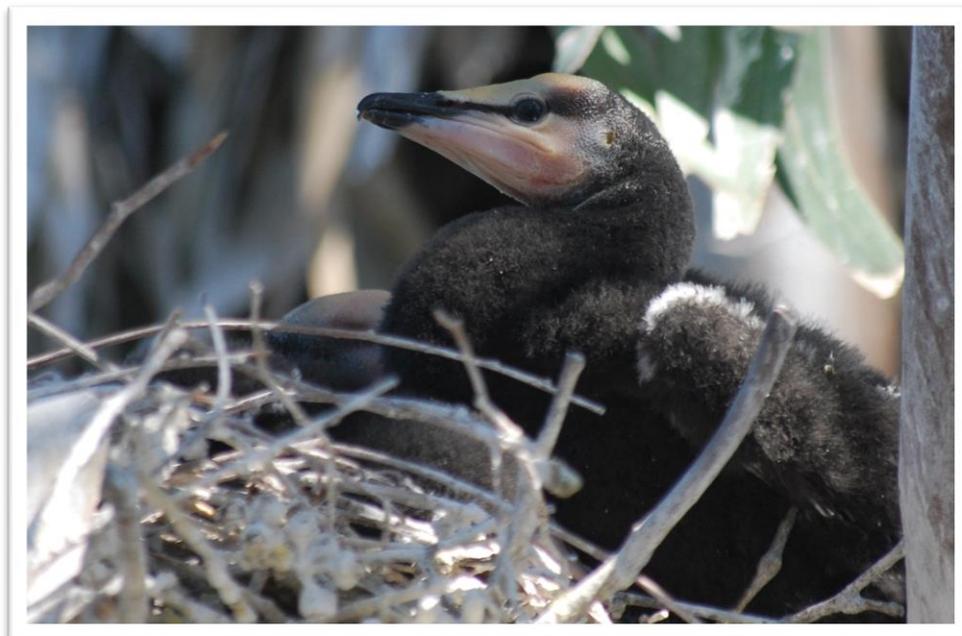


Figure 4: Little Pied Cormorant chicks on nest at Moodies Swamp September 2011.

Photo: J. Wood, GB CMA 2011.

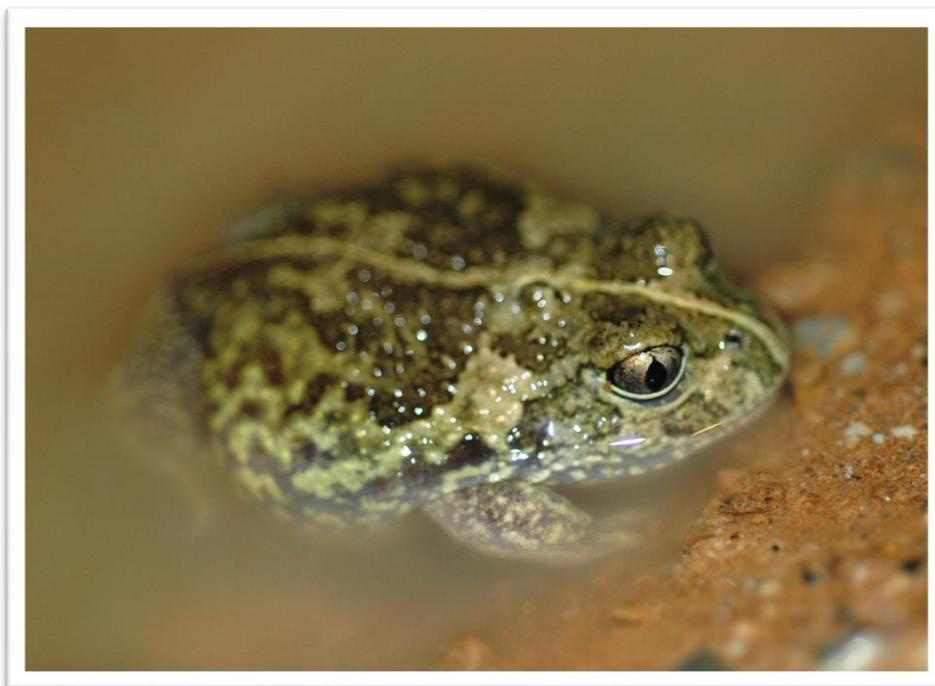


Figure 5: Common Spadefoot Toad found at Moodies Swamp in 2008 after environmental water delivery.

Photo: D. Cook, Australian Ecosystems 2008.



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

| Common Name | Scientific Name | Type | International agreements | FFG | DSE Status |
|--------------------------------|-------------------------------------|------|--------------------------|-----|------------|
| Australasian Shoveler | <i>Anas rhynchos</i> | B | | | Vul |
| Australian Reed Warbler | <i>Acrocephalus stentoreus</i> | B | B(A2H) | | |
| Brolga | <i>Grus rubicundas</i> | B | | L | Vul |
| Caspian Tern | <i>Hydroprogne caspia</i> | B | C,J | L | NT |
| Cattle Egret | <i>Ardea ibis</i> | B | J,C | | |
| Eastern Great Egret | <i>Ardea modesta</i> | B | J,C,B | L | Vul |
| Glossy Ibis | <i>Plegadis falcinellus</i> | B | C,B(A2s) | | NT |
| Hardhead | <i>Aythya australis</i> | B | | | Vul |
| Intermediate Egret | <i>Ardea intermedia</i> | B | | L | Cr |
| Marsh Sandpiper | <i>Tringa stagnatilis</i> | B | C,J,R,B(A2H) | | |
| Pied Cormorant | <i>Phalacrocorax varius</i> | B | | | NT |
| Royal Spoonbill | <i>Platalea regia</i> | B | | | Vul |
| Whiskered Tern | <i>Chidonias hybridus javanicus</i> | B | | | NT |
| White-bellied Sea-Eagle | <i>Haliaeetus leucogaster</i> | B | C | L | vu |

Legend

Type: (Bird (B))

International: CAMBA (C), JAMBA (J), ROKAMBA (R), Bonn (B), A2S species listed explicitly in Bonn Appendix 2., A2H species is in a family listed in Bonn Appendix 2.

EPBC Status: Vulnerable (Vu)

FFG Status: Listed as threatened (L)

DSE Status: (Cr) Critically Endangered, Vulnerable (Vu), Near Threatened (NT)



3.1.2 SIGNIFICANT FAUNA

Moodies Swamp provides critical breeding habitat for the vulnerable Brolga and is one of only a few places in the Goulburn Broken Catchment used as a regular breeding site. The protection of the Southern Cane-grass (*Eragrostis infecunda*) in the swamp is required to ensure breeding habitat for the Brolga is maintained. Brolga breed in response to flooding (Rogers and Ralph, 2011). Brolga numbers in Northern Victoria have diminished rapidly over the past few decades and it is imperative that these wetlands are protected to allow Brolga breeding to occur. Brolga flock together between December and May usually in areas with deep freshwater marshes. This flocking behaviour may be the beginning of initial pair bonding between Brolga (Arnol et al., 1984). Between May and August Brolga scope areas for nesting sites and breeding pairs return to traditional nesting swamps waiting for them to fill (Arnol et al., 1984). Nest construction begins around July and August when wetlands fills from winter rains. Egg laying and incubation occurs between August and December with nests being built in water less than 30cm deep (Arnol et al., 1984), and eggs being incubated for 31 days (Rogers and Ralph, 2011). Young are reared between October and December (Figure 6) and one to two days after hatching the chicks leave the nest and are totally dependent on their parents for food, warmth and protection for two to three months (Arnol et al., 1984).

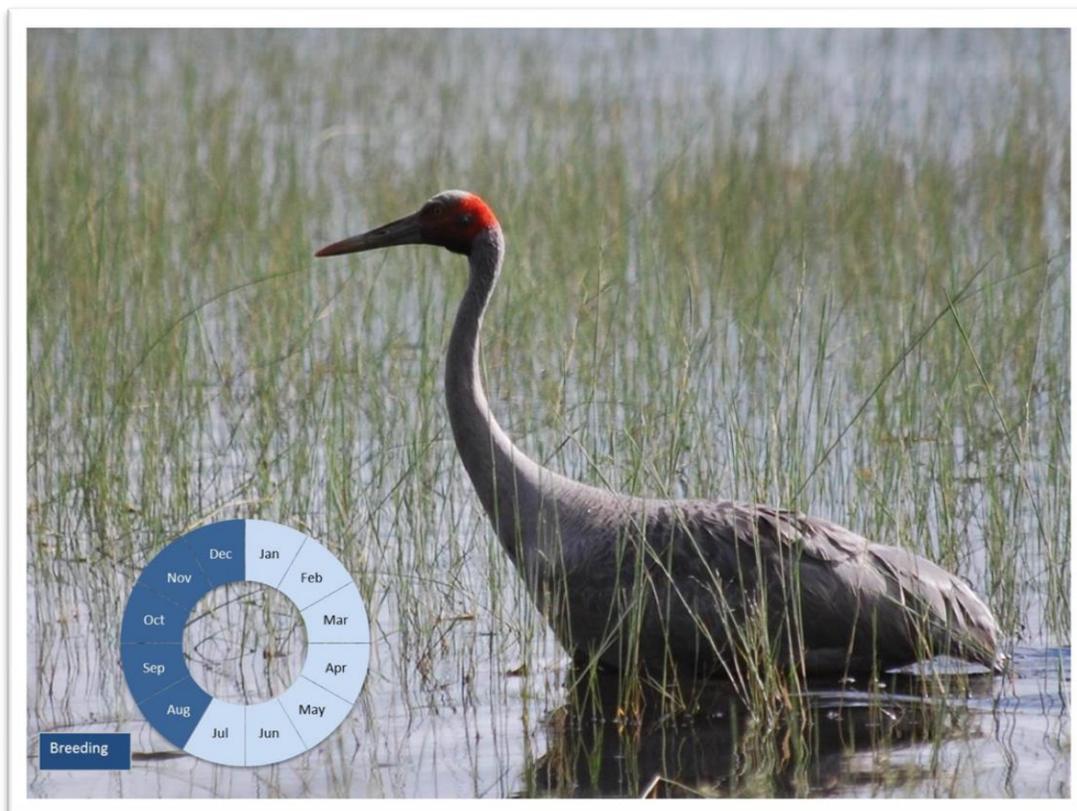


Figure 6: Female Brolga at Moodies Swamp 2010.

Photo: J. Wood, GB CMA 2010.



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.

Vegetation change at Moodies Swamp has been influenced by human-induced changes to its hydrological regime (SKM, 2007). Evidence of dead red gums within the swamp indicates that at some stage the wetland has possibly undergone prolonged wetting, drowning out the red gums.

Surveys of the swamps vegetation in 2012, indicated that the wetland supports an extensive Cane Grass Wetland-EVC #291, with the deeper central part of the wetland being a combination of Cane Grass Wetland/ Aquatic Herbland Complex-EVC #602 and a fringe of Intermittent Swampy Woodland-EVC #813 (Appendix 5).

Table 4 shows the conservation status of the EVCs present at Moodies Swamp within the Victorian Riverine Bioregion.

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

| EVC Number | EVC Name | Bioregional Conservation Status | Bioregional Conservation Status |
|------------|--|---------------------------------|---------------------------------|
| | | Vic Riverine Bioregion | Northern Inland Slopes |
| 291 | Cane Grass Wetland | Vulnerable | Vulnerable |
| 602 | Cane Grass Wetland/ Aquatic Herbland Complex | - | - |
| 813 | Intermittent Swampy Woodland | Depleted | - |



3.2.1 FLORA – SPECIES LISTING AND SIGNIFICANCE

A total of 167 native flora species have been recorded at Moodies Swamp including 65 water dependent species (Appendix 6). Of these species nine are considered rare, threatened, endangered or poorly known in Victoria and rigid water-milfoil is considered to be vulnerable within Australia (Table 5, Figure 7).

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

| Common Name | Scientific Name | EPBCA Status | FFG Status | DSE Status |
|-----------------------|--|--------------|------------|------------|
| Dwarf Brooklime | <i>Gratiola pumilo</i> | | | r |
| Groundsel | <i>Senecio campylocarpus</i> | | | r |
| In-land Club-sedge | <i>Isolepis australiensis</i> | | | k |
| Rigid Water-milfoil | <i>Myriophyllum porcatum</i> | V | L | v |
| Riverina Bitter-cress | <i>Cardamine moirensis</i> | | | r |
| Slender Water-milfoil | <i>Myriophyllum gracile var. lineare</i> | | L | en |
| Slender Water-ribbons | <i>Triglochin dubia</i> | | | r |
| Wavy Marshwort | <i>Nymphoides crenata</i> | | L | v |
| Winged Water-starwort | <i>Callitriche umbonata</i> | | | r |

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



3.2.2 FLORA - SIGNIFICANCE

Moodies Swamp is of high conservation value as it contains a large population 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*).

Myriophyllum porcatum (rigid water-milfoil) is an annual aquatic herb that occurs in shallow, ephemeral wetlands. It was recorded for the first time at Moodies Swamp in 2008 following the delivery of environmental water in autumn after a prolonged dry period (approximately 5 years) (Figure 7). 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 7: The EPBC listed rigid water-milfoil (*Myriophyllum porcatum*) growing at Moodies Swamp.

Photo: Damien Cook, Australian Ecosystems 2008



Myriophyllum gracile var. lineare (slender water-milfoil) was recorded for the first time at Moodies Swamp in 2008 following the delivery of environmental water (Figure 8). Population counts in 2008 determined that approximately 50 plants were present (Cook et al., 2009). 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 8: Slender Water-milfoil (*Myriophyllum gracile var. lineare*) growing at Moodies Swamp.

Photo: Damien Cook, Australian Ecosystems 2008



The Moodies Swamp Wildlife Reserve Proposed Management Plan (DCE, 1991) focuses on the preservation of Southern Cane-grass (Figure 9) to ensure there is suitable habitat for Brolga to breed at the site. Southern Cane-grass grows rapidly in response to rainfall or flooding. It flowers between September and May in response to rainfall. It tolerates a flooding duration of 1-6 months at an approximate depth between 10-50cm and a flooding frequency of 2-3 years.



Figure 9: Southern Cane-grass at Moodies Swamp (Brolga chick in middle of photo)

Photo: J. Wood, GB CMA 2010.



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).

Moodies Swamp is classified as a shallow freshwater marsh. Shallow freshwater marshes have declined by 60 per cent within Victoria. Within the Goulburn Broken Catchment shallow freshwater marshes have declined by 40 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).

Moodies 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

Moodies Swamp 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). Moodies 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 6). Evidence of past traditional owner occupation includes scarred trees and artefact scatters recorded along the Broken Creek and within the Swamp (Figure 10).

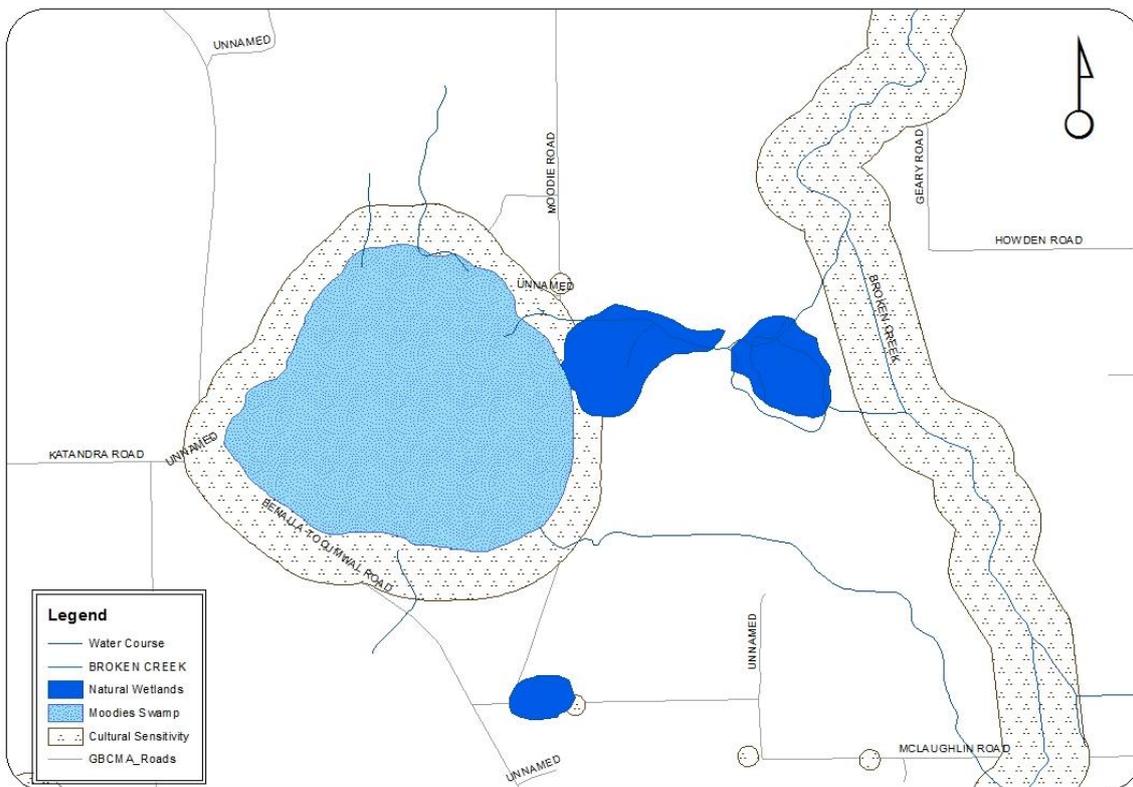


Figure 10: Cultural sensitive areas within and surrounding Moodies Swamp.



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. Hunting in season is permitted at Moodies Swamp as it is classified as a Natural Features Reserve – Wildlife Area (ECC, 2001).

3.5 ECONOMIC

Wetlands provide both direct and indirect economic values to Goulburn Broken Catchment (Cork et al., 2001) . The direct economic values that Moodies Swamp provides to the Goulburn Broken Catchment include non-consumptive uses such as tourism and recreation. Indirect economic values that Moodies 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

Prior to European settlement Moodies Swamp was a seasonal shallow freshwater marsh, primarily feed by flooding of the Broken Creek and local catchment run-off. Under natural conditions the wetland would have been wet during winter/spring (SKM, 2007). The low capacity of the Broken creek would have made flooding and filling of the wetland a regular event under natural conditions, however evaporation rates over summer of 50-60cm and a ponded depth of 50cm, the wetland would have dried out most years (DCE, 1991).

4.1.2 POST-REGULATION

Settlement occurred around Moodies Swamp in 1876 when land was acquired by James Moodie (SKM, 2006). Moodies Swamp was proclaimed as a "common" in 1882 (Anon, 1882). In 1985, Moodies Swamp was recommended as a wetland Wildlife Reserve, 1991 a State Game Reserve (SKM, 2006) and in 2001 a Natural Features Reserve – Wildlife Area (ECC, 2001).

Moodies Swamp hydrology was majorly changed with the construction of Casey's Weir on the Broken River in the late 1890s which diverted water to the Broken Creek to supply stock and domestic water to the district. Prior to 1890 a section of the Broken Creek was straightened (which now forms part of Geary's channel) and River Red Gums removed from the swamp bed. In 1910, Geary's channel was extended to Moodies Swamp (Figure 2). This was extended to facilitate dam fills in the area between the Broken Creek and Moodies Swamp (SKM, 2006). In 1951, another channel (Moodies Channel) was connected to Moodies Swamp. Works on Geary Channel occurred in 1986 and 1993, to facilitate dams but contributed to an increase in the frequency of unseasonal inflows into Moodies Swamp (SKM, 2006). Works occurred on Geary's channel again in 1986 to facilitate dam fills; however these works possibly contributed to an increase in the frequency of unseasonal inflows into Moodies Swamp. In 1993, a regulator was installed on Geary's Channel to prevent rain rejection flows entering Moodies Swamp from the Broken Creek. At this time, the Broken Creek was also dredged in an attempt to increase the channel capacity of the creek and to lower the running level of the creek (SKM, 2006). This caused difficulties in filling the dams along Geary's channel and inadvertently reduced the natural flood events entering Moodies Swamp.



In 1985, the Land Conservation Council recommended that Moodies Swamp as a Wildlife Reserve which was passed in 1989. In 1991, the wetland was classified as a State Game Reserve and in 1995 it was listed on *A Directory of Important Wetlands* (EA, 2001). In 1996, the wetland was recommended as part of the Broken Boosey State Park however this recommendation was changed to Natural Features Reserve – Wildlife Area within the Box Iron Bark region so that hunting could be retained as a recreational value of the swamp (ECC, 2001, SKM, 2006). 2008 saw the upgrade of the regulator on the Broken Creek and the extension of Geary’s channel to outfall directly into Moodies Swamp to allow efficient water delivery to the swamp (Figures 11 and 12).



Figure 11: Upgrade of the regulator on the Broken Creek.

Photo. S. Casanelia, GBCMA 2008



Figure 12: Extension of Geary's Channel into Moodies Swamp.

Photo. S. Casanelia, GBCMA 2008

4.1.3 WETLAND VOLUME

Based on field measurements Moodies Swamp is 181.6 hectares in size and has an average depth of approximately 0.5m. The volume of the swamp equates to approximately 908ML. It is estimated, however, that approximately 50 per cent more of this volume would be required to compensate against loss to the soil profile in the event that environmental water was to be released to fill the wetland from a dry state.

4.1.4 ENVIRONMENTAL WATER

A total of 50 ML of environmental water was delivered to Moodies Swamp via Geary's Channel in 2008. Water delivery began on 29th April and ceased in the second week of June. This inundated approximately 60% of the wetland area to a maximum depth of 200mm. The swamp then dried out between July and October 2008.



5. THREATS AND CONDITION

5.1 WATER DEPENDENT THREATS

The key threats to the values of Moodies 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 and Systems Operations, the natural hydrological regime of Moodies Swamp has been significantly altered by the introduction of irrigation and deepening of the Broken Creek channel.

Altered physical form – Physical form means the area and bathymetry of a wetland. The area of Moodies Swamp has been reduced slightly by agricultural encroachment on its eastern side. Future impacts on the physical form of the swamp are unlikely to occur due to the protection provided by its current land managers.

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 Moodies Swamp may be impacted by:

- Carp (*Cyprinus carpio*) feeding in sediment which can increase turbidity. If the carp develop into adults there foraging of benthic matter may also be a threat to the rare *Myriophyllum* species within the wetland.
- Run-off containing high nutrient loads entering Moodies Swamp from surrounding agricultural land.

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 Moodies Swamp include:

- Human visitation (walking or driving 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 42 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) poses a major threat to the wetland. Couch (*Cynodon dactylon var.dactylon*) and water couch (*Paspalum distichum*) also pose a threat to the wetland due to their ability to outcompete other native flora.

Pest animals threaten the ecological values of wetlands by preying on native species, transmitting diseases, and competing for food and habitat and feeding on native fauna. Pest animals recorded at Moodies 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.
- Feral Cat (*Felis catus*).
- European Hare (*Lepus capensis*).



5.2 CURRENT CONDITION

The condition of Moodies 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 overall IWC score for Moodies Swamp in December 2010 was eight out of ten, which is considered to be good (Table 6). Of note, 75 per cent of the land surrounding Moodies Swamp is used for high intensity land uses such as irrigated agriculture and cropping. Hydrology is considered 20/20 however; the swamp is disconnected from the Broken Creek with agricultural properties in between the swamp and the creek. Reassessment of the hydrology at the site may need to be undertaken.

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

| IWC subindex | Score | Condition category |
|--------------------------|-------------|--------------------|
| Wetland catchment | 10/20 | Moderate |
| Physical form | 20/20 | Excellent |
| Hydrology | 20/20 | Excellent |
| Water properties | 15/20 | Good |
| Soils | 19.25/20 | Excellent |
| Biota | 17.6/20 | Good |
| Overall IWC Score | 8/10 | Good |

5.3 CONDITION TRAJECTORY

Ongoing management including the delivery of environmental water and continued monitoring of Moodies Swamp is critical to protecting the ecological values at Moodies Swamp. If no intervention occurs such as environmental water delivery, Moodies Swamp will only receive water via Geary’s Channel in times of high flows in the Broken Creek, 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 Moodies Swamp is derived from sources including information from the Moodies Swamp Environmental Wetland Management Plan (DCE, 1991), 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.

Moodies Swamp water management goal

“To provide a watering regime that supports a Cane Grass Wetland EVC and its significant biota that occur there, particularly Brolgas and milfoils”

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 Moodies Swamp are based on values that the wetland provides for the larger Broken Creek area 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 Moodies Swamp are:

- Maintain the Cane Grass wetland EVC.
- Reduce the cover and diversity of exotic flora species.
- Maintain populations of rigid water milfoil (*Myriophyllum porcatum*) and slender water-milfoil (*Myriophyllum gracile var. lineare*).
- Provide opportunities for Brolga breeding and other waterbirds during flood events.

Table 7: Ecological requirements for Moodies Swamp

| Ecological Objective | Justification (Value based) |
|---|--|
| Maintain the diversity of native wetland flora species to be consistent with Cane grass Wetland EVC benchmark*. | 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 Moodies Swamp notably Aster Weed and the highly invasive native Water couch. |
| Maintain populations of rigid water-milfoil and slender water-milfoil [#] | Moodies Swamp has recorded populations of the nationally threatened rigid water-milfoil and slender water-milfoil. |
| Provide opportunities for Brolga breeding. | Moodies Swamp supports breeding populations of Brolga. |

*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 optimum water regime for Moodies Swamp is for flooding to occur 5 in 10 years, in Autumn-spring, and drying out within a year (Table 8). A watering regime of 5 in 10 years in autumn – spring will suit the Cane Grass Wetland EVC, and reduce the abundance and distribution of aquatic weeds. This coincides with Brolga breeding, hence water delivery may need to be extended into early summer in order to avoid birds abandoning nests and drawdown should be slow (Brolga usually breed between the months of July and November (Rogers and Ralph, 2011)). Monitoring will be needed in order to determine how long water should be held within the swamp. Watering the wetland every 5 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 the Cane Grass Wetland EVC. 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).



Table 8: Hydrological and ecological requirements for Moodies 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 | | | |
| Maintain native wetland flora species to be consistent with Cane grass Wetland EVC #. | Wetland body and riparian zone | 3 | 5 | 10 | 6 | 6-9 | 36 | 3 | 6 ¹ | 9 | Autumn – Spring | 482.5 | Variable to 500mm |
| Maintain populations of rigid water-milfoil and slender water-milfoil. | Floodway and Wetland body | NA | NA | NA | 12 ² | NA | NA | NA | NA | NA | Late Autumn | 482.5 | Variable to 500mm |
| Provide opportunities for Brolga breeding. | Wetland body | 3 | 5 | 10 | 6 | 9 | 12 | 3 | 6 | NA | Autumn-Spring ³ | 482.5 | Variable to 500mm ⁴ |

1. Six months for deepest area of Swamp.
2. *Myriophyllum porcatum* may need dry period of at least 12 months (Committee, 2012).
3. Environmental water will need to occur in autumn to allow Brolga to scope the area and begin their lag phase before breeding.
4. Water depth should be kept fairly constant if waterbirds are nesting/ breeding to avoid nests being abandoned (Young 2003).



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 three flooding events in ten years. Fill wetland to variable depths up to 500mm to maintain Cane Grass Wetland EVC to allow survival of existing vegetation and provide habitat for aquatic biota.

Optimum watering regime

Provide five flooding events in ten years. Fill wetland to variable depths up to 500mm to provide Cane Grass Wetland EVC with appropriate watering requirement, allow regeneration and recruitment of species within the wetland body and provide breeding opportunities for aquatic biota.

Maximum watering regime

Provide ten flooding events over a ten year period. Fill wetland to various depths to promote plant diversity and protect Cane Grass Wetland EVC vegetation or provide breeding opportunities for aquatic biota.



Filling the wetland to full supply level is not always desired. Flooding Moodies 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 protect and maintain Moodies 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 13).

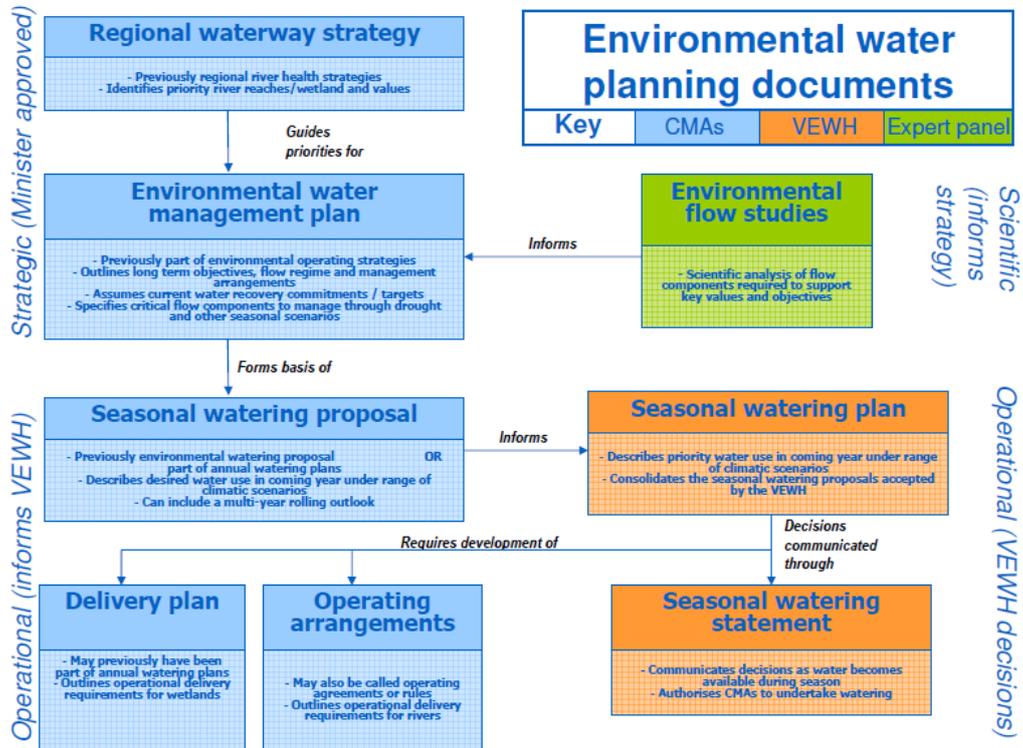


Figure 13: Flow chart for Environmental water planning



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 Moodies 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 Moodies 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 Broken Creek, 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 Broken Creek or Geary's channel system may have low dissolved oxygen, high turbidity, increased salinity and nutrient levels when adding environmental water to Moodies 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 Aster weed 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 Moodies Swamp

| Risk | Description | Environmental | | Social | | Economic | Mitigation | | |
|----------------------------------|----------------------------------|---|------------------------|-----------------------|-------------------------------|---------------------------|---|--|--|
| | | Impact on native Fauna | Impact on native Flora | Public | Cultural | Flooding | Environmental Water | Monitor | Liaise |
| Required watering regime not met | Flood duration too long or short | Birds and Amphibians | Yes | x | x | x | Determine requirements based on seasonal conditions and to support potential bird breeding events | Flood duration and ecological response | |
| | Flood timing too early or late | Birds and Amphibians | Yes | Reduced public access | x | x | x | Flood timing and ecological response | G-MW to seek optimum timing of water delivery |
| | Flood depth too shallow or deep | Birds | Yes | Reduced public access | Degradation of cultural sites | Flooding of adjacent land | Determine requirements based on seasonal conditions and to support potential bird breeding events | Flood depth | Adjoining landowners prior to and during delivery. |
| | Flood Frequency | Birds, Amphibians and Invertebrates | Yes | Reduced public access | x | x | Prioritise water requirements of wetlands in annual seasonal watering proposal. | Condition of wetland and ecological response | |
| Water quality | Low dissolved oxygen (DO) | Fish and birds | Yes | | | | Add or drawdown water where appropriate | DO levels and ecological response | |
| | High turbidity | Fish | Yes | | | | Add or drawdown water where appropriate | Turbidity levels and ecological response | |
| | High water temperature | Fish | | | | | Add or drawdown water where appropriate | Water temperature and ecological response | |
| | Increased salinity | Fish, amphibians and invertebrates | Yes | | | | Add or drawdown water where appropriate | Salinity levels and ecological response | |
| | Increased nutrient levels | Fish | | | | | | Nutrient or Blue-green algae levels and ecological response | Public signage erected if BGA levels are a public risk |
| | Increased organic matter | Fish | Yes | | | | | Implement required watering regime | |
| Pest plants and animal invasion | Introduction of pest fish | Fish, amphibians and invertebrates | Yes | | | | Implement appropriate drying regime | Ecological response of wetland to flooding and install Carp screen if possible | |
| | Establishment of pest plants | Fish, birds, amphibians and invertebrates | Yes | | | | Implement appropriate drying regime | Monitor pest plant and control by spraying or mechanically removing. | |



8. ENVIRONMENTAL WATER DELIVERY INFRASTRUCTURE

8.1 CONSTRAINTS

Environmental Water can be delivered to Moodies Swamp via the Broken Creek and Geary's Channel. Delivery of an environmental water allocation can be constrained by the following:

- Timing of flows – water may not be able to be delivered at appropriate time for ecological benefit.
- Irrigation demands – Moodies Swamp does not have a delivery share, therefore environmental water can only be delivered when there is spare capacity to carry water in the Broken Creek.

8.2 IRRIGATION MODERNISATION

The Goulburn-Murray Water Connection Project (previously Northern Victoria Irrigation Renewal Project) 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.

Moodies Swamp is situated outside the Goulburn Murray Irrigation District and is not included in this project.

8.3 INFRASTRUCTURE RECOMMENDATIONS

Geary's Channel is the main delivery mechanism for environmental water to Moodies Swamp from the Broken Creek. Additional works along the channel are proposed for future environmental water delivery. Temporary works along the channel during environmental water delivery may include using sandbags to push water from the broken creek into Geary's channel more efficiently.



9. KNOWLEDGE GAPS AND RECOMMENDATIONS

There are currently a number of knowledge gaps in relation to environmental water management at Moodies 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 recommendations and that may assist with more efficient environmental water delivery to Moodies Swamp.

| Recommendation | Justification |
|---|--|
| Monitor sites environmental conditions and issues that may pose threats. | Monitoring species such as the native water couch and exotic species such as the Aster Weed when conditions are deemed favourable for their prolific growth. This monitoring should continue on a long-term basis ensuring control of these plants. Pest animals should be monitored and prevention should occur where possible. Investigations of management options for exotic fish species entering Moodies Swamp should occur. |
| Simulate the natural hydrological regime to provide ecological benefits. | Deliver environmental water on average every 5 years in 10 if climatic conditions do not naturally fill the wetland. |
| Monitor water quality in Moodies Swamp | During environmental water delivery, monitor water quality to ensure nutrient loads do not reach critical levels. |
| Undertake a risk management matrix | Undertake risk management matrix before delivery of environmental water to Moodies Swamp |
| Undertake macroinvertebrate population survey at Moodies Swamp | Macroinvertebrate populations at Moodies Swamp are not well understood or studied. |
| Undertake a cultural heritage survey of Moodies Swamp and the surrounding area. | Better understand traditional owner occupation of the swamp and the surrounding area. |
| Upgrade Geary’s Channel | Upgrade Geary’s Channel for more efficient water delivery to Moodies Swamp. |



The following list describes recognised recommendations and that may assist with more efficient environmental water delivery to Moodies Swamp.

| Knowledge Gap | Justification |
|---|--|
| Research the ecology and water requirements of rigid water-milfoil and slender water-milfoil. | Little is known about the biological functions of rigid water-milfoil and slender water-milfoil. Research into the biology, water requirements and functions of these species will give a better understanding of how to maintain and protect these populations. |



10. GLOSSARY

Complex – A conceptual whole made up of complicated parts.

Metamorphic - Relating to rocks that have undergone metamorphism. Metamorphic rocks are formed when igneous, sedimentary, or other metamorphic rocks undergo a physical change due to extreme heat and pressure. These changes often produce folded layers or banding in the rocks, and they can also cause pockets of precious minerals to form. The folds and banding can be produced by incomplete segregation of minerals during recrystallization, or they can be inherited from pre-existing beds in sedimentary rocks or pre-existing layers in igneous rocks. The precious minerals can form as the result of recrystallization when the rocks undergoing metamorphism are subjected to changes in pressure and temperature.

Paludal - Sediments that accumulated in a marsh environment.

Quaternary – The most recent of the three periods of the Cenozoic Era.

Sedimentary - Relating to rocks formed when sediment is deposited and becomes tightly compacted. Depending on the origin of the sediments they contain, sedimentary rocks are classified as clastic sedimentary rocks, chemical sedimentary rocks, or evaporites. Sandstone and conglomerate, for example, consist of fragments of broken pre-existing rocks or minerals and are classified as clastic sedimentary rocks. Limestone forms from the precipitation of calcium carbonate through water and is classified as a chemical sedimentary rock. Gypsum and halite deposits form through the evaporation of mineral-rich water and are classified as evaporites.



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APPENDICES

APPENDIX 1: 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 2: 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 Goulburn-Murray Water Connections Program (GMW CP) Environmental Water Entitlements -

One third of water savings from Stage 1 of the GMW CP 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 GMW CP 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 (DSE 2008). 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 3: LEGISLATIVE FRAMEWORK

Acts, Agreements and Conventions

Ramsar Convention on wetlands (Ramsar) 1971 – 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.

Environment Protection and 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 or 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).



APPENDIX 4: FAUNA SPECIES LIST

Fauna list of Moodies Swamp – taken from D. Cook 2008-2009, 2010-11 counts, Eremaea Bird Atlas observations.

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 | FFG | VROTS | Origin and guild |
|--|---------------------------------------|-----|-------|------------------|
| BIRDS | | | | |
| Australasian Darter | <i>Anhinga melanogaster</i> | | | w |
| Australasian Grebe | <i>Tachybaptus novaehollandiae</i> | | | w |
| Australasian Pipit | <i>Anthus novaeseelandiae</i> | | | |
| Australasian Shoveler | <i>Anas rhynchotis</i> | | vu | w |
| Australian Hobby | <i>Falco longipennis</i> | | | |
| Australian Magpie | <i>Gymnorhina tibicen</i> | | | |
| Australian Pelican | <i>Pelecanus conspicillatus</i> | | | w |
| Australian Raven | <i>Corvus coronoides</i> | | | |
| Australian Reed Warbler | <i>Acrocephalus stentoreus</i> | | | w |
| Australian Shelduck | <i>Tadorna tadornoides</i> | | | w |
| Australian Spotted Crane | <i>Porzana fluminea</i> | | | w |
| Australian White Ibis | <i>Threskiornis molucca</i> | | | w |
| Australian Wood Duck | <i>Chenonetta jubata</i> | | | w |
| Black Swan | <i>Cygnus atratus</i> | | | w |
| Black-faced Cuckoo-shrike | <i>Coracina novaehollandiae</i> | | | |
| Black-shouldered Kite | <i>Elanus axillaris</i> | | | |
| Black-winged Stilt | <i>Himantopus himantopus</i> | | | w |
| Brolga | <i>Grus rubicunda</i> | L | vu | w, b 2008,10,11 |
| Brown Falcon | <i>Falco berigora</i> | | | |
| Brown Quail | <i>Coturnix pectoralis</i> | | | |
| Brown Songlark | <i>Cincloramphus cruralis</i> | | | |
| Brown Treecreeper (south-eastern ssp.) | <i>Climacteris picumnus victoriae</i> | | nt | |
| Brown-headed Honeyeater | <i>Melithreptus brevirostris</i> | | | |
| Caspian Tern | <i>Sterna caspia</i> | | | w |
| Cattle Egret | <i>Ardea ibis</i> | | | w |
| Chestnut Teal | <i>Anas castanea</i> | | | w |
| Cockatiel | <i>Nymphicus hollandicus</i> | | | |
| Crested Pigeon | <i>Ocyphaps lophotes</i> | | | |
| Crested Shrike-tit | <i>Falcunculus frontatus</i> | | | |
| Dollarbird | <i>Eurystomus orientalis</i> | | | |
| Dusky Moorhen | <i>Gallinula tenebrosa</i> | | | w |
| Dusky Woodswallow | <i>Artamus cyanopterus</i> | | | |



| | | | | |
|-------------------------|-------------------------------------|---|----|---------|
| Eastern Great Egret | <i>Ardea modesta</i> | L | vu | w |
| Eastern Rosella | <i>Platycercus eximius</i> | | | |
| Eurasian Coot | <i>Fulica atra</i> | | | w |
| Fairy Martin | <i>Hirundo ariel</i> | | | w |
| Galah | <i>Eolophus roseicapilla</i> | | | |
| Glossy Ibis | <i>Plegadis falcinellus</i> | | | w |
| Golden Whistler | <i>Pachycephala pectoralis</i> | | | |
| Golden-headed Cisticola | <i>Cisticola exilis</i> | | | |
| Great Cormorant | <i>Phalacrocorax carbo</i> | | | w |
| Grey Fantail | <i>Rhipidura albiscarpa</i> | | | |
| Grey Shrike-thrush | <i>Colluricincla harmonica</i> | | | |
| Grey Teal | <i>Anas gracilis</i> | | | w |
| Hardhead | <i>Aythya australis</i> | | | w |
| Hoary-headed Grebe | <i>Poliiocephalis poliocephalis</i> | | | w |
| Horsfields Bushlark | <i>Mirafrja javanica</i> | | | |
| Intermediate Egret | <i>Ardea intermedia</i> | | | w |
| Laughing Kookaburra | <i>Dacelo novaeguineae</i> | | | |
| Little Black Cormorant | <i>Phalacrocorax sulcirostris</i> | | | w |
| Little Corella | <i>Cacatua sanguinea</i> | | | |
| Little Friarbird | <i>Philemon citreogularis</i> | | | |
| Little Grassbird | <i>Megalurus gramineus</i> | | | w |
| Little Pied Cormorant | <i>Microcarbo melanoleucos</i> | | | W b2011 |
| Little Raven | <i>Corvus mellori</i> | | | |
| Magpie-lark | <i>Grallina cyanoleuca</i> | | | |
| Marsh Sandpiper | <i>Tringa stagnatilis</i> | | | w |
| Masked Lapwing | <i>Vanellus miles</i> | | | w |
| Nankeen Kestrel | <i>Falco cenchroides</i> | | | |
| Noisy Friarbird | <i>Philemon corniculatis</i> | | | |
| Noisy Miner | <i>Manorina melanocephala</i> | | | |
| Olive-backed Oriole | <i>Oriolus sagittatus</i> | | | |
| Pacific Barn Owl | <i>Tyto javanica</i> | | | |
| Pacific Black Duck | <i>Anas superciliosa</i> | | | w b |
| Peaceful Dove | <i>Geopelia striata</i> | | | |
| Peregrine Falcon | <i>Falco peregrinus</i> | | | |
| Pied Butcherbird | <i>Cracticus nigrogularis</i> | | | |
| Pied Cormorant | <i>Phalacrocorax varius</i> | | nt | w |
| Plumed Whistling Duck | <i>Dendrocygna eytoni</i> | | | w |
| Purple Swamphen | <i>Porphyrio porphyrio</i> | | | w |
| Red Wattlebird | <i>Anthochaera carunculata</i> | | | |
| Red-rumped Parrot | <i>Psephotus haematonotus</i> | | | |
| Restless Flycatcher | <i>Myiagra inquieta</i> | | | |
| Royal Spoonbill | <i>Platalea regia</i> | | vu | w |
| Rufous Songlark | <i>Cincloramphus mathewsi</i> | | | |
| Rufous Whistler | <i>Pachycephala rufiventris</i> | | | |
| Sacred Kingfisher | <i>Todiramphus sanctus</i> | | | |
| Scarlet Robin | <i>Petroica multicolor</i> | | | |



| | | | | |
|----------------------------|--------------------------------------|---|----|---|
| Southern Boobook | <i>Ninox novaeseelandiae</i> | | | |
| Spotted Harrier | <i>Circus assimilis</i> | | | |
| Straw-necked Ibis | <i>Threskiornis spinicollis</i> | | | w |
| Striated Pardalote | <i>Pardalotus striatus</i> | | | |
| Striated Thornbill | <i>Acanthiza lineata</i> | | | |
| Stubble Quail | <i>Coturnix pectoralis</i> | | | |
| Sulphur-crested Cockatoo | <i>Cacatua galerita</i> | | | |
| Swamp Harrier | <i>Circus approximans</i> | | | w |
| Tawny Frogmouth | <i>Podargus strigoides</i> | | | |
| Tree Martin | <i>Hirundo nigricans</i> | | | w |
| Wedge-tailed Eagle | <i>Aquila audax</i> | | | |
| Weebill | <i>Smicrornis brevirostris</i> | | | |
| Welcome Swallow | <i>Hirundo neoxena</i> | | | w |
| Western Gerygone | <i>Gerygone fusca</i> | | | |
| Whiskered Tern | <i>Chlidonias hybridus javanicus</i> | | nt | w |
| Whistling Kite | <i>Haliastur sphenurus</i> | | | w |
| White-backed Swallow | <i>Cheramoeca leucosternus</i> | | | w |
| White-bellied Sea-Eagle | <i>Haliaeetus leucogaster</i> | L | vu | w |
| White-browed Woodswallow | <i>Artamus superciliosus</i> | | | |
| White-faced Heron | <i>Egretta novaehollandiae</i> | | | w |
| White-fronted Chat | <i>Epthianura albifrons</i> | | | w |
| White-necked Heron | <i>Ardea pacifica</i> | | | w |
| White-plumed Honeyeater | <i>Lichenostomus penicillatus</i> | | | |
| White-winged Chough | <i>Corcorax melanorhamphos</i> | | | |
| White-winged Triller | <i>Lalage sueurii</i> | | | |
| Willie Wagtail | <i>Rhipidura leucophrys</i> | | | |
| Yellow Thornbill | <i>Acanthiza nana</i> | | | |
| Yellow-billed Spoonbill | <i>Platalea flavipes</i> | | | w |
| Yellow-rumped Thornbill | <i>Acanthiza chrysorrhoa</i> | | | |
| Zebra Finch | <i>Taeniopygia guttata</i> | | | |
| AMPHIBIANS | | | | |
| Common Froglet | <i>Crinia signifera</i> | | | Moist depressions |
| Common Spadefoot | <i>Neobatrachus sudelli</i> | | | Mostly found in dry habitats. Seek water when they breed and lay eggs |
| Peron's Tree Frog | <i>Litoria peronii</i> | | | Wet and Dry areas |
| Plains Froglet | <i>Crinia parinsignifera</i> | | | Moist depressions |
| Pobblebonk | <i>Limnodynastes dumerilii</i> | | | Most areas except Alpine and extreme dry |
| Sloane's Froglet | <i>Crinia sloanei</i> | | | Moist depressions |
| Spotted Marsh Frog | <i>Limnodynastes tasmaniensis</i> | | | Common in farm dams and wetlands |
| MAMMALS | | | | |
| Common Brushtail Possum | <i>Trichosurus vulpecular</i> | | | |
| Eastern Grey Kangaroo | <i>Macropus giganteus</i> | | | |
| Swamp Wallaby | <i>Wallabia bicolor</i> | | | |
| White-striped Freetail Bat | <i>Tadarida australis</i> | | | |



| REPTILES | | | | |
|-----------------------------|-------------------------------|--|--|---|
| Boulenger's Skink | <i>Morethia boulengeri</i> | | | |
| Eastern Brown Snake | <i>Pseudonaja textilis</i> | | | |
| Eastern Snake-necked Turtle | <i>Chelodina longicollis</i> | | | |
| Eastern Striped Skink | <i>Ctenotus robustus</i> | | | |
| Olive-legless lizard | <i>Delma inornata</i> | | | |
| Tiger Snake | <i>Notechis scutatus</i> | | | |
| INTRODUCED SPECIES | | | | |
| Brown Hare | <i>Lepus capensis</i> | | | |
| Common Blackbird | <i>Turdus merula</i> | | | |
| Common Starling | <i>Sturnus vulgaris</i> | | | |
| Common Myna | <i>Sturnus tristis</i> | | | |
| Eurasian Tree Sparrow | <i>Passer montanus</i> | | | |
| European Carp | <i>Cyprinus carpio</i> | | | w |
| Feral Cat | <i>Felis catus</i> | | | |
| Hare | <i>Lepus capensis</i> | | | |
| House Sparrow | <i>Passer domesticus</i> | | | |
| Rabbit | <i>Oryctolagus cuniculus</i> | | | |
| Red Fox | <i>Vulpes vulpes</i> | | | |
| Spotted Dove | <i>Streptopelia chinensis</i> | | | |

Note: The Welcome Swallow, White-backed Swallow, Tree Martin and Whistling Kite are not strictly wetland species; however they can be associated with wetlands. They have been included in this category as they appeared to have been attracted to the wetlands to prey on species that are reliant on the wetlands containing water, and for this reason could be considered to have directly benefited from the delivery of environmental water (Cook et al., 2009)



APPENDIX 5: ECOLOGICAL VEGETATION CLASSES

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

Cane Grass Wetland [EVC #291]

Species-poor vegetation dominated by Southern Cane Grass occurring in association with seasonal wetlands of low rainfall areas, typically on extremely heavy, grey clay soils.

Cane Grass Wetland/ Aquatic Herbland Complex [EVC #602]

Wetland vegetation with open Southern Cane-grass in association with freshwater aquatic herbs. Rare, scattered localities within the west and north of the state.

EVCs SURROUNDING MOODIES SWAMP

Plains Woodland [EVC #803]

An open, eucalypt woodland to 15m tall occurring on a number of geologies and soil types. Occupies fertile clays and clay loam soils on flat or gently undulating plains at low elevations in areas with <600mm annual rainfall. The understory consists of a few sparse shrubs over a species-rich grassy herbaceous ground layer and chenopods are often present.

Lunette Woodland [EVC #652]

An open, eucalypt woodland to 15m tall with a grassy and herb-rich understory. Occurs on generally fertile, relatively well-drained, clay-loam soils on source bordering lunettes.

Shallow Sands Woodland [EVC #882]

Woodland or open-forest to 15m tall, with a sparse shrub layer of healthy, ericoid shrubs and a species-rich ground cover dominated by grasses and annual herbs. Typically it occurs between the heavier soils of the plains and the depp-sand Aeolian dunefields which overlay these plains, but also occurs on broader areas of plains covered by shallow fluvial, outwash or Aeolian sands overlaying drainage-impending clays.



APPENDIX 6: FLORA SPECIES LIST

Flora list from D. Cook 2008-2012 observations.

Note: EVC information is recorded only from D. Cook Surveys 2012.

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

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

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 813 | EVC 291 | EVC 602 | 2008 data | EPBC | FFG | VROTS | Origin | Indigenous Use |
|----------------------------|---|---------|---------|---------|-----------|------|-----|-------|--------|-----------------|
| Gold-dust Wattle | <i>Acacia acinacea s.l.</i> | | | | ✓ | | | | | |
| Rough Wattle | <i>Acacia aspera</i> | | | | ✓ | | | | | |
| Early Black Wattle | <i>Acacia decurrens</i> | | | | ✓ | | | | | |
| Lightwood | <i>Acacia implexa</i> | | | | ✓ | | | | | |
| Mallee Wattle | <i>Acacia montana</i> | | | | ✓ | | | | | |
| Golden Wattle | <i>Acacia pycnantha</i> | | | | ✓ | | | | | |
| Delicate Hair-grass | <i>Aira elegans</i> | | | | ✓ | | | | | |
| Buloke | <i>Allocasurina luehmannii</i> | | | | ✓ | | | | w | |
| Lesser Joyweed | <i>Alternanthera denticulata s.s</i> | ✓ | | | ✓ | | | | w | |
| Common Swamp Wallaby-grass | <i>Amphibromus nervosus</i> | | | | ✓ | | | | w | |
| Brush Wire-grass | <i>Aristida behriana</i> | | | | ✓ | | | | | |
| Nodding Chocolate-lily | <i>Arthropodium fimbriatum</i> | | | | ✓ | | | | | Tubers eaten. |
| Small Vanilla-lily | <i>Arthropodium minus</i> | | | | ✓ | | | | | Tubers eaten |
| Lily | <i>Arthropodium sp.2 (twin flowered)</i> | | | | ✓ | | | k | | |
| Chocolate Lily | <i>Arthropodium strictum s.l.</i> | | | | ✓ | | | | | Tubers eaten |
| Common Wallaby-grass | <i>Austrodanthonia caespitosa</i> | | | | ✓ | | | | w | |
| Brown-back Wallaby-grass | <i>Austrodanthonia duttoniana</i> | | | | ✓ | | | | w | |
| Stiped Wallaby-grass | <i>Austrodanthonia racemosa var. racemosa</i> | | | | ✓ | | | | | |
| Bristly Wallaby-grass | <i>Austrodanthonia setacea</i> | | | | ✓ | | | | | |
| Spurred Spear-grass | <i>Austrostipa gibbosa</i> | | | | ✓ | | | | r | |
| Rough Spear-grass | <i>Austrostipa scabra</i> | ✓ | | | ✓ | | | | | |
| Pacific Azolla | <i>Azolla filiculoides</i> | ✓ | | | | | | | w | |
| Tah-vine | <i>Boerhavia dominii</i> | | | | ✓ | | | | # | Tap roots eaten |
| Red-leg Grass | <i>Bothriochloa macra</i> | | | | ✓ | | | | | |
| Water Starwort | <i>Callitriche hamulata</i> | | | | ✓ | | | | w | |
| Matted Water-starwort | <i>Callitriche sonderi</i> | | | | ✓ | | | | w | |
| Water Starwort | <i>Callitriche sp (germinant)</i> | | | | ✓ | | | | w | |



| | | | | | | | | | | |
|-----------------------------|---|---|---|---|---|--|--|---|---|--------------------------------------|
| Winged Water-starwort | <i>Callitriche umbonata</i> | | | | ✓ | | | r | w | |
| White Cypress-pine | <i>Callitriche columellaris</i> | | | | ✓ | | | | | |
| Burr-daisy | <i>Calotis cuneifolia</i> | | | | ✓ | | | | | |
| Riverina Bitter-cress | <i>Cardamine moirensis</i> | | | | ✓ | | | r | w | |
| Common Sedge/ Knob Sedge | <i>Carex inversa</i> | | | | ✓ | | | | w | |
| Poong'ort / Rush Sedge | <i>Carex tereticaulis</i> | | | | ✓ | | | | w | |
| Drooping Cassinia | <i>Cassinia arcuata</i> | | | | ✓ | | | | | |
| Common Sneezeweed | <i>Centipeda cunninghamii</i> | | | | ✓ | | | | w | |
| Chara | <i>Characeae spp.</i> | | | ✓ | | | | | w | |
| Small-leaf Goosefoot | <i>Chenopodium desertorum ssp. microphyllum</i> | | | | ✓ | | | | | |
| Clammy goosefoot | <i>Chenopodium pumilio</i> | ✓ | | | | | | | # | |
| Windmill Grass | <i>Chloris truncata</i> | | | | ✓ | | | | | |
| Bindweed | <i>Convolvulus erubescens</i> | | | | ✓ | | | | | |
| Swamp Billybuttons | <i>Craspedia paludicola</i> | | | | ✓ | | | | | |
| Spreading Crassula | <i>Crassula decumbens var. decumbens</i> | | | | ✓ | | | | | |
| Australian Stonecrop | <i>Crassula sieberi ssp. tetramera</i> | | | | ✓ | | | | w | |
| Sieber Crassula | <i>Crassula sieberiana s.s.</i> | ✓ | | | | | | | | |
| Spiny Flat-sedge | <i>Cyperus gymnocaulos</i> | ✓ | | | ✓ | | | | w | |
| Star Fruit | <i>Damasonium minus</i> | ✓ | | | ✓ | | | | w | |
| Black-anther Flax-lily | <i>Dianella revoluta s.l.</i> | | | | ✓ | | | | | |
| Riverine Flax-lily | <i>Dianella sp.aff.longifolia (Riverina)</i> | | | | ✓ | | | v | | |
| Waterwort | <i>Elatine gratioloides</i> | | | | ✓ | | | | w | |
| Common Spike-sedge | <i>Eleocharis acuta</i> | | ✓ | ✓ | ✓ | | | | w | |
| Nigger-heads | <i>Enneapogon nigricans</i> | | | | ✓ | | | | | |
| Spider Grass | <i>Enteropogon acicularis</i> | | | | ✓ | | | | | |
| Grey Willow-herb | <i>Epilobium billardierianum var. cinereum</i> | | | | ✓ | | | | w | |
| Common Love-grass | <i>Eragrostis brownii</i> | | ✓ | | | | | | | |
| Close-headed Love-grass | <i>Eragrostis elongata</i> | | | | ✓ | | | | | |
| Southern Cane-grass | <i>Eragrostis infecunda</i> | ✓ | ✓ | ✓ | ✓ | | | | | |
| River Red-gum | <i>Eucalyptus camaldulensis</i> | | | | ✓ | | | | w | |
| Yellow Box | <i>Eucalyptus melliodora</i> | | | | ✓ | | | | | |
| Grey Box | <i>Eucalyptus microcarpa</i> | | | | ✓ | | | | | |
| Annual Cudweed | <i>Euchiton sphaericus</i> | | | | ✓ | | | | | |
| Common Eutaxia | <i>Eutaxia microphylla var. diffusa</i> | | | | ✓ | | | | | |
| Variable Cranesbill | <i>Geranium sp2</i> | | | | ✓ | | | | | |
| Slender Carpet-weed | <i>Glinus oppositifolius</i> | ✓ | | | | | | | | |
| Twining Glycine | <i>Glycine clandestine var. sericea</i> | | | | ✓ | | | | | Tap root chewed for licorice flavour |
| Cut-leaf Goodenia | <i>Goodenia pinnatifida</i> | | | | ✓ | | | | | |
| Dwarf Brooklime | <i>Gratiola pumilo</i> | ✓ | | | ✓ | | | r | | |
| Rough Raspwort | <i>Haloragis aspera</i> | | | | ✓ | | | | | |
| Bluish Raspwort | <i>Haloragis glauca</i> | | | | ✓ | | | k | | |
| Jersey Cudweed | <i>Helichrysum luteoalbum</i> | | | | ✓ | | | | | |
| Quillwort | <i>Isoetes muelleri</i> | | | | ✓ | | | | | |
| Southern Club-sedge | <i>Isolepis australiensis</i> | | | | ✓ | | | k | | |



| | | | | | | | | | | |
|------------------------------|---|---|---|---|---|---|---|---|---|------------------------------------|
| Broad-fruit Club-sedge | <i>Isolepis cernua var. platycarpa</i> | | | | ✓ | | | | | |
| Grassy Club-sedge | <i>Isolepis hookeriana</i> | | | | ✓ | | | | w | |
| Toad Rush | <i>Juncus bufonius</i> | | | | ✓ | | | | w | |
| Yellow Rush | <i>Juncus flavidus</i> | | | | ✓ | | | | w | |
| Joint-leaf Rush | <i>Juncus holoschoenus</i> | | | | ✓ | | | | w | |
| Plains Rush | <i>Juncus semisolidus</i> | | | | ✓ | | | | w | |
| Finger Rush | <i>Juncus subsecundus</i> | | | | ✓ | | | | w | |
| Common Blown-grass | <i>Lachnagrostis filiformis var.1</i> | ✓ | | | ✓ | | | | w | |
| Austral Water-mat | <i>Lepilaena australis</i> | | | ✓ | | | | | w | |
| Austral Mud-mat | <i>Limosella australis</i> | ✓ | | | ✓ | | | | w | |
| Poison Lobelia | <i>Lobelia pratoides</i> | | | | ✓ | | | | w | |
| Wattle Mat-rush | <i>Lomandra filiformis subs. coriacea</i> | | | | ✓ | | | | | |
| Many-flowered Mat-rush | <i>Lomandra mutiflora</i> | | | | ✓ | | | | | |
| Small Loosestrife | <i>Lythrum hyssopifolia</i> | ✓ | | | ✓ | | | | w | |
| Wingless Bluebush | <i>Maireana enchylaenoides</i> | | | | ✓ | | | | | |
| Common Nardoo | <i>Marsilea drummondii</i> | | | | | | | | w | |
| Minnie Daisy | <i>Miniura leptophylla</i> | | | | ✓ | | | | | |
| Tangled Lignum | <i>Muehlenbeckia florulenta</i> | | | | ✓ | | | | w | |
| Upright Water-milfoil | <i>Myriophyllum crispatum</i> | ✓ | ✓ | | ✓ | | | | w | |
| Clustered Water-milfoil | <i>Myriophyllum glomeratum</i> | | | | | | | | w | |
| Slender Water-milfoil | <i>Myriophyllum gracile var. lineare</i> | | | | ✓ | | L | e | w | |
| Rigid Water-milfoil | <i>Myriophyllum porcatum</i> | | | | ✓ | V | L | v | w | |
| Red Water Milfoil | <i>Myriophyllum verucosum</i> | ✓ | | | ✓ | | | | w | |
| Stonewort | <i>Nitella spp.</i> | | ✓ | | | | | | w | |
| Wavy Marshwort | <i>Nymphoides crenata</i> | | | | | | L | v | w | |
| Grassland Wood-sorrel | <i>Oxalis perennans</i> | | | | ✓ | | | | | |
| Australian Millet | <i>Panicum decompositum var. decompositum</i> | | | | ✓ | | | | w | |
| Creeping Knotweed | <i>Persicaria prostrata</i> | ✓ | | | | | | | w | |
| Austral Pillwort | <i>Pilularia novaehollandiae</i> | | | | ✓ | | | | w | |
| Curved Rice-flower | <i>Pimelea curviflora s.s.</i> | | | | ✓ | | | | | |
| Grey Tussock-grass | <i>Poa sieberiana var. sieberiana</i> | | | | ✓ | | | | | Used for string and making baskets |
| Red Pondweed | <i>Potamogeton cheesemanii</i> | ✓ | ✓ | ✓ | ✓ | | | | w | |
| Jersey Cudweed | <i>Pseudognaphalium luteoalbum</i> | ✓ | | | | | | | | |
| Pussy Tails | <i>Ptilotus spathulatus</i> | | | | ✓ | | | | | |
| Drumsticks | <i>Pycnosorus globosus</i> | | | | ✓ | | | | # | |
| Ferny Small-flower Buttercup | <i>Ranunculus pumilio var. pumilio</i> | | | | ✓ | | | | w | |
| Crystalwort | <i>Riccia duplex</i> | | | | ✓ | | | | w | |
| Slender Dock | <i>Rumex brownii</i> | ✓ | | | | | | | w | |
| Wiry Dock | <i>Rumex dumosus</i> | | | | ✓ | | | | | |
| Narrow-leaf Dock | <i>Rumex tenax</i> | | | | ✓ | | | | w | |
| Grey Roly-poly | <i>Sclerolaena muricata var. villosa</i> | | | | ✓ | | | | | |
| Groundsel | <i>Senecio campylocarpus</i> | | | | ✓ | | | r | | |
| Tall Fireweed | <i>Senecio runcinifolius</i> | | | | ✓ | | | | | |
| Variable Sida | <i>Sida corrugata</i> | | | | ✓ | | | | | |



| | | | | | | | | | | |
|----------------------------|---|---|--|---|---|--|--|---|---|------------------------|
| Sand-spurrey | <i>Spergularia brevifolia</i> | | | | ✓ | | | | | |
| Broughton Pea | <i>Swainsona procumbens</i> | | | | ✓ | | | | | |
| Grey Germander | <i>Teucrium racemosum s.l.</i> | | | | ✓ | | | | | |
| Slender Water-ribbons | <i>Triglochin dubia</i> | | | ✓ | ✓ | | | r | w | |
| Annual New Holland Daisy | <i>Vittadinia cervicalis</i> | | | | ✓ | | | | | |
| Woolly New Holland Daisy | <i>Vittadinia gracilis</i> | | | | ✓ | | | | | |
| River Bluebell | <i>Wahlenbergia fluminalis</i> | ✓ | | | ✓ | | | | | |
| Granite Bluebell | <i>Wahlenbergia graniticola</i> | | | | ✓ | | | | | |
| Yellowish Bluebell | <i>Wahlenbergia luteola</i> | | | | ✓ | | | | | |
| Rigid Panic | <i>Walwhalleya proluta</i> | | | | ✓ | | | | w | Seeds ground to flour. |
| Exotic Species | | | | | | | | | | |
| Aster-weed | <i>Aster subulata</i> | ✓ | | | ✓ | | | | w | |
| Bearded Oat | <i>Avena barbata</i> | | | | ✓ | | | | | |
| Lesser Quaking-grass | <i>Briza minor</i> | | | | ✓ | | | | | |
| Great Brome | <i>Bromus diandrus</i> | | | | ✓ | | | | | |
| Soft Brome | <i>Bromus hordeaceus subsp. hordeaceus</i> | | | | ✓ | | | | | |
| Common Mouse-ear Chickweed | <i>Cerastium glomeratum</i> | | | | ✓ | | | | | |
| Skeleton Weed | <i>Chondrilla juncea</i> | | | | ✓ | | | | | |
| Spear Thistle | <i>Cirsium vulgare</i> | | | | ✓ | | | | | |
| Flax Fleabane | <i>Conyza bonariensis</i> | ✓ | | | ✓ | | | | | |
| Couch | <i>Cynodon dactylon var. dactylon</i> | ✓ | | | ✓ | | | | | |
| Paterson's Curse | <i>Echium plantagineum</i> | | | | ✓ | | | | | |
| Ox-tongue | <i>Helminthotheca echioides</i> | | | | ✓ | | | | | |
| Barley Grass | <i>Hordeum vulgare</i> | | | | ✓ | | | | | |
| Smooth Cat's-ear | <i>Hypochoeris glabra</i> | | | | ✓ | | | | | |
| Cat's Ear | <i>Hypochoeris radiata</i> | | | | ✓ | | | | | |
| Awnead Club-sedge | <i>Isolepis hystrix</i> | | | | ✓ | | | | | |
| Tiny Flat-sedge | <i>Isolepis tenellus</i> | | | | ✓ | | | | | |
| Hairy Toadflax | <i>Kickxia elatine</i> | ✓ | | | | | | | | |
| Willow-leaf Lettuce | <i>Lactuca saligna</i> | | | | ✓ | | | | | |
| Prickly Lettuce | <i>Lactuca serriola</i> | ✓ | | | ✓ | | | | | |
| Hairy Hawkbit | <i>Leontodon taraxacoides subsp. taraxacoides</i> | | | | ✓ | | | | | |
| Wimmera Rye-grass | <i>Lolium rigidum</i> | | | | ✓ | | | | | |
| Small-flower Mallow | <i>Malva parviflora</i> | | | | ✓ | | | | | |
| Horehound | <i>Marrubium vulgare</i> | | | | ✓ | | | | | |
| Burr Medic | <i>Medicago polymorpha</i> | | | | ✓ | | | | | |
| Water Couch | <i>Paspalum distichum</i> | ✓ | | | | | | | w | |
| Kikuyu | <i>Pennisetum clandestinum</i> | | | | ✓ | | | | | |
| Toowoomba Canary-grass | <i>Phalaris aquatica</i> | | | | ✓ | | | | w | |
| Paradoxical Canary-grass | <i>Phalaris paradoxa</i> | | | | ✓ | | | | | |
| Sticky Ground-cherry | <i>Physalis viscosa</i> | | | | ✓ | | | | | |
| Prostate Knotweed | <i>Polygonum aviculare</i> | | | | ✓ | | | | | |
| Celery Buttercup | <i>Ranunculus sceleratus</i> | | | | ✓ | | | | | |
| Onion Grass | <i>Romulea rosea</i> | | | | ✓ | | | | | |

Moodies Swamp Environmental Watering Plan



| | | | | | | | | | | |
|----------------------|---------------------------------------|---|--|--|---|--|--|--|---|--|
| Annual Cat's-tail | <i>Rostraria cristata</i> | ✓ | | | | | | | | |
| Curled Dock | <i>Rumex crispus</i> | | | | ✓ | | | | w | |
| Black Nightshade | <i>Solanum nigrum</i> | ✓ | | | | | | | | |
| Rough Sow-thistle | <i>Sonchus asper</i> | | | | ✓ | | | | | |
| Common Sow-thistle | <i>Sonchus olercea</i> | | | | ✓ | | | | | |
| Caltrop | <i>Tribulus terrestris</i> | | | | ✓ | | | | | |
| Hare's-foot Clover | <i>Trifolium arvense var. arvense</i> | ✓ | | | | | | | | |
| Suckling Clover | <i>Trifolium dubium</i> | ✓ | | | ✓ | | | | | |
| Squirrel-tail Fescue | <i>Vulpia bromoides</i> | | | | ✓ | | | | | |
| Bathurst Burr | <i>Xanthium spinosum</i> | | | | ✓ | | | | | |



APPENDIX 7: 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 | <ul style="list-style-type: none"> The more intensive the land use the lower the score |
| | 2. The width of the native vegetation surrounding the swamp and whether it is a continuous zone or fragmented | <ul style="list-style-type: none"> 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 | <ul style="list-style-type: none"> A reduction in area results in a lowering of the score |
| | 4. The percentage of the swamp bed which has been excavated or filled | <ul style="list-style-type: none"> 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 | <ul style="list-style-type: none"> 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 | <ul style="list-style-type: none"> 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 | <ul style="list-style-type: none"> 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 | <ul style="list-style-type: none"> 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 | <ul style="list-style-type: none"> 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.



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 (Table 13). 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 |
| Wetland catchment | 0.26 |
| Water properties | 0.47 |
| Hydrology | 0.31 |
| Physical form | 0.08 |
| Soils | 0.07 |

Five wetland condition categories have been assigned to the subindex scores (Table 14) and total IWC scores (Table 15), 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: Wetland condition categories assigned to subindex scores.

| Sub-index score range (all except biota) | Biota sub-index score range | Wetland 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: Wetland condition categories assigned to total IWC scores

| IWC total score range | Wetland 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 8: EVC BENCHMARKS FOR MOODIES SWAMP

EVC benchmarks have been determined for Moodies Swamp by monitoring that was undertaken at the site in 2008 and 2011 by Australian Ecosystems.

The benchmark for Cane Grass Wetland includes: critical life form Cane grass 5% cover. Aquatic herbs or medium sedges aim to have two species and + cover. Small (to medium) semi-aquatic herbs aim to have 5 species and 10% cover on verges.



APPENDIX 9: 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 <i>Crinia signifera</i> | * | * | * | C | CB | CB | C | 2-4 |
| Plains Froglet <i>Crinia parsignifera</i> | * | * | * | C | CB | CB | C | 2-4 |
| Pobblebonk <i>Limnodynastes dumerili</i> | | * | * | CT | CB | CB | C | 5-6 |
| Barking Marsh Frog <i>Limnodynastes fletcheri</i> | | * | * | C | CB | B | | 3-4 |
| Spotted Marsh Frog <i>Limnodynastes tasmaniensis</i> | * | * | * | C | CB | B | | 3-4 |
| Perons Tree Frog <i>Litoria peronii</i> | * | * | * | C | CB | B | | 3-4 |
| Growling Grass Frog <i>Litoria raniformis</i> | | * | * | C | CB | B | | 3-5 |

C = Calling, B= Breeding, T = Tadpoles may be present