

Department for Environment and Heritage
Park Management and Ramsar Plan



Bool Lagoon Game Reserve and
Hacks Lagoon Conservation Park
2006



Government
of South Australia

This plan of management was adopted on 13 August 2006 and was prepared pursuant to section 38 of the *National Parks and Wildlife Act 1972*.



Government of South Australia

Department for Environment
and Heritage

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Front cover photograph courtesy of Daniel Harley: Magpie
Geese flocking at Bool Lagoon

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FOREWORD

Bool Lagoon Game Reserve and Hacks Lagoon Conservation Park are located approximately 24 kilometres south of Naracoorte, in South Australia's South East. Combined, the parks conserve 3,220 hectares of one of the most important remnant wetlands in a region where wetlands have been reduced to less than six percent of their original area.

Bool Lagoon Game Reserve and Hacks Lagoon Conservation Park are recognised internationally as the Bool and Hacks Lagoons Ramsar site, a Wetland of International Importance under the Convention on Wetlands (Ramsar, Iran 1971).

Bool and Hacks Lagoons are considered a major conservation asset, protecting a mosaic of aquatic and semi-aquatic vegetation interspersed with areas of open water, which at maximum capacity fills with water to cover an extensive 2,530 hectares. The lagoons support a diversity of species and habitats, including a number of global, national and state threatened species. In particular the site provides an important refuge for migratory bird species and significant breeding habitat for a diversity of waterbirds.

The plan defines a series of objectives and strategies for the future management and use of these significant reserves and facilitates the development and implementation of high quality integrated regional conservation programs.

Many people have contributed to the development of this plan of management. Their interest and helpful suggestions are gratefully acknowledged.

I now formally adopt the plan of management for Bool Lagoon Game Reserve and Hacks Lagoon Conservation Park under the provisions of section 38 of the *National Parks and Wildlife Act 1972*, and encourage you to visit these exceptional parks.



HON GAIL GAGO MLC

MINISTER FOR ENVIRONMENT AND CONSERVATION



PREFACE

This document is the plan of management for Bool Lagoon Game Reserve and Hacks Lagoon Conservation Park. This plan also fulfills the requirements of the *Australian Ramsar Management Principles* (Regulation 10.2 of the *Environment Protection and Biodiversity Conservation Act 1999*) to prepare a management plan for the Bool and Hacks Lagoon Ramsar site.

Bool and Hacks Lagoons were included on the List of Wetlands of International Importance (Ramsar List) in 1985. The site meets eight Ramsar Criteria, in particular for the diversity of waterbird species, waterbird breeding habitat and refuge, and its role as an important remnant wetland in the region. In addition to their recognition as a site for waterbirds, the lagoons are important for the maintenance of biodiversity in the region, and as a site of cultural significance.

Since the introduction of the *Environment Protection and Biodiversity Conservation Act 1999*, the inclusion of a wetland on the Ramsar List entails specific management obligations, namely the maintenance of the ecological character of the site and the wise use of resources. This Ramsar plan recognises the importance of the management of water to maintain the present suite of habitats and wetland functions. The plan focuses on the cooperative management of the off-site and on-site ground and surface water characteristics which impact on the wetland, while recognising and protecting the wide-ranging ecological and cultural values of the site.

The development of the plan engaged a wide range of community and specialist stakeholders. Emphasis was placed on facilitating community and specialist input prior to the drafting process, and providing multiple opportunities to comment throughout the planning process. Community involvement in the planning process was facilitated by a Community Reference Group (CRG), comprising local community stakeholders. A Technical Reference Group (TRG) was formed to provide a network of specialist stakeholders.

The purpose of the CRG was to provide a forum for community input on all management issues. The CRG met four times prior to the drafting of the management plan, including site visits to Bool and Hacks Lagoons. Many CRG members represented local organisations, and were therefore responsible for the two-way exchange of information between the CRG and their respective community organisations during the planning process. A *Management Issues Paper* was developed to provide background information to inform Group discussions.

Prior to the drafting of the management plan, DEH staff met with representatives from three regional Aboriginal Heritage organisations, including a site visit to Bool and Hacks Lagoon. Bool Lagoon landholders were given the opportunity to meet with DEH staff to comment on management issues, as well as having three representatives on the CRG.

The Technical Reference Group functioned as an informal network of individuals with specialist wetland knowledge. The majority of input from the TRG was done individually through the DEH Planning Officer through comment on the *Management Issues Paper* and by way of submissions on a pre-release draft plan. The TRG met formally for a Ramsar Workshop, held in April 2004. The purpose of the Ramsar Workshop was to address the update of the Ramsar Information Sheet for Bool and Hacks Lagoons, and develop guidelines for the description of the ecological character of the site. The TRG made a significant contribution to the development of monitoring priorities and principles.

DEH recognises the important contribution of community and specialist stakeholders throughout the planning process, and commends their enthusiastic and constructive involvement. Individuals involved in the process are acknowledged.

SYNOPSIS

Reserve name and type:	Bool Lagoon Game Reserve Hacks Lagoon Conservation Park
Management Region:	South East
Location:	24 kilometres from Naracoorte, South East. Naracoorte Coastal Plain bioregion
Bool Lagoon Game Reserve:	3,023 hectares
Hacks Lagoon Conservation Park:	198 hectares
First proclamation date:	1967
Purpose/reason for proclamation:	Bool Lagoon: Protection of wetland values and duck hunting opportunities. Hacks Lagoon: Protection of wetland values and waterfowl refuge area free from hunting.
Bool and Hacks Lagoons Ramsar site:	Bool Lagoon Game Reserve and Hacks Lagoon Conservation Park comprise the Bool and Hacks Lagoons Ramsar site.
Biodiversity values:	Wetland of International Importance under the Convention on Wetlands (Iran 1971). One of the most important remnant wetlands in the South East Region; example of a freshwater wetland over high pH soils. Supports a diversity of species and habitats, including a number of global, national and state threatened animal species, regionally threatened plant communities, and migratory bird species. Key waterbird habitat and dry-season and drought refuge. Floodwater storage basin in the regional drainage scheme.
Cultural values:	Of significance to Indigenous groups of the South East. Site of early European settlement in the region, and remains a focus of the local community.
Major activities/uses:	Wetland-based recreation activities, bird watching, walking on boardwalks, and closely monitored duck hunting.
Major management goals:	Maintenance of the ecological character of the site, including the present diversity of habitats and species, in particular through a partnership approach to the management of water. The provision of a recreation and tourism resource for the enjoyment of the public. An integrated monitoring program to inform active adaptive management.
Key strategies:	Development of a MoU with the South Eastern Water Conservation and Drainage Board regarding the management of water. Work with regional and cross border agencies and specialists regarding the minimisation of off-site impacts to the ecological character. Integrated monitoring program to ensure the maintenance of the ecological character.

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ABBREVIATIONS AND GLOSSARY OF TERMS

AARD:	Aboriginal Affairs and Reconciliation Division
ALRM:	Aboriginal Legal Rights Movement
ANZECC:	Australia and New Zealand Environment and Conservation Council
DEH:	South Australian Department for Environment and Heritage
DEHAA:	(former) South Australian Department for Environment, Heritage and Aboriginal Affairs
DENR:	(former) South Australian Department of Environment and Natural Resources
CFS:	Country Fire Service
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999</i> (Cwth)
GIS:	Geographic Information System
IBRA:	Interim Biogeographic Regionalisation for Australia
IUCN:	International Union for Conservation of Nature and Natural Resources (The World Conservation Union)
LCRDB	Limestone Coast Regional Development Board
MoU	Memorandum of Understanding
NP&W	National Parks and Wildlife
NP&W Act	<i>National Parks and Wildlife Act 1972</i> (SA)
Ramsar	Convention on Wetlands/Ramsar Convention
SECWMB	(former) South East Catchment Water Management Board
SEDB	(former) South Eastern Drainage Board
SENRC	(former) South East Natural Resources Consultative Committee
SENRM	South East Natural Resources Management Board
SEWC&DB	South Eastern Water Conservation and Drainage Board

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1 INTRODUCTION

1.1 Park Description

Bool Lagoon Game Reserve and Hacks Lagoon Conservation Park are located 24 kilometres by road south of Naracoorte, in the South East Region of South Australia (Figure 1).

Bool Lagoon Game Reserve covers an area of 3,023 hectares, comprising DP35232 Allotment 11, DP35231 Allotment 4 and 5, DP29651 Allotment 5 and Sections 223, 224, 323, 330, 356 and 380 of the Hundred of Robertson. Hacks Lagoon Conservation Park covers an area of 198 hectares, comprising Sections 249, 372, 373, 379, 382, and 383 of the Hundred of Robertson. At their maximum storage capacity, the lagoons fill with water to cover an area of 2,530 hectares. Together, Bool Lagoon Game Reserve and Hacks Lagoon Conservation Park comprise the Bool and Hacks Lagoons Ramsar site, a Wetland of International Importance under the Convention on Wetlands (Ramsar, Iran 1971).

Bool Lagoon Game Reserve and Hacks Lagoon Conservation Park comprise the Bool and Hacks Lagoons Ramsar site (Figure 2).

Bool and Hacks Lagoons are located on an interdunal flat characterised by circular, shallow swamps. Lunettes are a distinctive feature of the Bool Lagoon landscape. Lunettes are low, crescent-shaped ridges which commonly occur on the eastern (lee) side of shallow lakes and depressions. The Bool Lagoon lunette, one of the largest in South Australia, is located on the eastern side of the main lagoon basin. Within the larger Bool Lagoon basin lies a complex of smaller lagoons, each with an associated lunette. Prior to extensive drainage, the interdunal flats of the South East were transformed each winter and spring into a succession of interconnected wetlands. Today, wetlands in the South East have been reduced to less than six percent of their original area (DEH & DWLBC 2003, p. 35). Bool and Hacks Lagoons form an important remnant wetland in an area that has been extensively drained for agriculture.

Bool and Hacks Lagoons are a mosaic of aquatic and semi-aquatic vegetation interspersed with areas of open water. The wetland zones of the reserves are dominated by aquatic floating-leaved vegetation (*Triglochin procerum*), reeds including *Phragmites australis* and *Typha domingensis*, sedges *Baumea articulata*, *B. juncea*, tussock vegetation *Gahnia filum* and *G. trifida*, and tall shrubland of Swamp Paperbark (*Melaleuca halmaturorum*).

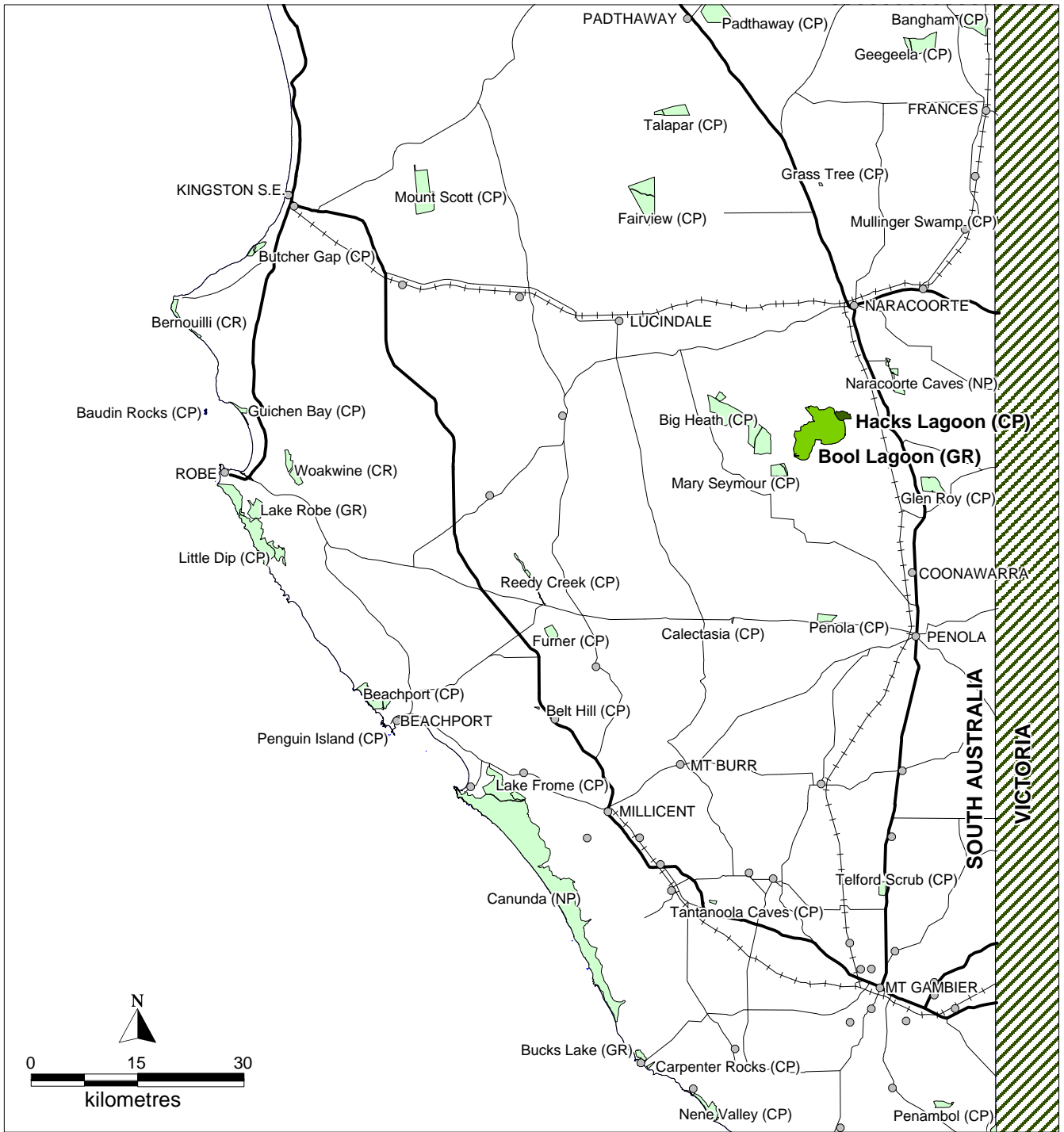
The reserves contain small areas of native grasses of high conservation value. Improved pasture grass, cereal crops and weeds dominate the remaining dryland areas of the reserves.

Climate

The climate at Bool and Hacks Lagoons is Mediterranean, comprising warm to hot, dry summers and cool, wet winters. Annual average rainfall is approximately 550-600mm; annual evaporation is approximately 1,400mm. The highest rainfall occurs during the winter months, between June to September; highest evaporation occurs during January and February.

Climate Feature	Amount	Month
Highest mean monthly rainfall	84mm	September
Lowest mean monthly rainfall	11mm	February
Highest mean monthly temperature	28°C	February
Lowest mean monthly temperature	14°C	July

Source: Bureau of Meteorology 2004.



LEGEND





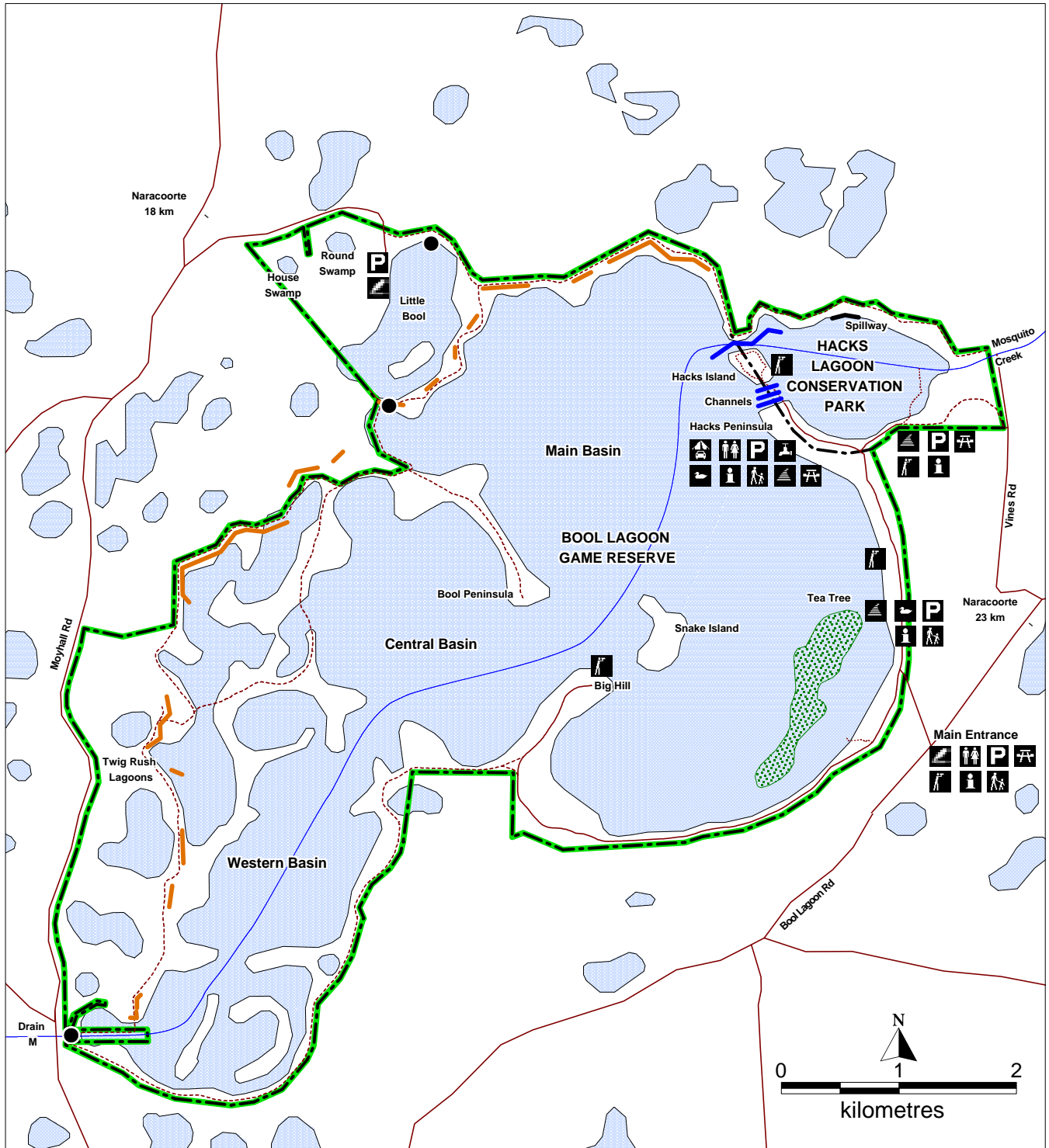
-  State of Victoria
-  Hacks Lagoon Conservation Park
-  Bool Lagoon Game Reserve
-  Other Parks

Figure 1

Bool Lagoon Game Reserve and Hacks Lagoon Conservation Park

Location

Map designed and created by Reserve Planning using PAMS
 Projection: MGA Zone 54 (GDA 94)
 Date: March 2006



LEGEND

	Bird Hide		Channels
	Parking		Stop Banks
	Information		Spillway
	Walking Trail		Drainage Flowpath
	Toilets		Management Track
	Lookout		Public Access Track
	Self Registration Site		Walking Trail
	Picnic Area		Park Boundary
	Boardwalk		Ramsar Boundary
	Drinking Water		Wetlands
	Camping		Tea Tree
	Regulator		

Figure 2

Bool Lagoon Game Reserve and Hacks Lagoon Conservation Park

Features

Map designed and created by Reserve Planning using PAMS
 Projection: MGA Zone 54 (GDA 94)
 Date: 2006

1.1.1 Regional Setting

The South East of South Australia - as defined by the *Biodiversity Plan for the South East of South Australia* - comprises approximately 2,100,000 hectares (Croft et al 1999). The economy of the South East is largely dependent upon primary production, and this is reflected in the relative landcover type of the Region.

Landcover Type	Approx. Area (ha)	% of total area
Urban	2,680	<1.0 %
Perennial Lake/Swamp	76,200	3.6 %
Native Vegetation	270,000	13.0 %
Agro-forestry	98,000	4.6 %
Agricultural Land	1,641,000	78 %
Other (inc Sand, Rock)	12,120	<1.0 %
Total:	2,100,000	

Source: Croft et al 1999, p. 5

There are approximately 2,600 agricultural enterprises in the region, with production totalling \$498 million in 2000 (LCRDB 2000). Dairy (20,000 hectares), viticulture (13,000 hectares) and potato production (15,000 hectares) are significant contributors to the regional economy (SECWMB 2003; LCRDB 2000).

Bool and Hacks Lagoons are surrounded by agricultural land used predominantly for grazing and cropping, with areas of viticulture. The Mosquito Creek catchment supports grazing and dryland cropping, in addition to areas of forestry, viticulture and irrigation.

The native vegetation remaining in the South East is unevenly distributed, concentrated in areas less suited to agriculture, such as deep sands, saline soils or sheet limestone. Twenty five percent of native vegetation is conserved within 66 Department for Environment and Heritage reserves and 50 Native Forest Reserves with a further 15 percent held in private land under approximately 220 Heritage Agreements. Consequently, 60 percent of the remaining native vegetation in the South East is not included in reserves or under Heritage Agreements. For a number of vegetation types, most of the remaining areas are along roadsides or scattered woodland and forest trees in farmland.

Bool and Hacks Lagoons are not directly connected to other areas of remnant vegetation. However, the reserves are within close proximity of two significant areas of remnant vegetation, Mary Seymour Conservation Park, and Big Heath Conservation Park. A project funded by the South East Natural Resources Management Board has also revegetated a link connecting Big Heath Conservation Park with Bool Lagoon, providing an important corridor to facilitate the movement of species. Sections of the regional drainage network (Drain M and Killanoola Drain) also connect the reserves.

The high level of hydrological alteration in the South East region, in particular through drainage, has resulted in most remaining wetland plant communities being considered rare and threatened. For example, sedgeland communities present at Bool and Hacks Lagoons containing *Gahnia filum*, *Gahnia trifida*, *Baumea juncea*, and *Phragmites australis* - *Typha domingensis* are considered vulnerable, endangered or rare in the South East region (Croft et al 1999, pp. 115-6).

The *Biodiversity Plan for the South East of South Australia* (Croft et al 1999) identifies the Bool Lagoon–Big Heath–Mary Seymour District as a key biodiversity area and large remnant area of high importance. This District includes Bool Lagoon Game Reserve and Hacks Lagoon Conservation Park.

Bool and Hacks Lagoons are located within the Naracoorte Coastal Plain IBRA Bioregion (Interim Biogeographic Regionalisation for Australia), which extends into Western Victoria. The Naracoorte Coastal Plain Bioregion covers an area of 2,8905 km², and contains 13 nationally important wetlands (Environment Australia 2001).

The Naracoorte Coastal Plain bioregion is a broad coastal plain of Tertiary and Quaternary sediments with a regular series of calcareous sand ridges separated by inter-dune swales, closed limestone depressions and young volcanoes at Mount Gambier. Vegetation is dominated by heathy woodlands and mallee shrublands with wet heaths in the inter-dune swales. The region has been extensively cleared for agriculture.

1.1.2 History of Reserve Management

Prior to their proclamation, Bool and Hacks Lagoons were held under private pastoral leases.

As early as 1940, the Flora and Fauna Committee and the South Australian Ornithological Association (which is now known as Birds SA) proposed that all or part of the wetland be declared a Bird Sanctuary. Murdoch (1991) notes that whilst receiving limited local backing, the case put forward by the proponents was short on sustainable arguments. Conversely, opponents of the proposal, in particular landholders and the shooters lobby, were well organised and influential. Subsequently, the proposal was denied.

In 1960, the (former) South Eastern Drainage Board proposed to drain Bool Lagoon and use it as a pondage basin to relieve floodwaters from Mosquito Creek. Widespread concern existed regarding the effects of drainage on the birdlife of Bool Lagoon. The Stockowners Association expressed fears that draining the Lagoon would adversely affect the Straw-necked Ibis, which were effective in controlling the pest Redheaded Cockchafer Beetle.

In 1963, a Parliamentary Committee of Investigation was formed to adjudicate on the core issues of drainage and management control. Views put before the Committee ranged from those supporting total preservation – making Bool Lagoon a sanctuary, with no grazing, no fires, and no shooting – to a variety of proposals for conditional conservation including the dedication of a Game Reserve, through to maintaining the status quo.

Hunting groups supported the dedication of a Game Reserve, and were an organised and influential lobby group.

It was noted by Murdoch (1991) that, at that time, little or no conflict of values existed between preserving Bool Lagoon and permitting controlled shooting in the minds of conservationists. Indeed, many ornithologists involved in the dedication process were keen duck hunters. In addition, Murdoch (1991) noted that the success of previous private shoots held at Bool Lagoon prior to 1960 contributed in a significant way to the eventual dedication of Bool Lagoon as a Game Reserve. Private shoots had raised significant amounts of money for charity, and it was recognised by the Department of Fisheries and Game that herein lay the economic base for a successful Game Reserve.

In 1964, the Parliamentary Committee of Investigation concluded:

Bool Lagoon should be developed as a Game Reserve. By so doing not only would native flora and fauna be protected, but those interested in shooting would still be permitted to shoot over the open area during periods when certain species of wildfowl were in excess.

The strongest opposition to Bool Lagoon's proclamation as a Game Reserve came from those local farmers who stood to lose income with the cancellation of their grazing licences.

In 1963, the (former) Fisheries and Game Department developed the first management plan for the reserves. Initially, the management of the lagoons for flood mitigation purposes held precedence over conservation requirements (DEP 1985). However, subsequent negotiations between the (former) South Eastern Drainage Board and the Department agreed on water levels required in the lagoons to enable the area to service the dual roles of a floodwater pondage basin and waterbird habitat.

In 1967, Bool Lagoon was the first dedicated Game Reserve in South Australia. The initial Game Reserve did not include the area now known as Little Bool; Little Bool was later acquired and added to the Reserve. Since that time, the Lagoons have been jointly managed for the purposes of conservation and flood mitigation.

The regulator gates on the western side of the lagoon were operational in 1966, and water was ponded in the lagoons for the first time during the winter of 1968.

In 1981, a one in 50 year¹ flooding event occurred and land to the north of the lagoon was flooded.

¹ A one in 50 year flooding event is the result of a rainfall episode that occurs on average once every 50 years.

Adjacent landholders held concern that the agreed levels in the lagoons were set too high to provide adequate storage in the event of large intakes of water late in the season (for example, during September). It was felt that this increased the risk of flooding adjacent agricultural land.

The development of the 1988 management plan for the reserves comprised extensive negotiation regarding the management of water levels. The agreed water levels of the 1988 (and 1992 amended plan) reflect extensive consultation between DEH, the South Eastern Water Conservation and Drainage Board, and the community, in particular local landholders.

Additional sections of land were added to Bool Lagoon Game Reserve (DP 29651 Allotment A, DP 35231 Allotments 4, 5, DP 35232 Allotment 11, Section 330 Hundred of Robertson) and Hacks Lagoon Conservation Park (Section 372 Hundred of Robertson) in 1993.

1.2 Key Values

International

- A Wetland of International Importance under the Convention on Wetlands (Ramsar Convention).
- Bool and Hacks Lagoons fulfil all eight Ramsar Criteria for Identifying Wetlands of International Importance.
- Habitat for 22 species of migratory birds listed under international agreements and conventions (Ramsar Convention, Japan-Australia Migratory Bird Agreement (JAMBA), China-Australia Migratory Bird Agreement (CAMBA) and the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention).
- Important habitat for the globally vulnerable Australasian Bittern (*Botaurus poiciloptilus*), included on the IUCN Red List of Globally Threatened Species.
- Important Australian drought refuge for waterbirds, particularly waterfowl.
- Important on an Australian scale for colonial breeding waterbirds.
- The wetlands regularly support in excess of one percent of the individuals in populations of ten different species or subspecies of waterbird.
- Regularly supports between 15,000 and 50,000 ducks and between 1,000 and 5,000 Black Swans.

National

- Included in the Directory of Important Wetlands in Australia (Environment Australia 2001).
- Regional stronghold of the Southern Bell Frog (*Litoria raniformis*), listed as vulnerable at both state and national level.
- One of two known habitats in South Australia for the nationally vulnerable Striped Legless Lizard (*Delma impar*).
- Important habitat for the nationally vulnerable Painted Snipe (*Rostratula benghalensis*).
- The Mosquito Creek-Bool Lagoon system is habitat for the nationally vulnerable Yarra Pygmy Perch (*Nannoperca obscura*) and Dwarf Galaxias (*Galaxiella pusilla*).
- Included on the Register of the National Estate (Australian Heritage Commission) as a place of natural heritage importance.
- Significant drought refuge for waterbirds in south eastern Australia.

South Australia

- Supports 30 South Australian threatened species including 26 bird species (see Appendix B), the Swamp Wallaby (*Wallabia bicolor*), Striped Legless Lizard (*Delma impar*), Glossy Grass Skink (*Pseudemoia rawlinsoni*) and the Southern Bell Frog (*Litoria raniformis*).
- Provides habitat for 79 waterbird species, including important breeding habitat for 48 species known to have bred there.
- Important flocking site for the summer concentrations of the southern Australian population of Brolga (*Grus rubicunda*).

South East

- One of the most important wetland areas remaining in the South East; only around six percent of wetlands remain in the Region (DEH & DWLBC 2003, p. 35).
- Contains important examples of floristic diversity and regionally threatened wetland vegetation associations.
- Bool Lagoon is the most important wetland in the South East of South Australia in terms of numbers of grebes, pelicans, cormorants, herons and allies, ducks and allies, rails, plovers and terns it supports (ANCA 1999, p. 500).
- The wetland has the highest recorded waterbird diversity, and diversity of breeding species, in the South East of South Australia (ANCA 1999, p. 500).
- Bool Lagoon is the only area in the South East where the Little Bittern (*Ixobrychus minutus*) and Magpie Goose (*Anseranas semipalmata*) have been recorded.
- The Lagoons are an important flood storage basin in a regional flood mitigation scheme, managed by the South Eastern Water Conservation and Drainage Board under the *South Eastern Water Conservation and Drainage Act 1992*.
- Bool and Hacks Lagoons are an important example of a freshwater wetland over fertile, high pH soil.
- The reserves support the highest diversity of colonial nesting birds in the South East (ANCA 1999, p. 500).
- Bool and Hacks Lagoons are also considered to have significant social importance including:
 - Indigenous cultural significance;
 - use for passive recreational pursuits (eg. tourism, camping, bird-watching and photography); and
 - use of Bool Lagoon Game Reserve for duck hunting.

1.3 Vision

To conserve the ecological character of the wetland while utilising the natural resources of the area in a sustainable manner.

Strategic objectives to achieve the vision are:

- Meet the requirements of the Ramsar Convention on Wetlands and the *Environment Protection and Biodiversity Conservation Act 1999*.
- Maintain a diversity of native species, including international, national, state and regional threatened species, communities and migratory species, and the preservation of the key habitats and processes that support them.
- Maintain a partnership approach to the management of water in a local and catchment context, in particular the implementation of a formal management arrangement with the South Eastern Water Conservation and Drainage Board to ensure the management of water is consistent with ecological objectives, and flood mitigation requirements.
- Provide a recreational and tourism resource for the amenity and enjoyment of the public, underpinned by the principle of wise use to ensure the promotion and protection of ecological values.

2 MANAGEMENT FRAMEWORK

2.1 National Parks and Wildlife Act 1972

Reserves are managed by the Director of National Parks and Wildlife subject to any direction by the Minister for Environment and Conservation or the Chief Executive of the Department for Environment and Heritage (DEH). When managing reserves, the Director is required under section 37 of the *National Parks and Wildlife Act 1972* to have regard to, and set forth proposals that are consistent with the following objectives of management stated in the Act:

- preservation and management of wildlife;
- preservation of historic sites, objects and structures of historic or scientific interest within reserves;
- preservation of features of geographical, natural or scenic interest;
- destruction of dangerous weeds and the eradication or control of noxious weeds and exotic plants;
- control of vermin and exotic animals;
- control and eradication of disease of animals and vegetation;
- prevention and suppression of bush fires and other hazards;
- encouragement of public use and enjoyment of reserves and education in, and a proper understanding and recognition of, their purpose and significance;
- generally, the promotion of the public interest; and
- preservation and protection of Aboriginal sites, features, objects and structures of spiritual or cultural significance within reserves.

Section 38 of the Act states that a management plan is required for each reserve. A management plan should set forth proposals in relation to the management and improvement of the reserve and the methods by which it is intended to accomplish the objectives of the Act in relation to that reserve. The legislation anticipates that management plans will be formally reviewed, but there are no prescribed time limits for this to occur. Management plans are intended to accommodate management aspirations over a five to ten year time frame. The management plan for Bool Lagoon Game Reserve and Hacks Lagoon Conservation Park will be reviewed every seven years in accordance with Ramsar guidelines (see 2.3.1 Ramsar Management Plans).

DEH is responsible for preparing management plans and undertaking the prescribed community consultation process for the park. A standard management planning process is mandated, to ensure that all statutory obligations are met. Help and guidance with plan preparation is sought and obtained from individuals, community groups or relevant advisory committees, although the Minister ultimately decides whether to adopt a management plan.

The draft plan for Bool Lagoon Game Reserve and Hacks Lagoon Conservation Park was released for public exhibition in November 2006. At the close of the comment period, 6 submissions were received. All comments and concerns were considered by the Community Reference Group, the South East Consultative Committee and the Steering Committee. The plan was then forwarded to the South Australian National Parks and Wildlife Council for advice before the plan was presented to the Minister for adoption.

In accordance with the Act, the provisions of this management plan must be carried out and no actions undertaken unless they are in accordance with this plan. In order to achieve this, each year park managers, taking regional and district priorities into account, draw up work programs to implement strategies proposed in management plans. Implementation of these projects is determined by, and subject to, the availability of resources (eg. staffing and funding).

2.1.1 Park Proclamation

Conservation Parks are proclaimed for the purpose of preserving any wildlife or the natural or historic features of that land. Game Reserves are proclaimed for the purpose of conservation of wildlife and management of game.

Bool Lagoon was proclaimed as a Game Reserve in 1967 under the *Fauna Conservation Act 1964*. The initial function of a Game Reserve under the Act was to preserve particular endangered species, yet permit controlled harvests of duck populations at a level that would ensure their maintenance in perpetuity. Concurrently, Hacks Lagoon was dedicated a Conservation Park to provide a close wetland refuge area free from hunting.

In 1972, Bool Lagoon was constituted a Game Reserve under the *National Parks and Wildlife Act 1972*, and Hacks Lagoon dedicated a Conservation Park.

In 1993, additional sections of land were added to Bool Lagoon Game Reserve (DP 29651 Allotment A, DP 35231 Allotments 4, 5, DP 35232 Allotment 11, Section 330 Hundred of Robertson) and Hacks Lagoon Conservation Park (Section 372 Hundred of Robertson).

IUCN Classification

Bool Lagoon Game Reserve and Hacks Lagoon Conservation Park are classified as a Category IV: Habitat/Species Management Area, which is described as an area of land and/or sea subject to active intervention for management purposes so as to ensure the maintenance of habitats to meet the requirements of specific species. Management will be consistent with the following IUCN Category IV objectives:

- to secure and maintain the habitat conditions necessary to protect significant species, groups of species, biotic communities or physical features of the environment where these require specific human manipulation for optimum management;
- to facilitate scientific research and environmental monitoring as primary activities associated with sustainable resource management;
- to develop limited areas for public education and appreciation of the characteristics of the habitats concerned and of the work of wildlife management;
- to eliminate and thereafter prevent exploitation or occupation inimical to the purposes of designation; and
- to deliver such benefits to people living within the designated area as are consistent with the other objectives of management.

2.2 The Ramsar Convention²

Bool and Hacks Lagoons were included on the List of Wetlands of International Importance under the Ramsar Convention in 1985. Bool and Hacks Lagoons fulfil the eight Ramsar Criteria for Identifying Wetlands of International Importance.

Under the Ramsar Convention, a wetland should be considered Internationally important if:

1. It contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.
2. It supports vulnerable, endangered, or critically endangered species or threatened ecological communities.
3. It supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.
4. It supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.
5. It regularly supports 20,000 or more waterbirds.

² The official title of the Convention is the *Convention on Wetlands of International Importance especially as Waterfowl Habitat*. The use of the title The Convention on Wetlands, or the Ramsar Convention after the Iranian town in which the treaty was developed, is commonly accepted.

6. It regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.
7. It supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.
8. It is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.

Under the Ramsar Convention, sites included on the List of Wetlands of International Importance (the Ramsar List) attract specific management obligations.

Bool and Hacks Lagoons fulfil all eight criteria. Full justification of the Ramsar criteria is contained in the Ramsar Information Sheet for Bool and Hacks Lagoons (Appendix D).

2.2.1 Ecological Character

Article 3.2 of the Convention requires the notification of any change in the ecological character of a Ramsar wetland: *Each Contracting Party shall arrange to be informed at the earliest possible time if the ecological character of any wetland in its territory and included in the List has changed, is changing, or is likely to change as the result of technological developments, pollution or other human interference.*

The **ecological character** of a wetland is defined as:

The sum of the biological, physical and chemical components of the wetland ecosystem, and their interactions, which maintain the wetland and its products, functions and attributes.

Furthermore, **change in ecological character** is defined as:

The impairment or imbalance in any biological, physical or chemical components of the wetland ecosystem, or in their interactions, which maintain the wetland and its products, functions and attributes.

The Ramsar Convention clearly differentiates between adverse and favourable change to a wetland caused by human activities. The definition of change in ecological character refers explicitly to adverse human-induced change. The Convention commits Contracting Parties to the maintenance of the ecological character of Listed Ramsar wetlands in their jurisdiction, in accordance with the listed features contained in the Ramsar Information Sheet (Appendix D).

2.2.2 Wise Use

The **wise use** of wetlands is one of the fundamental principles of the Ramsar Convention. Wise use is closely linked with the principles of ecologically sustainable development. The Ramsar Convention defines the wise use of wetlands as:

The sustainable utilisation for the benefit of mankind in a way compatible with the maintenance of the natural properties of the ecosystem.

Upon designation of wetlands to the Ramsar List, signatory countries are required to prepare plans of management to promote the wise use, and describe and maintain the ecological character of declared wetlands.

2.3 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) establishes a Commonwealth approval process for assessment of proposed actions that are likely to have a significant impact on the following matters of National Environmental Significance:

- World Heritage properties
- National heritage places
- Ramsar wetlands of international significance
- Nationally threatened species and ecological communities
- Listed migratory species
- Commonwealth marine areas
- Nuclear actions (including uranium mining)

Under the Act, there are three matters of National Environmental Significance at Bool and Hacks Lagoons: the ecological character of a Ramsar listed wetland, listed threatened species, and listed migratory species. The Dwarf Galaxias (*Galaxiella pusilla*), Yarra Pygmy Perch (*Nannoperca obscura*), Striped Legless Lizard (*Delma impar*) and the Painted Snipe (*Rostratula benghalensis*) all occur at Bool and Hacks Lagoons and are listed as vulnerable under the EPBC Act.

Several bird species recorded for the park are also listed migratory species (Appendix B). The EPBC Act provides for the protection for migratory species identified in approved international treaties such as the Migratory Bird Agreements with Japan ([JAMBA](#)) and China ([CAMBA](#)), and the [Bonn Convention](#).

Any action that has, will have or is likely to have a significant impact on these matters of National Environmental Significance must be referred to the responsible Australian Government Minister for assessment and approval in addition to any approval that may be required in the State of South Australia.

Australia is the first country to translate its responsibilities under the Ramsar Convention into legislation. The matter protected under the EPBC Act is the ecological character of a Ramsar Wetland, not just features of the wetland located within the site boundary. Under the Act's administrative guidelines on significance, an action has, will have, or is likely to have a significant impact on the ecological character of a declared Ramsar Wetland if it does, will, or is likely to result in:

- Areas of the wetland being destroyed or substantially modified;
- A substantial and measurable change in the hydrological regime of the wetland, for example, a substantial change to the volume, timing, duration and frequency of ground and surface water flows to and within the wetland;
- The habitat or lifecycle of native species dependent upon the wetland being seriously affected;
- A substantial and measurable change in the physico-chemical status of the wetland, for example, a substantial change in the level of salinity, pollutants, or nutrients in the wetland, or water temperature which may adversely impact on biodiversity, ecological integrity, social amenity or human health; or
- An invasive species that is harmful to the ecological character of the wetland being established in the wetland.

Note that an action which has, will have, or is likely to have a significant impact on the ecological character of a declared Ramsar wetland might take place outside the boundaries of the wetland.

2.3.1 Ramsar Management Plans

The *Australian Ramsar Management Principles* (Regulation 10.2 of the EPBC Act) state general standards for Ramsar wetlands in Australia, including requirements for management, management planning, and environmental impact assessment and approval. Importantly, the Principles stipulate that a management plan should be prepared for all Ramsar wetlands, and should describe and state what must be done to maintain the ecological character of the wetland. Management plans must be reviewed at intervals of not more than seven years.

This plan of management addresses the requirements of the Australian Ramsar Management Principles. In particular, the Principles are addressed through the description of the ecological character of the wetland (section 3), and the provision of management objectives and strategies to maintain the ecological character (section 4).

2.4 Native Title Act 1993

Native Title describes the rights and interests Aboriginal and Torres Strait Islander People have in land and waters according to their traditional laws and customs. Commonwealth legislation, in the form of the *Native Title Act 1993* was enacted to:

- Provide for the recognition and protection of native title;
- Establish ways in which future dealings affecting native title may proceed and to set standards for those dealings;
- Establish a mechanism for determining claims to native title; and
- Provide for, or permit, the validation of past acts, and intermediate period acts, invalidated because of the existence of native title.

This management plan is released and will be adopted subject to any native title rights and interests that may continue to exist in relation to the land and/or waters. Before undertaking any acts that might affect native title, DEH will follow the relevant provisions of the *Native Title Act 1993*.

2.5 Regional Planning

Biodiversity Plan for the South East of South Australia

The *Biodiversity Plan for the South East of South Australia* (Croft et al 1999, p. 126) identifies priority actions for the Bool Lagoon–Big Heath–Mary Seymour District:

- Establish linkages and stepping-stones between the three main remnant blocks of native vegetation based on existing road and drain reserves, to allow exchange of populations and/or recolonisation of species.
- Re-establish wetlands to create further habitat in the district and assist in the linkages between the blocks.
- Re-establish a wider area of terrestrial native vegetation around wetlands, to create a buffer.
- Encourage revegetation with native species to the area, especially in conservation area.
- Avoid the selection of inappropriate species for revegetation in native grassland and sedgeland.
- Undertake broad district control of fox, cat, and rabbits.
- Strategic control of environmental weeds, particularly phalaris, in remnant grasslands and revegetated areas.

The Plan identifies Bool and Hacks Lagoons as one of the most significant wetlands remaining in the region.

South East Natural Resources Management Plan

The *Natural Resources Management Act 2004* came into full operation on 1 July 2005 and replaced the *Animal and Plant Control (Agricultural Protection and Other Purposes) Act 1986*, the *Soil Conservation and Land Care Act 1989* and the *Water Resources Act 1997*. The NRM Act provides a framework for the integrated use and management of the State's natural resources. The Act establishes eight regional NRM boards which with support from the local community have developed comprehensive regional NRM plans.

The *South East Natural Resource Management Plan* has been developed to provide the strategic framework for achieving the vision for natural resource management in the South East:

The natural resources of the South East managed in an integrated manner to protect and/or enhance environmental values, promote sustainability in economic development, and build social capacity.

The Plan outlines a number of goals with relevance to the management of Bool and Hacks Lagoon, including the meeting of Ramsar obligations through best practice wetland ecology and management planning; protecting groundwater dependent ecosystems by maintaining the quantity and quality of groundwater from the unconfined aquifer; protecting surface water resources necessary to sustain ecosystems and biodiversity, including cross border flows; and to minimise adverse impacts of flooding.

South Eastern Water Conservation and Drainage Board Management Plan 2003-2006

The responsibility for hydrological management of Bool and Hacks Lagoons is shared between DEH, and the South Eastern Water Conservation and Drainage Board (SEWC&DB). The *South Eastern Water Conservation and Drainage Act 1992* governs the function of the Board.

The *South Eastern Water Conservation and Drainage Board Management Plan 2003-2006* recognises the importance of managing Bool and Hacks Lagoons for the purposes of flood mitigation and its ecological importance. The Board has the following stated Objective and Action for the dual management of areas of the drainage network for conservation and flood mitigation:

Objective : *Promote the wise use of water for conservation in upper catchments for environmental enhancement and flow mitigation purposes.*

Action : *Identify opportunities where conservation and wetland goals and flow mitigation strategies can be met through the wise use of water (for example, the retention of water). Continue to monitor the areas where this practice is undertaken, to ensure that dual benefits are being achieved. (SEWC&DB 2003, p. 51).*

South East Catchment Water Management Plan 2003-2008

The South East Natural Resource Management Board (incorporating the former SECWMB) is charged with the responsibility to secure the integrity of all our natural resources. Part of their responsibility is to manage the region's water resources and their dependent ecosystems. The *South East Catchment Water Management Plan 2003-2008* identifies Bool and Hacks Lagoons as an important water-dependent ecosystem in the Region.

The Board outlines a number of key actions to be undertaken in partnership with relevant agencies with regard to water dependent ecosystems:

- Identify key regional water-dependent ecosystems and the major threats to environmental values for each asset.
- Develop management plans for key water-dependent ecosystems.
- Investigate and refine environmental water requirements for key water-dependent ecosystems.

DEH has been identified as the *Key Partner* for each of the above actions.

The Board also outlines actions of relevance to Bool and Hacks Lagoons pertaining to the development of surface water-sharing agreements with Victoria, participation in regional flood management, and the development of a regional flow management strategy.

The roles of the South Eastern Water Conservation and Drainage Board, and the South East Natural Resources Management Board with regard to hydrological issues affecting Bool and Hacks Lagoons is discussed further in section 4.1 Hydrology.

Water Allocation Plans

Water Allocation Plans must be developed for each of the prescribed water resources in the South East Natural Resources Management Board's catchment area. They identify how water will be allocated, the amount of water for allocation, and rules for transferring licences and how trading will occur. Water allocation plans are also required to assess any impacts on ecosystems due to the taking of water, assess whether the taking and use of water will have a detrimental effect on the quantity and quality of the resource, and the ability of the resource to meet future demands.

There are currently four Prescribed Wells Areas in the South East: The Lower Limestone Coast (previously Comaum-Caroline, Lacepede Kongorong and Naracoorte Ranges), Tintinara Coonalpyn, Padthaway and Tatiara Prescribed Wells Areas. The Naracoorte Ranges Water Allocation Plan was adopted on 22 January 2001. The review and amendment of the Water Allocation Plan commenced in 2004 and is scheduled for completion in 2006.

2.6 Adaptive Management

The management of Bool and Hacks Lagoons is guided by the principle of *adaptive management*; that is, learning by doing, and aiming for continuous improvement of knowledge and management practices. It is the intention of this plan to facilitate management actions that guide meaningful and targeted monitoring activities, and respond and adjust to feedback. Figure 3 illustrates the adaptive management model for Bool and Hacks Lagoons.

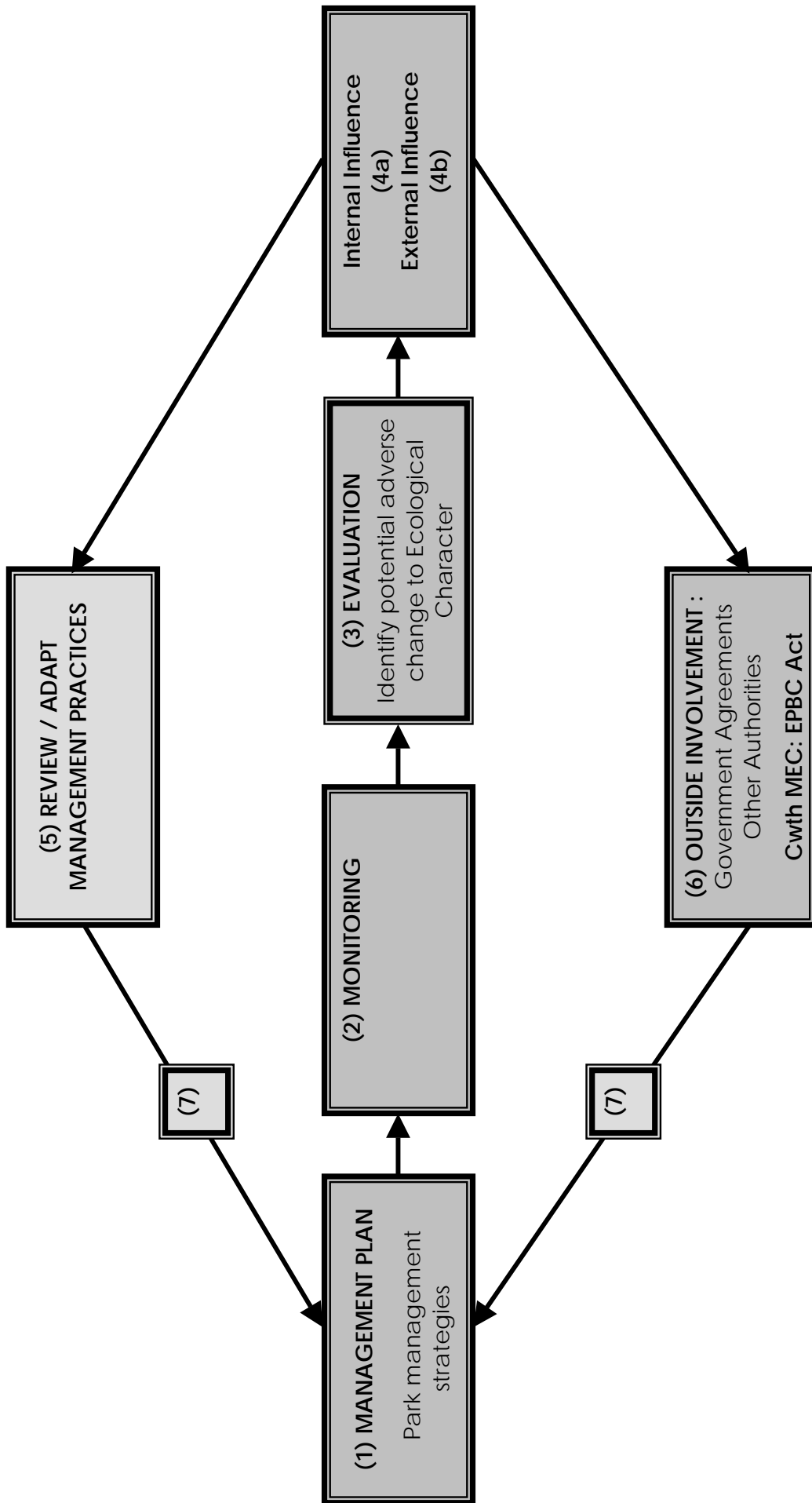
In particular, the adaptive management framework for Bool and Hacks Lagoons aims to achieve the following outcomes:

- **Management Plan (1):** Strategies for park management and identification of threats to ecological character.
- **Monitoring (2):** Targeted monitoring of key ecological character components, interactions and identified threats to ecological character;
- **Evaluation (3):** Monitoring utilised to identify and evaluate potential change to ecological character. This evaluation includes consultation with the Australian Government department/Minister responsible for the administration of the *Environment Protection and Biodiversity Conservation Act 1999*;
- **Evaluation to enable differentiation between:**
 - Internal influences (4a)** that can be addressed through the review and adaptation of reserve management practices, and
 - External influences (4b & 6)** requiring outside agency involvement, including relevant inter-government agreements, and the *Environment Protection and Biodiversity Conservation Act 1999*.
- **Management Review and Adaptation (5):** The review and adaptation of park management strategies subject to the identification of potential adverse change to the ecological character. This may include variations to the strategies outlined in this management plan providing these variations are consistent with the objectives of management. Significant changes to the management plan may require a plan amendment.
- **Future monitoring (7):** Activities guided by any review of on-park (internal) and external management practices, and identified threats to the ecological character of the site.

By enabling flexible management in response to identified threats and potential changes, key management decisions are not postponed while further data is collected. The adaptive management model provides an ongoing process for data collection, evaluation, review and adaptation, promoting continuous improvement of management practices toward the maintenance of the ecological character. It is important to note that management strategies must be consistent with the objectives of management.

Figure 3

Bool Lagoon Game Reserve and
Hacks Lagoon Conservation Park
Adaptive Management Model



3 ECOLOGICAL CHARACTER

The maintenance of the ecological character of Bool and Hacks Lagoons is a principal management obligation, and serves to underpin many of the management objectives and strategies within this document.

The Ramsar Convention Bureau (*Handbook 8 - Frameworks for managing Wetlands of International Importance and other wetlands*) emphasises the need to describe the ecological character at the time of the designation of the Ramsar site, but where significant time has passed since listing and a detailed ecological character description was not prepared at the time, and adequate data is not available, the description should be completed using current information, with reference to whatever historical data is available (Ramsar Convention Bureau 2000).

The following information describes the known components, interactions, and processes that comprise the ecological character of Bool and Hacks Lagoons. The description reflects where possible the known amplitude of natural change within the lagoons since the time of inclusion on the List of Wetlands of International Importance in 1985. The description is intended to be consistent with the *Environment Protection and Biodiversity Conservation Act 1999* Administrative Guidelines on Significance regarding actions likely to have significant impact ecological character of Ramsar wetlands (see 2.3 Environment Protection and Biodiversity Conservation Act 1999). Accordingly, the description (where possible) will provide information necessary to assess key threats identified in the Guidelines, namely wetland modification/destruction, change in hydrological regime, changes in habitat or lifecycles of native species, change in physico-chemical status of the wetland, and invasive species.

This plan of management seeks to identify the amplitude of fluctuations since 1985 responsible for shaping the present composition of species and habitats. In order to maintain the present ecological characteristics, future fluctuations must be managed where possible to occur within these identified parameters, by managing human-induced threats that may result in unprecedented changes to the wetland.

Since the time of Ramsar Listing in 1985, wide climatic variations within the South East Region and the catchment of Bool and Hacks Lagoons have resulted in significant fluctuations in hydrological conditions. Between 1985 and 1993, Bool and Hacks Lagoons experienced an extended period of high recorded pondage levels in the lagoons. Conversely, between 1993 and 2002 the wetlands sustained a period of below average surface water inflow, resulting in greatly reduced pondage levels, except in 1996 when the regulator gates needed to be operated and a full supply level was achieved. The response of the wetland to the prolonged wet and dry periods is strongly reflected in the identified ecological parameters comprising the ecological character description.

Critical to the maintenance of ecological character is the identification and protection of the present suite of habitats. Maintaining present habitat diversity is necessary for the continuance of all species of flora and fauna.

3.1.1 Landscape

The topography of the Naracoorte Coastal Plain bioregion is dominated by a series of 13 stranded sandstone dunes. Each dune lies parallel to the existing coastline in a north westerly to south easterly direction and was deposited by successive Quaternary marine incursions. The dunes are progressively higher towards the east; Bool and Hacks Lagoons lie adjacent to the West Naracoorte Range, the oldest and highest of the dunes.

Lunettes (see 1.1 Park Description) are a common feature of the Bool Lagoon landscape. The lunette ridges have well drained soils of moderate fertility. The sediment beneath Bool Lagoon consists of alternating layers of white marl and greenish clay, with a surface layer of peaty loam. These black organic soils have a high pH and are generally poorly drained.

3.1.2 Hydrology

Under the Ramsar Convention on Wetlands, Bool and Hacks Lagoons are classified as (in order of area):

- Seasonal/intermittent freshwater lake (>8ha);
- Permanent freshwater marshes/pools; ponds (<8ha); marshes, swamps on inorganic soils, with emergent vegetation water logged for at least most of the growing season; and
- Shrub dominated wetlands, shrub swamps, shrub-dominated freshwater marshes, shrub carr, or alder thicket on inorganic soils.

Surface Water

Mosquito Creek is one of a number of seasonal, high discharging creeks with their origins in Victoria, which descend onto the Naracoorte Plains. Owing to the low gradient of the interdunal flats, these creeks generally lose integrity and flood low-lying areas. Prior to regional drainage, a significant area of the interdunal flat was inundated during winter and spring as a result of surface water from Mosquito Creek. Figure 4 shows the regional watercourse and drainage network.

Prior to the creation of a defined channel, during times of high flow Mosquito Creek discharged into the north side of Hacks Lagoon through a relatively small channel near the site of the present concrete spillway. Bool and Hacks Lagoons filled only during times of high flow, and during very wet years overflowed to the northwest side. With the exception of this overflow, floodwater entering the lagoons was naturally impounded; water was lost through evaporation and seepage in the summer/autumn months. Under this natural regime, it is estimated that during summer and autumn water was present only periodically.

Due to the considerable seasonal flooding of low-lying areas, drainage works in the Bool Lagoon area commenced as early as 1909-1910. However, major drainage works did not commence until 1960.

Between 1960 and 1970, the following drainage works were undertaken in the Bool Lagoon area:

- The extension of Drain M to meet the western side of Bool Lagoon, providing a continuous 73-kilometre drain from the lagoons to the coast at Beachport.
- The installation of a regulating structure at the western outlet of Bool Lagoon to control flow into Drain M.
- 21 stopbanks to the north and the west of the lagoons to increase pondage capacity and prevent the spill of water to the north and north-west of the lagoons.
- The construction of the Mosquito Creek channel to divert all Mosquito Creek flows into Hacks Lagoon.
- Seymour/Robertson drainage system to discharge surface water from this area into Bool Lagoon.

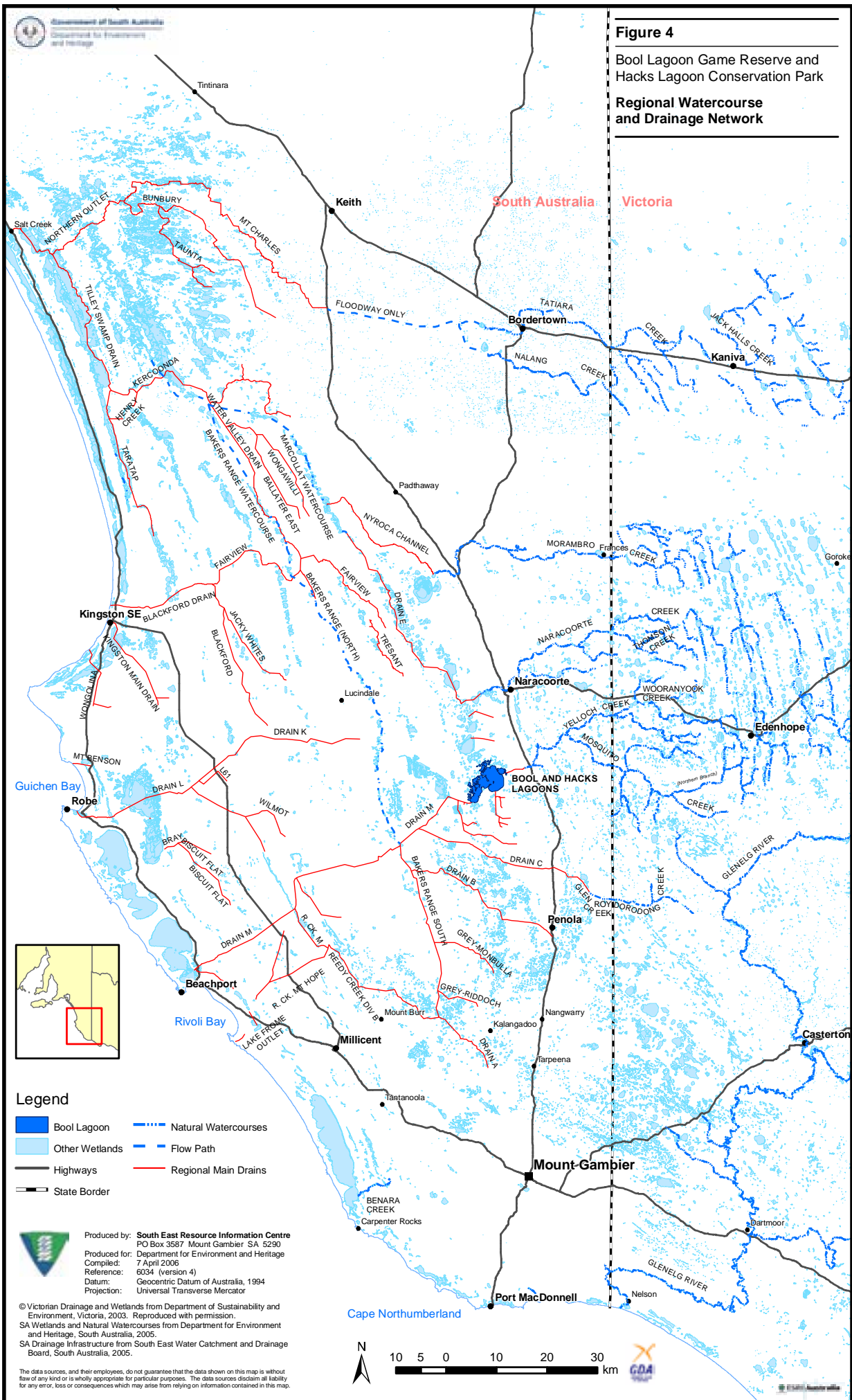


Figure 4
 Bool Lagoon Game Reserve and
 Hacks Lagoon Conservation Park
**Regional Watercourse
 and Drainage Network**

Legend

- Bool Lagoon
- Other Wetlands
- Highways
- Natural Watercourses
- Flow Path
- Regional Main Drains
- State Border

Produced by: **South East Resource Information Centre**
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Today, the reserves now receive the total volume of flows from Mosquito Creek. Due to the development of stopbanks and a regulating structure on the western side of the Bool Lagoon basin, water is more effectively impounded in the basins (Figure 2). The site of the pre-drainage inlet into Hacks Lagoon has been transformed into a concrete spillway, complete with stoplogs to enable the release of floodwaters to the north. The stoplogs have only been removed in 1981, due to what was considered a one in 50 year rainfall event, resulting in widespread flooding.

In 1969, three channels, each about 30 metres wide, were cut between Hacks Lagoon and the main Bool Lagoon basin in order to compensate for the very low gradient across the lagoons and accelerate the movement of water from east to west. The efficiency of the flowpath to move water across the lagoons was impeded by the growth of reed and rush vegetation. Aerial spraying of the flow path was undertaken between 1979 and 1984.

The capacity of the Mosquito Creek inlet is up to three times greater than that of Drain M downstream of Bool Lagoon. In addition, there are several drains discharging water into Drain M downstream of Bool Lagoon, increasing the volume of water in the drain. As a consequence, the South Eastern Water Conservation and Drainage Board are limiting the volume of water that can be safely released from Bool Lagoon. In the past, excess surface water has been diverted north from Drain M along the Baker's Range Watercourse, which intersects Drain M at right angles downstream of Bool Lagoon at the Callendale Regulator. The Upper South East Dryland Salinity and Flood Management Scheme has prepared detailed feasibility studies to allow works for more frequent northward diversion of flows in Drain M at the Callendale Regulator, and further, increase capacity to the Hacks Lagoon outlet of Mosquito Creek to enable greater flexibility in diverting excess flow through Hacks Lagoon, Mosquito Creek, Drain E and Marcollat Watercourse. Any future diversion of water downstream of Bool Lagoon would enable an increase in the volume of release of water for flood mitigation purposes from Bool Lagoon during high rainfall events.

Ponding Levels

The regulator on the western side of the Bool Lagoon basin remains closed unless it is considered necessary to release water into Drain M for flood mitigation purposes. It is estimated that the only water losses from the lagoons during winter is via the regulator; seepage to the unconfined aquifer and evaporation are considered negligible during the winter months.

Since 1985, climatic conditions, superimposed with the existing water management regime and operation of the regulator, have resulted in wide variation in hydrological characteristics. The period 1985 to 1992 is characterised by high volume of inflow relative to outflow, which is indicative of the impoundment of water within the lagoons. With the exception of 1996, when the regulator gates needed to be opened and a full supply level was achieved, the period between 1993 to 2002 is characterised by very low volumes of inflow, and little if any outflow via the regulator. Subsequently, little pondage of water was possible, in particular during the summer and autumn months. In January and February 2002, and again in December 2002, both Bool and Hacks Lagoons were completely dry, and the spring-fed base flow of Mosquito Creek ceased.

The 1988 and 1992 management plans for Bool and Hacks Lagoons provided for the following agreed pondage levels within the lagoons:

- 48.15m AHD (Australian Height Datum) during June;
- 48.24m AHD during July;
- 48.30m AHD at the end of the first week in August;
- 48.40m AHD during the third week of August;
- 48.55m AHD at the end of August; and
- 48.61m AHD for as long as possible from the second week in September.

It is recognised that these levels reflected the dual management requirements of maintaining ecological value and flood mitigation. The 1992 prescription noted that these levels offer a guide only, and where special circumstances exist, the South Eastern Water Conservation and Drainage Board may vary these levels.

The *Guidelines for the Operation of Bool Lagoon and Drain M Regulators for Flood Mitigation Purposes* (South East Drainage Board 1984) provides expected average frequencies³ for key hydrological events at Bool and Hacks Lagoons:

- With the present operating guidelines it is expected that water will have to be released from Bool Lagoon for flood mitigation purposes at a frequency of about 1 in every 3 years on the average. The main body of the lagoon will probably dry out at a frequency of about 1 in 2 years, but some water should be retained in Hacks Lagoon throughout most years, except if a series of very dry years occurs. Since 1985, the pattern of release via the regulator has demonstrated wide disparity; between 1985 and 1993, the regulator was opened for nine successive years. From 1997, no water was released via the regulator for seven consecutive years.
- Levels equalling or exceeding the spillway level at Hacks Lagoon and the top of the closed regulator gates (49.22m AHD) can be expected on average once every 20 years; levels exceeding the stoplogs at Hacks Lagoon expected to occur on average once every 50 years.
- When water levels exceed 49.52m AHD, stopbanks are threatened, and the flow of water over the top of the regulator gates becomes uncontrollable.
- It is recognised that during wet winters (61 days of rainfall greater than approximately 200mm), it will not be possible to limit the water level in the lagoon to 48.61m AHD (maximum agreed level), regardless of operational procedures adopted, due to the limited capacity of Drain M downstream, relative to the possible high intake rates.
- Hydrological studies carried out show that the balancing storage of Bool Lagoon should be adequate to cope with floods with a recurring frequency of not less than about one in 20 years on the average.

The peripheral lagoons located on the western and northern side of Bool Lagoon have different hydrological characteristics and potential management regimes to the main Bool and Hacks Lagoons basins. The peripheral lagoons include Little Bool and Round and House Lagoons to the north, and Gahnia, Twig Rush and Tea Tree Lagoons to the west of the main Bool Lagoon basin (Figure 2). After the construction of stop banks around Bool Lagoon in 1967 most of the peripheral lagoons were deprived of their natural water supply, via overflow from Bool Lagoon.

Since the late 1970s, the peripheral lagoons have progressively been linked to the hydrological regime of Bool Lagoon, thus dramatically increasing the availability of water to these wetlands. For example, there is two-way water control between Bool Lagoon and Little Bool, and greater capacity to hold water with the development of several stopbanks at Little Bool.

Prior to this re-flooding, the peripheral lagoons were very shallow and in most years dried by mid summer. Their value as habitat to waterbirds was considered to be limited (DEP 1987). After re-flooding, the species diversity of most lagoons increased dramatically. The ability to retain water in the peripheral lagoons over the summer and autumn months is critical to the value of Bool and Hacks Lagoons as a refuge area for waterbirds, as is the ability to provide for fluctuating water levels to maintain habitat diversity.

³ It should be noted that these comprise indicative averages for comparative purposes.

Groundwater

Bool and Hacks Lagoon is a groundwater dependant ecosystem and an understanding of the relationship between groundwater and surface water is important. In the vicinity of Bool and Hacks Lagoons, groundwater lies at a shallow depth, often within metres of the surface, particularly in low-lying areas. Most underground water in the region is derived from local rainfall. Due to the shallow depth to the water table, groundwater is highly responsive to rainfall recharge. Groundwater flow is generally from south-east to the north-west, with a declining gradient in a north-westerly direction.

Figure 5: Hacks Lagoons Average Groundwater Level 1971 to 2004

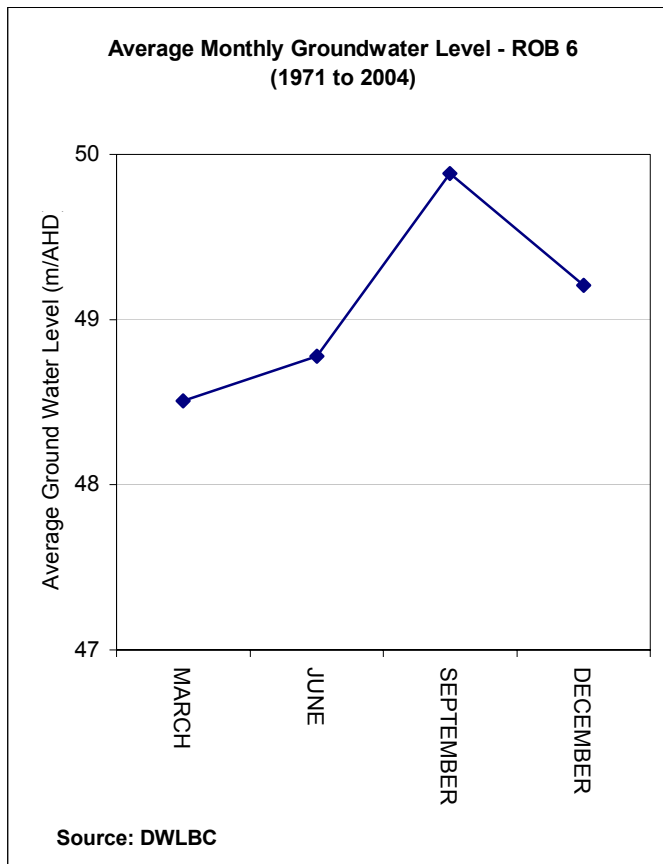


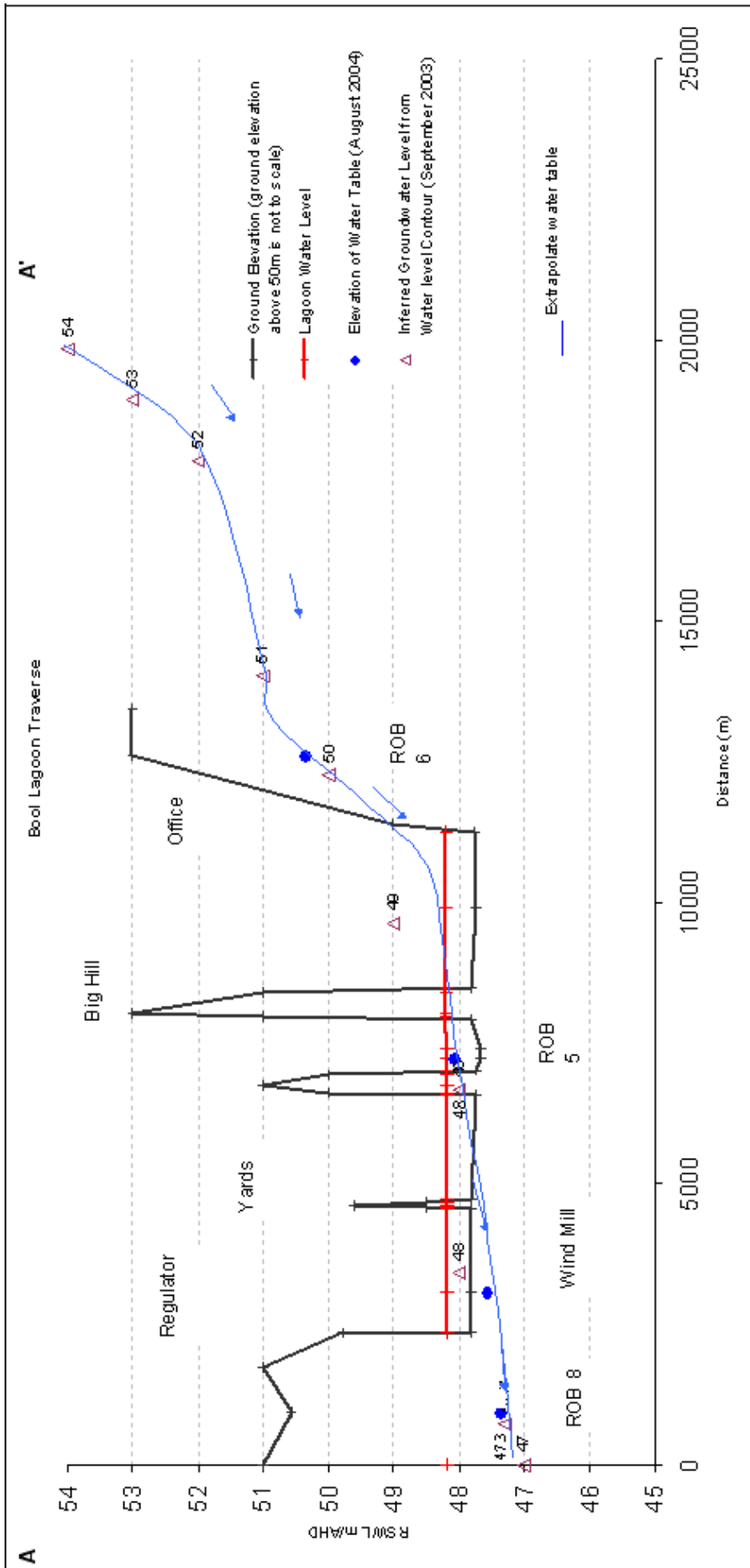
Figure 5 demonstrates the average monthly fluctuations in groundwater within proximity to Hacks Lagoons between 1971 and 2004. The observation bore is located approximately one kilometre to the east of Hacks Lagoon. Seasonal fluctuations are a result of groundwater elevation showing maximum recovery after the winter rainfall recharge period (around September), and the lowest level at the end of summer and towards the end of the irrigation season (around March). Comparison with the average annual groundwater levels of other observation bores in the region show similar magnitudes of seasonal fluctuation.

Within the lagoons, the water table lies close to the average lagoon floor level (47.9m AHD in Hacks Lagoon; 48m AHD in Bool Lagoon Western Basin), generally rising above it in winter and early spring and falling below it by late summer. Data collected from observation bore 5 (ROB 5) (sited on Bool Peninsula) shows winter groundwater levels as much as 0.6 – 0.7 metres above the lagoon floor during September 1982 (DEP 1985). A cross section provides basic

interpretation of the elevation of groundwater and surface water within the lagoon (Figure 6). The transect line runs in a north east/south west direction from Hacks Lagoon, across Bool Lagoon, intersecting the main, central and western basins. It was produced with a limited number of data control points. Further investigation is needed to quantify the relationship between ground and surface water. The blue dots on the graph represent groundwater levels recorded at observation bores in August 2004; the triangles represent inferred groundwater levels. The blue line indicates the groundwater levels using both sets of data from 2003 and 2004.

The cross section demonstrates a relative increase in groundwater influence in Hacks Lagoons to the east, due to the groundwater gradient lying higher to the east. On the eastern side, the observation bore level indicates that the water table is higher than the lagoon water level, and on the western side the water table is lower than the lagoon water level. The lagoon may be a flow-through wetland, receiving groundwater in the east and losing groundwater to the west.

Figure 6: Elevation Of Groundwater And Surface Water Within The Lagoon



Groundwater and Surface Water Interactions

Figures 7 & 8 demonstrate the available data on surface water inflow through Mosquito Creek, groundwater level in Bool Lagoon (western side near regulator) and Hacks Lagoon water levels since 1971. Both figures demonstrate the seasonal relationship between the increase in surface water inflow, groundwater level and lagoon water level. It should be noted that ROB 6 is situated on higher topography (about 1.5 kilometres up-gradient) than Hacks Lagoons, resulting in groundwater levels exceeding surface water levels when directly compared. It is the closest observation bore to Hacks Lagoon for comparative purposes. Observation bore 8 is located approximately 2 kilometres to the west of the Bool Lagoon outlet. Similarly, it is the closest bore for comparison.

Figure 7: Difference in Seasonal Water Level Fluctuations – Hacks Lagoon

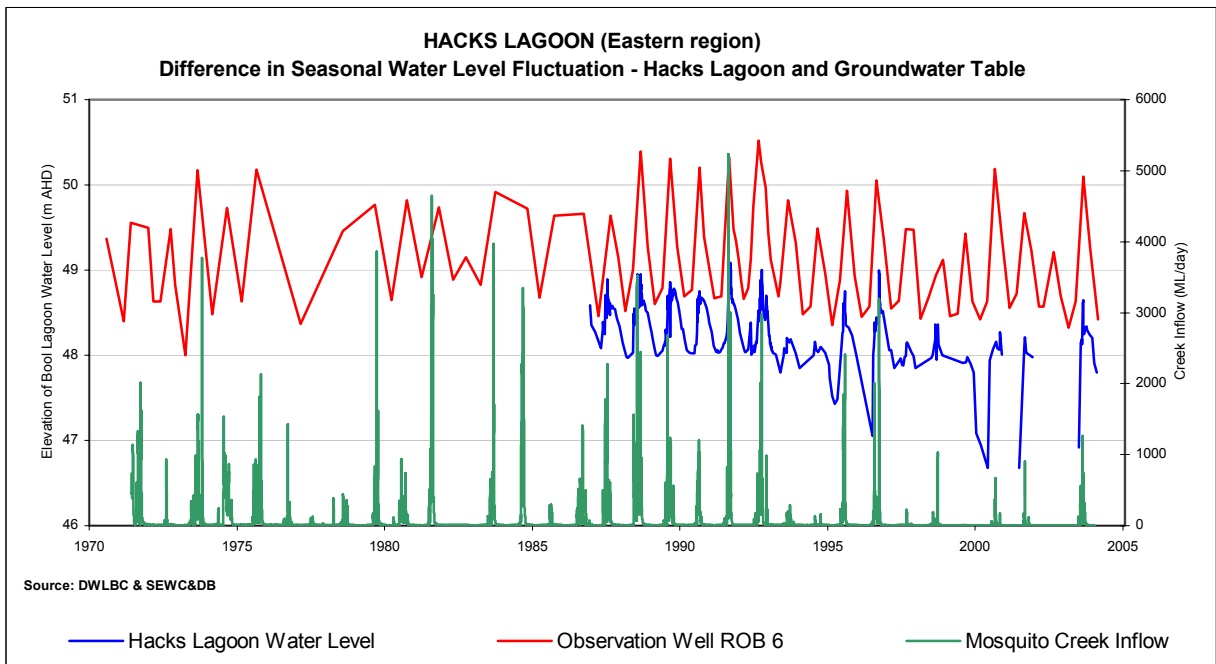
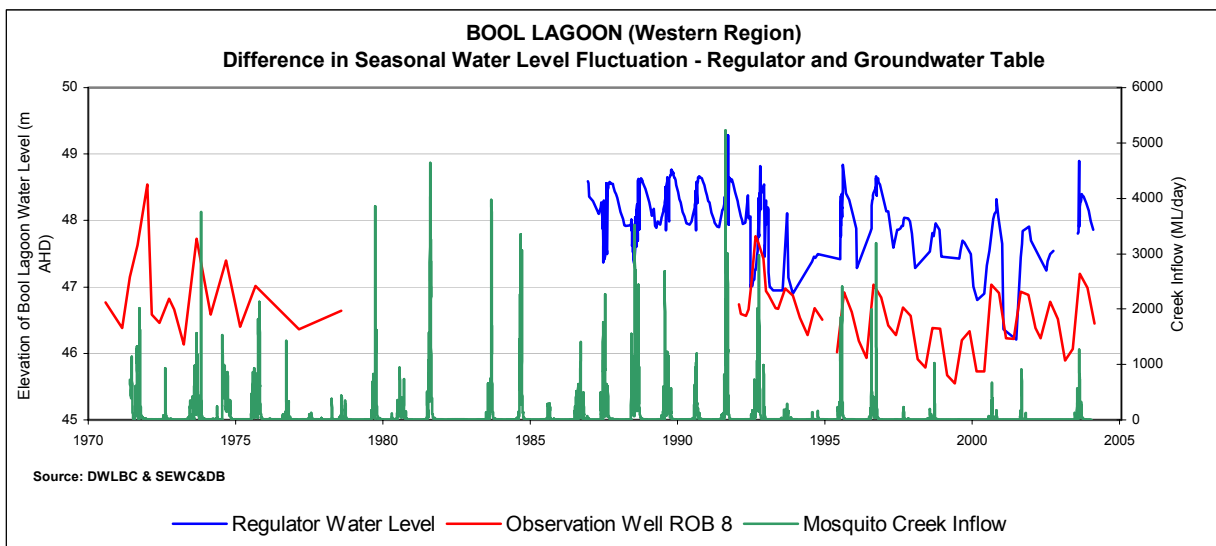


Figure 8: Difference in Seasonal Water Level Fluctuations – Bool Lagoon



Both hydrographs indicate a slight decline in groundwater level over the preceding 11 years. This is attributed to below average or unseasonal rainfall over that period. The lagoons were continuously wet for the period of 1985 to 1993 when surface water inflows were highest. In the drier years that followed, water was lost from the saturated zone and required recharging with a portion of subsequent inflows.

Regional groundwater and surface water levels are dependent on rainfall; however, Bool and Hacks Lagoons water level is also dependent on surface water inflows from the catchment area and is subject to high evaporation rates, outflows (loss to water table via seepage) and the controlled release through the regulator.

The volume, timing, duration and frequency of surface and groundwater flows are significant determinants of the ecological character of Bool and Hacks Lagoons. Primarily, it is the hydrological regime of the lagoons that has determined - and continues to shape - the wetland floristic composition, and the diversity of habitats.

High seasonal and inter-annual rainfall variability is a characteristic of Mediterranean climates. Consequently, the present flora and fauna of the site are adapted to frequent fluctuations in hydrological conditions. It has been demonstrated, however, that changes in water regime will result in major changes in floristic composition if the changes are outside of the tolerance limits of the existing flora (Brownlow 1997; Biggs 2001; Denton and Ganf 1994; Rea and Ganf 1994).

3.1.3 Water Quality

No long term, comprehensive data are available regarding water quality at Bool and Hacks Lagoons.

Data sourced from a multiplicity of references and studies provide an indication of the salinity fluctuations expected. Data from Spring and Summer 1980-81 suggest that salinity levels in the wetlands peak at the end of summer due to reduced freshwater inflows and the ponding of water across the basins leading to increased evaporation.

1980 - 1981

Location	TDS (mg/L) 7 October 1980	TDS (mg/L) 25 February 1981
Hacks Lagoon	400	2,020
Bool Lagoon - Big Hill	830	1,470
Bool Lagoon - outlet	920	2,340
Source: <i>Dept Environment & Planning 1985</i>		

1997

Location	Soil Conductivity uS/cm
Hacks Lagoon	1,580
Bool Lagoon - Big Hill	1,610
Bool Lagoon - outlet	1,496
Source: <i>Brownlow 1997</i>	

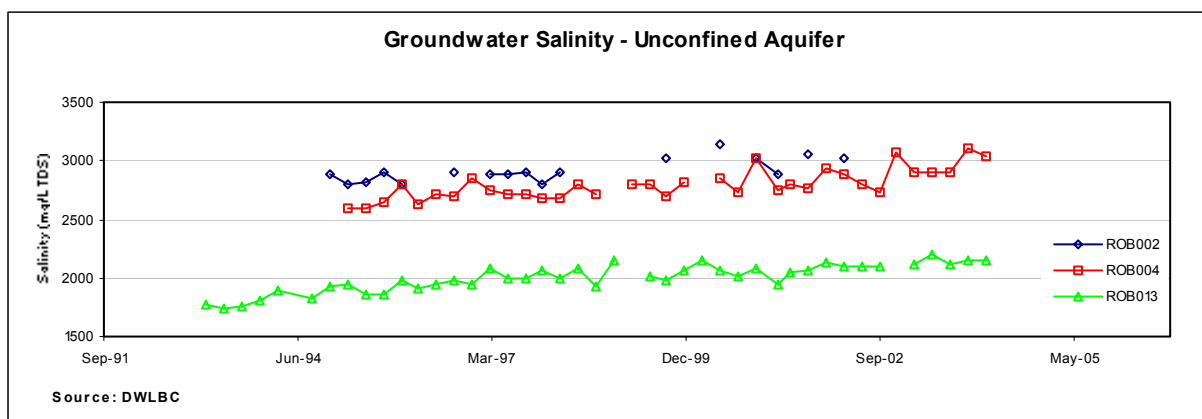
JUNE 1995

Location	pH	Soil Conductivity uS/cm	TDS mg/L
Hacks Lagoon - Mosquito Creek inlet	7.8	1,330	730
Bool Lagoon - outlet	8.7	24,500	15,000
Source: <i>South Australian Water Corporation, Australian Water Quality Centre Chemical Analysis Report. June 1995.</i>			

The June 1995 data demonstrates the variations recorded in water quality between Hacks Lagoons and Bool Lagoon. The contrast between the recordings can likely be explained by the relative location of each reading, and interactions between freshwater inflows and evaporation in different parts of the wetland. Given the time of the data collection at the commencement of winter, Hacks Lagoons may have been subject to freshwater inflow via Mosquito Creek. This is reflected by salinity readings showing fresh-marginal levels on the eastern side of Hacks Lagoons at the inlet of Mosquito Creek. However, the recordings from the Bool Lagoon outlet show much higher salinity levels. This is likely caused by evaporation of surface water causing a concentration of salts, and the delay in freshwater inflows reaching that part of the lagoon in early winter.

The salinity of groundwater shows a significant increase since 1992 (Figure 9). Observation bore ROB 13 displays salinity readings of marginal quality. Observation bores ROB 2 and ROB 4 show higher readings, of brackish quality.

Figure 9: Groundwater Salinity



Examples of impacts to the physico-chemical status of the wetland include substantial changes to salinity, pollutants, nutrients, or water temperature. However, the present data provide no support for the identification of measurable change in water quality and represents a priority for future monitoring.

3.1.4 Native Vegetation

Wetland Vegetation

Bool and Hacks Lagoons is recognised as being one of the most floristically diverse wetlands in the region. Nine of the 11 defined vegetation associations found in South East wetlands sampled by Brownlow (1997) are present at the site (Appendix A). Of the sampled wetlands, Bool and Hacks Lagoons have the highest level of diversity in the region (Brownlow 1997, p. 221-224). Figure 10 (Seaman 2004) shows the distribution of the vegetation associations within Bool and Hacks Lagoons.

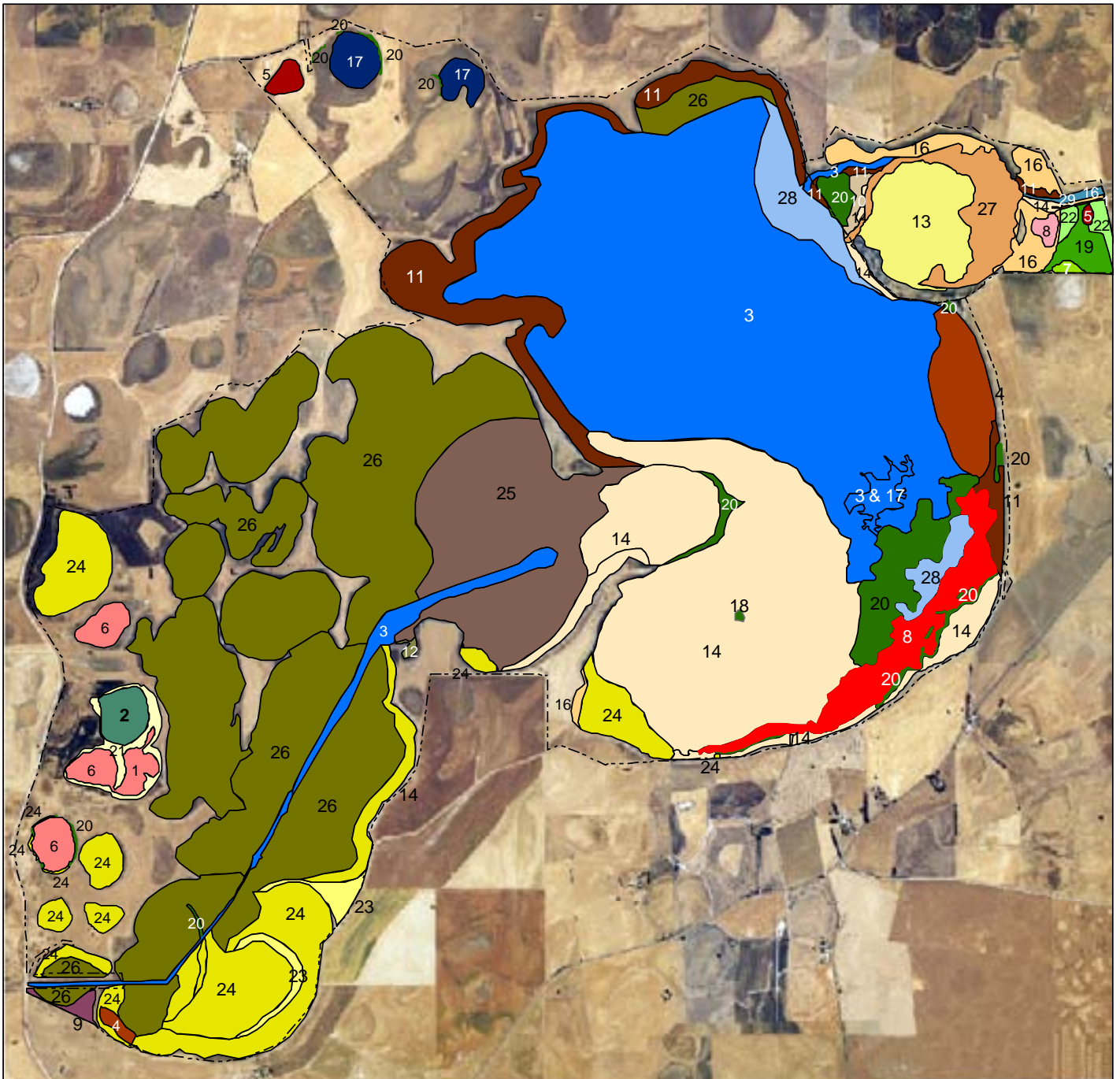
The stand of Swamp Paperbark (*Melaleuca halmaturorum*) in the main Bool Lagoon basin comprises important breeding habitat for a number of waterbird species and provides some protection from predation from cats and foxes when inundated. This stand pre-dates drainage development, and is indicative of pre-drainage conditions in the lagoons. Since the introduction of flood control structures, there has been a trend for Swamp Paperbark recruitment away from the main stand, and recruitment favouring the margins of the lagoons. Swamp Paperbark is susceptible to grazing, fire, and wind damage. The relative location and health of the two distribution patterns of Swamp Paperbark has been the subject of research at Bool and Hacks Lagoons (for example, Biggs 2001; Denton and Ganf 1994; Rea 1992).

Biggs (2001, p. 67) concluded that between 1958 and 1999 there has been a 40 percent canopy cover reduction in the main stand of Swamp Paperbark. However, the results of this research do not indicate a clear cause for this. A change in the frequency and/or duration of inundation sustained post-regulation is thought to be responsible for the recruitment of juvenile Swamp Paperbark along the fringes of the basin, and the lack of recruitment in the location of the main stand. Biggs (2001, p. 71) concludes that the regeneration niche for this species had shifted up the elevation gradient. This is supported by the findings of Denton and Ganf (1994), concluding that while mature individuals are able to withstand prolonged flooding, juveniles are ill adapted to long-lasting inundation. The ecological importance of this habitat type (tall shrubland surrounded by areas of open water), and its potential loss with extended inundation, has clear implications for water management objectives.

There has been a documented shift in the relative abundance of *Baumea spp* and *Triglochin procerum*. Alterations in the hydrological regime associated with drainage development of the late 1960s has been implicated in the large-scale shift in species dominance where sedgeland communities have retreated and semi-emergent species have increased in their range (Brownlow 1997, p. 4; Rea 1993; Rea & Ganf 1994). A shift in the abundance of the *Baumea* sedgeland could have a negative impact on the Australasian Bittern (*Botaurus poiciloptilus*), which is listed as globally vulnerable (see 3.1.6 Native Animals).

Dryland Vegetation

There are small areas of native grassland (*Distichlis distichophylla*; *Sporobolus virginicus*) of high conservation value. *Poa labillardieri* is associated with *Gahnia filum* in an open area of tussock grassland of about four hectares in the south-western corner of the main Bool Lagoon basin. The remaining dryland areas of the site are dominated by grasses, pasture plants and introduced species.



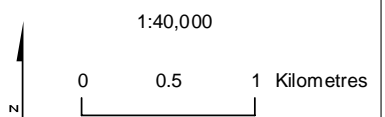
Legend

- | | |
|--|--|
| 1 <i>Wilsonia rotundifolia</i> , +/- <i>Gahnia filum</i> | 15 <i>Phalaris aquatica</i> , <i>Gahnia filum</i> |
| 2 <i>Wilsonia rotundifolia</i> | 16 <i>Phalaris aquatica</i> |
| 3 <i>Triglochin procerum</i> | 17 Open water |
| 4 <i>Selliera radicans</i> , <i>Sarcocornia quinueflora</i> | 18 <i>Melaleuca halmaturorum</i> , <i>Phragmites australis</i> |
| 5 <i>Selliera radicans</i> | 19 <i>Melaleuca halmaturorum</i> , <i>Gahnia filum</i> |
| 6 <i>Sarcocornia quinueflora</i> , <i>Wilsonia rotundifolia</i> | 20 <i>Melaleuca halmaturorum</i> |
| 7 <i>Melaleuca halmaturorum</i> , <i>Sarcocornia quinueflora</i> | 21 <i>Gahnia filum</i> , <i>Sarcocornia quinueflora</i> |
| 8 <i>Sarcocornia quinueflora</i> | 22 <i>Acacia Melanoxydon</i> , <i>Phalaris aquatica</i> |
| 9 <i>Acacia pycnantha</i> | 23 <i>Gahnia filum</i> , <i>Phalaris aquatica</i> |
| 10 <i>Phragmites australis</i> , <i>Selliera radicans</i> | 24 <i>Gahnia filum</i> |
| 11 <i>Phragmites australis</i> , <i>Phalaris aquatica</i> | 25 <i>Baumea arthropylla</i> , <i>Triglochin procerum</i> |
| 12 <i>Phragmites australis</i> , <i>Baumea arthropylla</i> | 26 <i>Baumea arthropylla</i> , +/- <i>Baumea juncea</i> |
| 13 <i>Phragmites australis</i> , <i>Atriplex prostrata</i> | 27 <i>Atriplex prostrata</i> , <i>Wilsonia rotundifolia</i> |
| 14 <i>Phragmites australis</i> , +/- <i>Typha domingensis</i> | 28 <i>Atriplex prostrata</i> , <i>Triglochin procerum</i> |
| | 29 <i>Atriplex prostrata</i> |

Figure 10

Bool Lagoon Game Reserve and
Hacks Lagoon Conservation Park

Vegetation Associations



Produced by: Regional Services, South East
Department for Environment and Heritage
Data source: DEH
Projection/Datum: MGA, GDA 94
Compiled: March 2005, ESRI ArcGIS

3.1.5 Habitats

The diversity of habitats present at Bool and Hacks Lagoons is principally a product of interactions between water regime and vegetation distribution.

Biggs (2001) identified eight dominant land-cover types present within the reserves through analysis of aerial photography. Jaensch (1982) identified eight waterbird habitat types in his analysis of waterbird usage of Bool and Hacks Lagoons. The two studies, in addition to the 2004 vegetation mapping (Seaman 2004), have been used as the basis for classifying habitat types at Bool and Hacks Lagoons.

The following habitat types are present at Bool and Hacks Lagoons (after Biggs 2001; Jaensch 1982; and Seaman 2004).

Habitat	Dominant species/genera	Characteristics
1. Aquatic / floating-leaved vegetation	<i>Triglochin procerum</i> , <i>Myriophyllum</i> , <i>Potamogeton</i>	<i>Triglochin</i> most common, emergent with green, spongy, floating or semi-erect leaves. Dominant in main basin and extensive in central basin. Found in deeper water in flowpath linking Hacks Lagoon and Bool Lagoon, and through Bool Lagoon. Subject to frequent and/or prolonged inundation.
2. Tea Tree Tall Shrubland	<i>Melaleuca halmaturorum</i>	Stand in the main basin approximately 8.5ha (Biggs 2001). Also found fringing eastern side of main basin, and Hacks Lagoon.
3. Tussock	<i>Gahnia trifida</i> , <i>G. filum</i>	Tall individuals growing as dense clumps up to 2m. Both generally occur in dense stands. Dominant in western basin and many peripheral western lagoons.
4. Sedge	<i>Baumea arthropphylla</i> , <i>B. juncea</i> , <i>B. articulata</i> , <i>Leptocarpus brownii</i> , <i>Eleocharis gracilis</i> .	1m in height, dense stands. Dominant in the Western Basin and peripheral western lagoons. Subject to inundation.
5. Bare Ground/Mud-mat	<i>Selliera radicans</i> , <i>Sarcocornia spp.</i>	Ground-hugging annual species, often intermingled with areas of unvegetated soil. Located around Little Bool, eastern and northern margin on main basin and western peripheral lagoons. Bare margins (often with receding water) valuable waterbird habitat.
6. Reed	<i>Phragmites australis</i> , <i>Typha domingensis</i>	Range of growth habits: scattered individuals <1m; dense stands 1.2-2m; impenetrable stands >2.2m. Located on fringes of lagoons, for example, southern lobe of Bool Lagoon main basin, Hacks Lagoon and Hacks Island.
7. Open Water		Little Bool, House and Round Swamps, Hacks Lagoons, Bool Lagoon main basin. Areas of open water critical waterbird habitat.
8. Native and Exotic Grassland	<i>Distichlis distichophylla</i> , <i>Sporobolus virginicus</i> ; <i>Phalaris aquatica</i> , <i>P. paradoxa</i>	Both dry and subject to inundation. Found on dry and marginal areas of the reserves, north and east boundary of Hacks Lagoon.

The diversity of fauna species present at Bool and Hacks Lagoons is a direct reflection of habitat diversity. Therefore, the maintenance of these habitats is a critical management consideration.

3.1.6 Native Fauna

Birds

Bool and Hacks Lagoons are noted for their diversity of waterbird species. There are 79 waterbird species recorded at the site, with numbers peaking in spring and again in early autumn. This pattern illustrates the importance of the complex as a breeding site and dry season refuge respectively (Harper 1990). Of particular significance is the use of the area by colonial breeding species. The site provides habitat for threatened species at a global, national, state and regional scale (see Appendix D - Ramsar Information Sheet). Jaensch (1982) concludes that the two most important habitats for waterbirds are bare ground/mud mat of the lagoon margins (both dry and subject to inundation), and the tall shrublands.

Bool and Hacks Lagoons are recognised as the most important wetland in Australia for the Australasian Bittern (*Botaurus poiciloptilus*), listed as globally vulnerable. The species is included on the IUCN Red List. It is estimated that 85 percent of the global population occur in Australia, confined to south-western Western Australia and south-east Australia. There are few known contemporary breeding localities for the Australasian Bittern throughout its range but Bool Lagoon is a confirmed breeding site for the species. Pairs occupy territories containing a mixture of tall and short sedges and rushes for breeding, though will feed in more open swamp vegetation. A shift in the abundance of the *Baumea* sedgeland could have a negative impact on this species. The main threat to the species is the diversion of water, salinisation or drainage of permanent swamps. Overgrazing by stock, and inappropriate fire regimes can also reduce habitat suitability. Due to their specialised habitat requirements, they are more sensitive to habitat loss than many wetland species (Garnett & Crowley 2000).

The reserves are an important site for the poorly understood wader the Painted Snipe (*Rostratula benghalensis*), whose numbers are thought to be declining in Australia. The Painted Snipe is listed as rare in South Australia, nationally vulnerable, and is protected under the China-Australia Migratory Bird Agreement (CAMBA). The species favours wetland margins and mudflats for feeding. Up to 30 individuals have been recorded at Bool and Hacks Lagoons, which exceeds one percent of the Australian population of the species.

Whilst Brolgas are widespread throughout northern, central and north-eastern Australia, the southern Australian population is isolated, confined to south-eastern South Australia and south-western Victoria, and estimated to comprise approximately 750 individuals (R. Sheldon, pers. comm., 2004). Bool and Hacks Lagoons is one of the most important flocking sites for this population during summer/autumn (late December to April), due to the presence of water during summer months, high level of habitat diversity, proximity of cropped agricultural land, and low disturbance. Numbers of Brolga at the lagoons peak during January and February, and historical records range from one pair to 190 individuals (SW Victoria Brolga Flocking Site Database 2004). Bool and Hacks Lagoons often support up to one quarter of the southern Australian population for up to half of the year.

The lagoons are of high value as a drought refuge and summer habitat for the Freckled Duck (*Stictonetta naevosa*), which is listed as vulnerable in South Australia. The Pacific Black Duck (*Anas superciliosa*) and Grey Teal (*A. gibberifrons*) are the most common species in the lagoons; historic numbers of Pacific Black Duck have been estimated between 1,000 to 100,000, and numbers of Grey Teal between 30,000 to 50,000 (J. Bourne, pers. comm., 2004). Species regularly present include: Pink-eared Duck (*Malacorhynchus membranaceus*), Hardhead (*Aythya australis*), Chestnut Teal (*Anas castanea*), Musk Duck (*Biziura lobata*), Cape Barren Goose (*Cereopsis novaehollandiae*), Yellow-billed Spoonbill (*Platalea flavipes*), Royal Spoonbill (*P. regia*), Eurasian Coot (*Fulica atra*), and Purple Swampphen (*Porphyrio porphyrio*). Many of these common species (including Pacific Black Duck, Grey Teal, Eurasian Coot, Purple Swamp Hen, Hardhead) exploit most, if not all, available habitats (Jaensch 1982, p. 13).

The lagoons are significant for providing breeding habitat for 48 species of waterbirds, including important colonial breeding species. Habitat requirements for breeding are most closely involved with vegetation, but also water levels and in certain species, availability of islands/margins. The tall shrubland, reedbeds and tussock patches are of the greatest importance for waterbird breeding (Jaensch 1982, p. 14). Royal Spoonbill (*Platalea regia*), Australian White Ibis (*Threskiornis molucca*), and Straw-necked Ibis (*Threskiornis spinicollis*) regularly breed at the site in large numbers, utilising the tall shrubland Swamp Paperbark (*Melaleuca halmaturorum*) habitat. Glossy Ibis (*Plegadis falcinellus*), Great Egret (*Egretta alba*), Little Pied Cormorant (*Phalacrocorax melanoleucos*), Intermediate Egret, Little Black Cormorant (*Phalacrocorax sulcirostris*), Great Cormorant (*Phalacrocorax carbo*) and Nankeen Night Heron (*Nycticorax caledonicus*) less frequently breed at the site, utilising the same habitat. The reduction of canopy cover in the main stand of Swamp

Paperbark (see 3.1.4 Native Vegetation), and the trend for recruitment of this species around the margins of the lagoons potentially reduces its value as breeding habitat for key species as it is subject to greater exposure, predation and possible disturbance. Mature individuals of Swamp Paperbark are favoured as breeding habitat by some species.

There are 22 migratory species recorded at the complex (Appendix B), recognised in international conventions and agreements (JAMBA, CAMBA, Bonn Convention). Many wader species are highly specialised in terms of habitat requirements, utilising only the bare or lightly vegetated mudflats. In particular, Little Bool is important wader habitat during late summer to autumn when mudflats in Bool and Hacks have dried out. The dependence of several species of waterbird on only one habitat type presents clear implications for the maintenance of every existing habitat type.

Bool and Hacks Lagoons are an important site for the Magpie Goose (*Anseranas semipalmata*). Prior to 1900, the lagoons were one of the few locations in south-eastern Australia where Magpie Geese were recorded breeding. By 1911, the species was extinct from South Australia. Magpie Geese are very susceptible to the affects of hunting, both directly, and by lead poisoning from the ingestion of spent lead shot. The use of lead shot at Bool Lagoon for hunting was banned in 1987.

In 1968, a program commenced to re-introduce Magpie Geese to Bool Lagoon. By 1989, approximately 320 individuals were present. Today a self-sustaining population of approximately 3,000 individuals is present, comprising one of the most important breeding populations in southern Australia. The species utilises a range of available habitats.

There is a high concentration of raptor species, including Wedge-Tail Eagle (*Aquila audax*), Swamp Harrier (*Circus approximans*), and White-bellied Sea Eagle (*Haliaeetus leucogaster*), all of which utilise a range of available habitats.

Fish

Nine species of native fish are present in the Mosquito Creek – Bool Lagoon system, including the nationally vulnerable Yarra Pygmy Perch (*Nannoperca obscura*) and Dwarf Galaxias (*Galaxiella pusilla*) (Hammer 2002). Other native species include Murray Darling Carp Gudgeon (*Hypseleotris* sp), Flathead Gudgeon (*Phlypnodon grandiceps*), Southern Pygmy Perch (*Nannoperca australis*), Western Blue Spot Goby (*Pseudogobius olorum*), Smallmouthed Hardyhead (*Atherinosoma microstoma*), River Blackfish (*Gadopsis marmoratus*) and the Mountain Galaxias (*Galaxias olidus*). The Common Galaxias (*Galaxias maculatus*) and the Mud Galaxias (*Neochanna cleaveri*) are recorded historically. Three exotic species are also recorded; Goldfish (*Carassius auratus*), Redfin (*Perca fluviatilis*) and Gambusia (*Gambusia holbrooki*), which may compete with native fish species (Hammer 2002).

The Mosquito Creek-Bool Lagoon system is a stronghold for nationally listed (vulnerable) Yarra Pygmy Perch and Dwarf Galaxias. The system contains five of the nine localities where Yarra Pygmy Perch have been recorded in the South East Region and the only known location for the Mud Galaxias (*Neochanna cleaveri*) in South Australia. A single specimen of Mud Galaxias was captured in Bool Lagoon in 1974 and it is not known whether it was a stray occasional migrant or a landlocked resident population (Hammer 2002 & pers. comm., 4 Nov 2004).

Loss of refuge habitats and connectivity for recolonisation has likely caused a reduction in the historic range of the Dwarf Galaxias. The species is greatly impacted by the drainage of swamps and the reduction in area of permanent water (Hammer 2002, p. 30).

The wetland system is a highly productive seasonal wetland offering significant habitat and food resources for rapid recruitment and population expansion of wetland fish species. The quality and quantity of habitat is important for providing a source of fish to seed surrounding areas during large wet events (Hammer, pers. comm., 4 Nov 2004).

Aquatic Invertebrates

The aquatic invertebrate communities of Bool and Hacks Lagoons are poorly documented, the only data available obtained during a single survey in 1982 (National Parks and Wildlife Service 1985). The 1982 survey recorded 46 aquatic invertebrate species from the following taxonomic groups: Annelida, Arachnida, Cnidaria, Crustacea, Insecta and Mollusca. However, this survey was quite limited in spatial and temporal scale and it is likely that many species present were not recorded. Aquatic invertebrates play a key role in the ecological functioning of Bool and Hacks Lagoon. Many species of higher trophic levels, for example fish and waterbirds, depend directly or

indirectly upon invertebrates as a food source. Observations of the wetland when water is present often reveal an enormous abundance of pelagic invertebrates. A greater understanding of the relationship between water regime, habitat type and invertebrate diversity and abundance at Bool and Hacks Lagoons would enable better informed management decisions.

Mammals, Reptiles and Frogs

Bool and Hacks Lagoons is a critical site for the survival of the nationally vulnerable Striped Legless Lizard (*Delma impar*) in South Australia. One of only two known populations in South Australia occur within the reserves. In the South East Region of South Australia the species is at the western limit of its range, which extends through Victoria, southern New South Wales and ACT. Within the reserves, the lizard inhabits temperate native grasslands (both intact and degraded) and adjacent areas of grassy woodland and exotic pasture, including areas dominated by *Phalaris aquatica*. It is possible that dense, continuous structure is more important than the floristic composition of the ground layer. The lizard shelters in the base of grass tussocks, under rocks and in cracks in the soil.

Threats to the Striped Legless Lizard include:

- Habitat destruction and degradation (<1 percent of native grasslands remain in the Region)
- Intensive grazing
- Pasture improvement
- Cultivation/ploughing
- Loss of refuge sites
- Weed invasion
- Inappropriate fire regimes
- Urban development

The South Australian endangered Glossy Grass Skink (*Pseudemoia rawlinsoni*) and Eastern Three-lined Skink (*Bassiana duperreyi*) are also present. The Glossy Grass Skink occurs in dense sedges on the margins of lakes and swamps and has been found in only three locations in South Australia.

The Eastern Tiger Snake (*Notechis scutatus*), Lowland Copperhead (*Austrelaps superbus*), Blotched Bluetongue (*Tiliqua nigrolutea*), Eastern Bluetongue (*T. scincoides*), Sleepy Lizard (*T. rugosa*) and the Long-necked Tortoise (*Chelodina longicollis*) are all common at the site.

Based on the available data, Bool and Hacks Lagoons are the regional stronghold for the nationally vulnerable Southern Bell Frog (*Litoria raniformis*). The reserves support several hundred, and seasonally possibly several thousand individuals (J. & P. Bourne pers. comm., 2004). Habitat for the species comprises vegetation within or at the edge of permanent or near-permanent water; preferred sites typically have a large amount of emergent and fringing vegetation. The species is highly mobile, and is frequently detected at some distance from permanent water bodies. The species breeds in summer, increasing the importance of permanent bodies of water. Threats to the species include:

- Destruction, modification and degradation of wetland habitats;
- Disruption to natural hydrological regimes;
- Loss of shelter sites;
- Fragmentation of suitable habitat (i.e. loss of connectivity between waterbodies);
- Disease caused by fungal pathogens;
- Introduced fish (eg. Gambusia (*Gambusia holbrooki*)) which may predate the aquatic eggs and larvae; and
- The semi-permeable skin of frogs makes them particularly susceptible to herbicides, insecticides and other pollutants. These chemicals may also reduce prey populations for Bell frogs.

Also present are Brown Tree Frog (*Litoria ewingi*), Eastern Banjo Frog (*Limnodynastes dumerilli*), Common Froglet (*Crinia signifera*), Brown Striped Frog (*L. peroni*), Spotted Grass Frog (*L. tasmaniensis*), Painted Frog (*Neobatrachus pictus*), and Sudell's Frog (*N. sudelli*).

The Western Grey Kangaroo (*Macropus fuliginosus*) and state vulnerable Swamp Wallaby (*Wallabia bicolor*), are resident within the reserves and also use them as a corridor and temporary refuge. There are also records of the Lesser Long-eared Bat (*Nyctophilus geoffroyi*), Chocolate Wattled Bat (*Chalinolobus morio*), Swamp Rat (*Rattus lutriolus*) and Water-rat (*Hydromys chrysogaster*).

3.2 Monitoring of Ecological Character

The implementation of an integrated monitoring program is a critical aspect to the identification of potential adverse change to the ecological character of Bool and Hacks Lagoons, and active adaptive management practices. It is not the intention of this plan of management to detail a specific monitoring program. Monitoring will be addressed through the development of an integrated monitoring program. However, there are three supporting aspects of the management plan to guide and focus the monitoring of adverse changes to the ecological character of the site:

1. Known ecological character data (see section 3 Ecological Character) and identified knowledge gaps;
2. Identified potential threats to ecological character (see section 4 Management Objectives and Strategies); and
3. The adaptive management framework for Bool and Hacks Lagoons (see section 2.6 Adaptive Management), and Principles and Objectives for Monitoring (see below).

Principles for Monitoring

As a result of consultation with the Technical Reference Group, formed to provide scientific input during the drafting of this management plan, principles guiding monitoring have been developed. These principles serve to underpin the design and implementation of a monitoring program for Bool and Hacks Lagoons.

- The design of a monitoring program should recognise that seasonal and cyclical climatic conditions have resulted in fluctuations to the wetland, as demonstrated since the time of Ramsar Listing in 1985. Adverse change to the ecological character is recognised as change outside of these known parameters.
- Each monitoring activity should support the adaptive management framework for Bool and Hacks Lagoons.
- Monitoring for the site should give consideration to the EPBC Act Administrative Guidelines on Significance, July 2000 (see 2.3 Environment Protection and Biodiversity Conservation Act 1999).
- In recognising the multiple sources of applicable monitoring information, the monitoring program should integrate data sourced from other agencies, research institutions and community specialist groups.
- Known data should be utilised in the first instance. Existing monitoring activities and data (for example, water inflow and pondage levels; vegetation mapping) should be integrated into the monitoring program.
- The monitoring program should represent best value and be achievable within budget limitations.
- The monitoring program should reflect good science. Activities should be simple, repeatable and well documented.
- The contribution of community/volunteer specialist groups should be integrated into the monitoring program.
- The monitoring program should provide for ongoing consultation with specialist stakeholders.

Objectives of a Monitoring Program for Bool and Hacks Lagoons

1. Address identified knowledge gaps in the ecological character description, identifying and refining existing parameters of acceptable change.
2. Identify potential change in the ecological character of Bool and Hacks Lagoons beyond acceptable parameters.
3. Monitor the impact of key threats identified in the management plan.
4. Provide data to support the adaptation of management practices in response to an identified adverse change to ecological character.
5. Ensure all management activities are consistent with the maintenance of the ecological character.
6. Integrate activities of partner agencies, research institutions, and volunteer community specialist groups into monitoring program.
7. Give consideration to data collected from relevant water quality monitoring programs and where applicable, employ the principles of the ANZECC *Guidelines for Fresh & Marine Waters* and *Guidelines for Monitoring and Reporting* to achieve consistency.

Existing Monitoring/Data

Examples of existing monitoring and available data includes:

- SEWC&DB: Water levels within the lagoons: Inflows via Mosquito Creek;
- Department of Water, Land and Biodiversity Conservation: Groundwater monitoring;
- DEH and specialist groups: Threatened species specific monitoring (Striped Legless Lizard, Southern Bell Frog);
- University of Adelaide: Aquatic vegetation;
- DEH and specialist groups: Pre-season waterbird monitoring (key species presence and abundance);
- DEH Vegetation mapping 2004;
- Environmental Protection Authority: Water monitoring program; and
- Australian River Assessment Scheme (AusRivAS): National River Health Program.

4 MANAGEMENT OBJECTIVES AND STRATEGIES

This section presents the management objectives and strategies for Bool and Hacks Lagoons. Each management objective aims to achieve at least one of the strategic objectives outlined in section 1.3 Vision. Each management strategy prescribed below serves at least one of the preceding management objectives for each section.

The description of ecological character (section 3) is intended to inform the following management objectives and strategies (section 4). In particular, this section aims to identify threats to ecological character and provide management strategies to address them.

4.1 Hydrology

At present, the active management of the water levels in Bool and Hacks Lagoons occurs primarily in response to water levels reaching or exceeding the agreed water levels. The present agreed levels, originally developed through extensive community consultation, aim to achieve both conservation and flood mitigation objectives. The primary conservation objective is to retain water in the lagoons for as long as possible into the summer period to maintain vegetation communities and provide breeding habitat and refuge for waterbirds, particularly when other parts of south-eastern Australia dry out. Bool Lagoon is also an integral part of the SEWC&DB's flood mitigation plan for Mosquito Creek. Inflow rates into the lagoon from Mosquito Creek during wet winters can be substantially higher than the capacity of Drain M downstream of the lagoon and when this occurs the overflow rates from the lagoon have to be regulated to safe rates with the excess water temporarily stored in the lagoon. The volume of water released at the regulator is directly related to the volume of flow discharged into Drain M from the Bakers Range Drain at Callendale and to a lesser degree by the discharge from Drain C and the Killanoola drainage system. The SEWC&DB must ensure that the capacity of Drain M downstream of Callendale is not breached from the sum of inflow of these drainage systems. The agreed levels and operating procedures are considered suitable by the SEWC&DB for flood mitigation purposes.

The SEWC&DB manage the lagoons in accordance with the *Guidelines for the Operation of Bool Lagoon and Drain M Regulators for Flood Mitigation Purposes* (South East Drainage Board 1984), and the existing DEH management plan for the site. Although this informal cooperation has worked effectively to date, the importance of water management necessitates the articulation of direct responsibility, and a mechanism for ongoing cooperation. Additionally, there is a need to reach formal agreement that transcends current and potential changes in natural resource management in the Region, and possible agency restructure and staff changes.

Landholders surrounding Bool and Hacks Lagoons are key stakeholders in the site's management, particularly in regard to the lagoon's role as a flood mitigation basin. Whilst the SEWC&DB consults with landholders on flood mitigation matters, it is important to maintain communication links between DEH, the South East Consultative Committee, the South Eastern Water Conservation and Drainage Board and landholders.

A formal agreement between DEH and the SEWC&DB could address the common management requirements of the two organisations, including:

- Agreed water levels;
- Variations to water level targets where special circumstances exist, for example, to assist in the management of water during particularly wet years or to achieve periodic drying out of the lagoon;
- Maintenance of the flowpath;
- Monitoring and reporting responsibilities;
- Legislative mandates for management through the *South Eastern Water Conservation and Drainage Act 1992*, *National Parks and Wildlife Act 1972*, and *Environment Protection and Biodiversity Conservation Act 1999*;
- Maintenance responsibilities; and
- Communication strategy.

The build up of aquatic vegetation may prevent the rapid movement of Mosquito Creek inflow from Hacks Lagoon to the larger Bool Lagoon main basin through the channels connecting the two lagoons. There is a periodic need for the maintenance of the flowpath within the wetland, in particular in the three channels between Hacks Lagoon and Bool Lagoon. During times of significant inflows through Mosquito Creek into Hacks Lagoon, the water level in Hacks Lagoon can be up to one metre higher than the level in Bool Lagoon due to the delay of moving water between the lagoons. While flowpath maintenance options include chemical, mechanical or controlled use of fire, the preferred method will be mechanical.

Since 1985, climatic variations (and regulator operation) have resulted in an extended wet period in the lagoons between 1987-1992, and a prolonged period of dry conditions in the wetland between 1998-2002. It is recognised that the two periods resulted in changes to the wetland (most notably on floristic characteristics). Hence, the hydrological conditions sustained during the two periods should reflect the parameters of acceptable change/fluctuations. However, there are limited opportunities to mitigate against extended dry periods caused by climatic conditions.

Since 1985, key characteristics of the hydrological regime of Bool and Hacks Lagoons necessary to maintain habitat diversity are:

- The semi-permanency of water in Hacks Lagoon. The influence of groundwater in retaining water during summer and autumn months in Hacks Lagoon is a key consideration;
- The contribution of groundwater, especially in periods of low surface water inflow;
- The seasonal nature of Bool Lagoon's hydrology, subject to freshwater inflows and surface water contribution during the winter and spring months;
- The ability to manipulate water levels to provide for the retention of water in Bool Lagoon during summer and autumn months to maintain/increase value as a drought refuge in southern Australia; and
- The ability to allow for periods of drying to benefit the health and recruitment of *Melaleuca halmaturorum*. Research has indicated that extended periods of inundation greater than 4 years can threaten *M. halmaturorum* (G. Ganf, pers. comm., 2004).

Some of the hydrological characteristics necessary to maintain habitat diversity appear to be conflicting. However, a degree of inter-annual variability is expected. Hence, it is not possible to achieve all the above conditions annually. However, it is practicable to plan to achieve the above requirements over a number of years. Many of these conditions will be achieved opportunistically, with regard to flood mitigation requirements, and inter-annual rainfall variations.

Threats to Ecological Character

The most significant hydrological threat to the ecological character is the change in the hydrological regime of the wetland, including changes to the timing, duration, frequency, and volume of surface water and groundwater flows to and within the wetland.

Changes to surface water characteristics may be brought about by changes to the Mosquito Creek catchment. The majority of the catchment is in the State of Victoria, severely limiting the jurisdiction of this management plan and the South Australian Government to ensure its protection. Under the *Environment Protection and Biodiversity Conservation Act 1999*, the Australian Government has legislative power over any action that has, will have, or is likely to have a significant impact on the ecological character of a Ramsar Wetland. However, this is dependent on such actions being referred to the Australian Government for approval.

Changes to the Mosquito Creek catchment may include, but are not limited to: extraction or diversion of surface water; ponding or dam construction; drainage development; installation of drainage bores; and cumulative landuse changes, such as forestry and viticulture development that may affect run-off characteristics.

In South Australia, the *South East Catchment Water Management Plan* (SECWMB 2003, pp. 119-120) provides for the following management objectives in the Mosquito Surface Water Policy Area:

- To protect the access of downstream water users to surface water resources;
- To protect against adverse impacts on environmental flows resulting from dam construction;
- To protect against groundwater mounding as a result of water storage in dams;
- To protect environmental flows and ecological processes within the surface water policy areas from adverse impacts of water storage;
- To preserve the geomorphic features of a watercourse and the floodplain of a watercourse; and
- To protect surface water environmental flows from adverse impacts from discharge to drainage wells.

Importantly, the Plan provides for the protection of environmental surface water flows for water-dependent ecosystems, by regulating a number of surface water affecting activities under the *Natural Resources Management Act 2004* (formerly covered by the *Water Resources Act 1997*). The South East Natural Resources Management Board (now incorporating the SECWMB) is responsible for the development of policy to ensure allocated groundwater use does not adversely impact on water dependant ecosystems.

The *South Eastern Water Conservation and Drainage Act 1992* also governs the management of surface water in the South East of South Australia. The South Eastern Water Conservation and Drainage Board have a long history of managing drainage and flooding to support agricultural development within the Region.

The objects of the Act are:

- The prevention or minimisation of damage to agricultural production and the natural environment caused by flooding within the South East.
- The improvement of the soil quality and the productiveness generally of rural lands in the South East.
- The enhancement or development of natural wetlands and the natural environment generally in the South East.

Under the Act, surface water is defined as water that collects on or flows onto or from the surface of land, and includes the water in any water management works, lake or watercourse. *Water management works* is defined as any drain, artificial drainage hole, dam, bank or other device or works constructed or used for the purposes of conserving, draining or altering the flow of surface water from or onto land or utilising any such water, including any ancillary access road, bridge or culvert or other ancillary works. The *South Eastern Water Conservation and Drainage Board Management Plan 2003-2006* provides for the licensing requirements of all private water management works within the Board's area, including the stipulation of *Wetland Management Principles* to address any environmental impact of drainage activities on wetlands. Water Taking Licences are available to divert water from Mosquito Creek, subject to approvals required under the *South Eastern Water Conservation and Drainage Act 1992*. There are no current licences.

Potentially, within South Australia, both the *South East Catchment Water Management Plan 2003-2008* under the *Natural Resources Management Act 2004*, and the *South Eastern Water Conservation and Drainage Board Plan 2003-2006* under the *South Eastern Water Conservation and Drainage Act 1992* work to minimise the risk of off-site surface water-affecting actions which may lead to an adverse change in the ecological character of Bool and Hacks Lagoons.

Any change in regional and local groundwater characteristics (for example, large-scale extraction; change in recharge characteristics) potentially can impact on the ecological character of the reserves. Important elements of the vegetation within the lagoons may be groundwater dependent, in particular during dry periods. Bool and Hacks Lagoons are located within the Lower Limestone Coast (previously Comaum-Caroline, Lacepede Kongorong and Naracoorte Ranges) Prescribed Wells Area. The *Naracoorte Ranges Water Allocation Plan* (SECWMB 2001), responsible for determining the allocation of the underground water resource of the area, recognises Hacks Lagoon as a semi-permanent wetland, and a groundwater dependent ecosystem. The Plan has determined a 10 percent of Permissible Annual Volume for environmental purposes.

Other hydrological threats to the ecological character include:

- The limited capacity of Drain M downstream of Bool Lagoon, compared to the capacity of Mosquito Creek, resulting in the impoundment of floodwater within the lagoons for short periods of time. Capacity limitations may be addressed with development of ecological surface water flow diversions through the Bakers Range Watercourse at Callendale and Mosquito Creek / Drain E at Hacks Lagoon.
- The unknown impacts of climate change on the hydrology of the wetland. Potentially, if the characteristics of the supply of surface or groundwater were to alter, there may be an adverse affect on the ecological character of the wetland.
- The increase in groundwater salinity evident from monitoring in the immediate area could pose a serious threat to the ecological character of the wetland.

Victorian controls

Licences for the diversion of surface water and groundwater in Victoria are issued through Victoria's *Water Act 1989*. Rural Water Authorities (RWA) are delegated the power to issue diversion licences by the Minister administering the Water Act. All diversions for irrigation and commercial use need a licence, but the need to licence domestic and stock use depends on the circumstances. In some instances the *Water Act* may not require a licence to be issued for new dams, however the *Planning and Environment Act 1987* may require a planning permit to be issued for the works if they alter drainage patterns.

When determining whether to issue a licence to take and use water, Section 40 of the *Water Act* requires RWAs to consider whether a proposal could result in adverse effects on existing users, including the environment. This essentially requires RWAs to consider the same issues outlined in the dot-points listed above in regard to South Australia's South East Catchment Water Management Plan.

Where necessary RWAs refer applications for new surface water diversions to referral agencies such as Catchment Management Authorities and the Department of Sustainability and Environment. These agencies provide comment in relation to the various Acts, Plans and other guidelines those agencies administer, for example, Regional Salinity Management Plans and the *Flora and Fauna Guarantee Act 1988* (Victoria).

The policy White Paper, *Securing Our Water Future Together*, released by the Victorian Government in June 2004 states the policy regarding the allocation of surface water across Victoria. The Millicent Coast Basin, which stretches east over the South Australian border into western Victoria, places a moratorium on the issuing of new surface water licences in the basin until a new diversion cap is in place. The capping mechanism will have a significant influence on the management of the Victorian portion of the Bool Lagoon catchment. Relevant South Australian organisations will be consulted during the development of the capping mechanism for the Millicent Coast Basin.

No new take and use licences are issued in Victoria that allow water to be taken during the summer months. Recognising that there is still water available for allocation for use in the winter months, many of Victoria's surface water sub-catchments have been assigned environmentally sustainable upper limits on winterfill diversions, which are based on the flows required to maintain healthy environmental systems. These sustainable upper limits on winterfill diversions have not been determined in the Millicent Coast Basin due to the lack of stream flow data.

Water use in the Murray Darling Basin was officially capped in 1997, meaning no additional water may be harvested from the basin. The Victorian portion of the Murray Darling Basin contains all areas north of the Great Dividing Range, and does not include the Millicent Coast Basin. In order for new diversions to be established within the Murray Darling Basin the diverter must secure entitlement to water from an existing licensee. Such transfers of entitlement may be temporary or permanent.

Objectives

Ensure regional water management objectives are consistent with the maintenance of the ecological character and habitat diversity.

Maintain habitat diversity through the management of water and addressing hydrological threats to the ecological character.

Secure cross-border agreements and protocols to ensure adequate supply of water to maintain ecological character.

Strategies

- Develop and implement a Memorandum of Understanding between DEH and SEWC&DB relating to water management.
- Subject to variations specified within the Memorandum of Understanding between DEH and SEWC&DB, manage water in accordance with the target levels of:
 - 48.15m AHD (Australian Height Datum) during June;
 - 48.24m AHD during July;
 - 48.30m AHD at the end of the first week in August;
 - 48.40m AHD during the third week of August;
 - 48.55m AHD at the end of August; and
 - 48.61m AHD for as long as possible from the second week in September.
- Maintain the health of *Melaleuca halmaturorum* through management of water levels to prevent where practicable greater than four years continuous inundation.
- Maximise ecological value of the peripheral lagoons through the development of a water management strategy.
- Coordinate surface and groundwater level and water flow monitoring in partnership with other relevant agencies, through the formation and implementation of an integrated monitoring program (see section 3.2 Monitoring of Ecological Character).
- Maintain flowpaths between and within the lagoons through the development and implementation of a flowpath management strategy in cooperation with SEWC&DB.
- Work with the SENRMB, other relevant agencies and programs to ensure surface water diversion schemes, groundwater use, and changes to landuse in the region do not adversely impact on ecological character.
- Support the development of formal cross-border arrangements between the Victorian and South Australian Governments to develop agreed strategies for the management of the water and ecosystems of Mosquito Creek.

4.2 Water Quality

The nature of Bool and Hacks Lagoons means that they are susceptible to off-site impacts affecting water quality. Consequently, there is a need for a cooperative approach to minimising the potential threat to the ecological character of the site posed by a change in water quality.

The Guidelines for Fresh & Marine Waters and Guidelines for Monitoring and Reporting (ANZECC 2000) provide a useful framework for the management and monitoring of physico-chemical properties of Bool and Hacks Lagoons. The main objective of the Guidelines is to provide an authoritative guide for setting water quality objectives required to sustain current, or likely future, environmental values [uses] for natural and semi-natural water resources in Australia and New Zealand. *The Guidelines provide a framework for water quality management that is based on policies and principles that apply nationwide.* The Water Quality Guidelines provide guidelines for biological and physico-chemical indicators of water and sediment quality that will protect the ecological health of aquatic ecosystems.

Threats to Ecological Character

Under the Administrative Guidelines on Significance under the EPBC Act, any action that has, will have, or is likely to have a substantial and measurable change in the physico-chemical status of the wetland is considered a significant impact to the ecological character. Examples of impacts include substantial changes to salinity, pollutants, nutrients, or water temperature.

Substantial changes to water quality at Bool and Hacks Lagoons could be caused by off-site impacts to ground and surface water, including:

- Increase in salinity of regional groundwater;
- Loss of riparian habitat and stability of Mosquito Creek leading to increased sedimentation of surface water inflows; and
- Diffuse and point source pollution to ground and/or surface water.

Potential on-site threats to water quality include an increase in salinity levels of water in the lagoons, nutrient enrichment from surrounding landuse, and the use of chemicals to clear the flowpath from vegetation.

Available data at Bool and Hacks Lagoons provide no support for the identification of substantial and measurable changes in water quality, with the exception of salinity where there is evidence to suggest a significant increase since 1992 (see 3.1.3 Water Quality). Therefore, the accretion of physico-chemical data on the wetlands is a priority for future monitoring at the site. The Environmental Protection Agency has been assessing water quality and biological health in Mosquito Creek and Drain M since 1995 as part of the agencies ambient water monitoring program for South Australia. Mosquito Creek at Struan has been sampled monthly for a suite of chemical and physical parameters and the site has been sampled and assessed using aquatic macro-invertebrates as biological indicators since 1994. The program was expanded in 2004 to include a site on Drain M at the Beachport to Robe Road. The National River Health Program included work carried out under the Australian River Assessment Scheme (AusRivAS) and this involved the bio-assessment of streams throughout the country including various sites on Drain M in 1994-1999.

Objectives

Improve knowledge on biological and physio-chemical water characteristics for future management evaluation and adaptive management actions.

Cooperatively work to reduce the threat of an adverse change in water quality to the ecological character to the site.

Strategies

- Work with relevant agencies in South Australia and Victoria to minimise the threat of a change in surface water quality that may result in adverse change to the ecological character of the site.
- Work with the SENRMB and other relevant agencies to minimise the threat of a change in groundwater quality that may result in an adverse change to the ecological character of the site.
- Work with the SENRMB and other relevant agencies to monitor the water quality, including biological indicators of Bool and Hacks Lagoons and off-site sources of ground and surface water, as part of an integrated monitoring program.

4.3 Native Vegetation

The maintenance of the diversity of the floristic composition of Bool and Hacks Lagoons is a key management consideration. The interrelationships between wetland vegetation and water management at the site are complex. Consequently, in the context of management planning, there is a strong requirement for adaptive management informed by on-going and purposeful monitoring.

It has been demonstrated that elevation, flooding frequency or water depth alone are insufficient to explain the present distribution of species at Bool and Hacks Lagoons (Brownlow 1997; Biggs 2001) (see 3.1.4 Native Vegetation). Rather, the present species distribution reflects the opportunistic occupation of all species across the elevation gradient in response to rising and falling water levels. Research has demonstrated that major changes to the water regime, outside the existing tolerance limits of existing flora, will result in major changes in floristic composition of the wetland at Bool and Hacks Lagoons (Biggs 2001; Brownlow 1997; Denton and Ganf 1994; Rea and Ganf 1994). Of particular importance is the hydrological regime necessary to maintain the Swamp Paperbark (*Melaleuca halmaturorum*). Research has indicated that extended periods of inundation of greater than 4 years can threaten *Melaleuca halmaturorum*. The importance of allowing periods of drying to benefit the health and recruitment of this species is recognised (see 4.1 Hydrology).

However, managing the water levels in the lagoons for floristic diversity is problematic. Whilst it is recognised that changes outside the present tolerance limits will bring about possible changes in diversity, the present tolerance limits are difficult to quantify. As Biggs (2001, p. 103) notes, if the lagoons were to remain dry for too long, or wet for too long, there is potential for loss of diversity and a reduction in the Lagoon's conservation value. The difficulty lies in knowing how long is too long, and the capacity to actively manage within seasonal limitations and cyclical climatic variations.

The high level of responsiveness of wetland species to fluctuations within the water regime, coupled with their current opportunistic distribution across the entire elevation gradient, makes the prescription of an ideal water regime to favour every species unlikely. Additionally, given the high level of inter-annual climatic variation experienced at the site, attempting to replicate ideal hydrological conditions is impossible.

The 2004 mapping of vegetation associations illustrates the present extent and distribution of key species, and will assist in monitoring change. The maintenance of the vegetation comprising key habitat types (see 3.1.5 Habitats) is critical in maintaining the ecological character of the wetland. Detailed, accurate mapping of vegetation associations at the time of Ramsar listing is not available as a benchmark for ecological character.

In 1984 grazing was permitted as a measure to control weeds and reduce fuel loads on dryland areas of Bool Lagoon. Licences were cancelled in 1998/99 due to the negative impact on wetland vegetation, particularly on the edges of the lagoon as water receded and the impracticality of restricting stock to these areas.

There is a need to update the revegetation strategy for the reserves, in order to achieve the following objectives:

- Promote dryland habitat;
- Increase vegetation buffer zones surrounding wetland areas;
- Promote wildlife corridors; and
- Strategically address the dominance of introduced species on dryland areas, including progressively phasing out areas available for cropping.

Threats to Ecological Character

- The consistency of flood mitigation objectives with the requirements to maintain wetland vegetation diversity.
- The lack of integrated and ongoing monitoring regarding the link between water management and the maintenance of floristic diversity at the site.
- The dominance of introduced species on dryland areas, threatening existing native flora communities, and disadvantaging the further recruitment of native dryland species.
- Inappropriate species selection in revegetation efforts.
- Grazing of wetland vegetation by domestic stock.
- Bushfire.
- Potential inappropriate use of licensed cropping as a weed and fire management tool on selected dryland areas.
- Introduced fauna species, such as rabbits and hares.
- Introduced pathogens and diseases.

Objectives

Seek to improve the integrity of native wetland vegetation associations, maintain habitat diversity and ecological character of the site.

Improve knowledge of vegetation communities to determine responses to various water regimes and requirements to maintain habitats.

Improve the ecological value of dryland areas.

Strategies

- Ensure water management requirements of vegetation associations and habitats are addressed as part of the implementation of agreed water levels and the Memorandum of Understanding between DEH and the SEWC&DB (see 4.1 Hydrology).
- Undertake surveying and monitoring to determine vegetation health and conservation significance as part of an integrated management program for the site, with the aim to minimise threats to native vegetation that may result in an adverse change to the ecological character of the site.
- Prohibit stock grazing in the reserves to prevent negative impacts on native vegetation.
- Improve the conservation value of dryland areas through the review and implementation of the revegetation strategy for the reserves.

4.4 Native Fauna

The conservation significance of Bool and Hacks Lagoons is highlighted by the exceptionally high number of waterbirds that have been recorded breeding there. Wetland habitat diversity is a function of fluctuating ground and surface water influence, resulting in varied distribution of vegetation and wetland characteristics necessary to support a wide range of animal species.

Similarly with water and native vegetation management, it is not possible to manage for every animal species on an annual basis. Many management actions are conditional on flood mitigation requirements, and inter-annual rainfall variations. Therefore, it is feasible to plan to achieve conditions to favour species diversity over a number of years.

The Australian Government Department of the Environment and Heritage has developed National Action Plans for many threatened species under the EPBC Act. The *Action Plan for Australian Frogs* addresses the requirements for the Southern Bell Frog (*Litoria raniformis*) as does the draft *National Recovery Plan 2004-2008*. The draft *National Recovery Plan for the Striped Legless Lizard (Delma impar): 2005-2009* aims to ensure the long-term survival of *D. impar* and maintain its potential for evolutionary development in the wild across its natural geographic range (Smith & Robertson 1999). Both plans provide guidance for the management of the species and habitat at Bool and Hacks Lagoons.

The use of lead shot for hunting at Bool Lagoon was banned in 1987 due to the impacts to waterbirds caused by lead poisoning. The ongoing impacts of residual lead is unknown.

Threats to Ecological Character

- The most significant threat to native fauna at Bool and Hacks Lagoons is the loss or simplification of supporting habitat. Threats to habitat (integrity, quality) include:
 - Change in water management, causing a change in hydrological characteristics (for example, prolonged inundation) resulting in a large-scale shift in vegetation species, or loss of habitat diversity and abundance;
 - Water quality changes (eg. salinity increases, nutrient enrichment);
 - Direct disturbance; and
 - Fragmentation.
- Licensed agricultural use (ie cropping) of dryland areas without appropriate and enforceable licence conditions to avoid a direct impact on native fauna, particularly threatened species.
- Introduced animal species threaten the diversity of native fauna, through habitat modification (Brown Hare, European Rabbit) and direct predation (Feral Cat, European Red Fox, Redfin, Gambusia).
- Bushfire.
- Inappropriate revegetation.
- Disturbance from recreational activities and hunting (see 4.11.2 Hunting).

Objectives

Maintain diversity of native fauna and supporting habitats, consistent with the maintenance of the ecological character of the site.

Minimise threats to native fauna species, specifically threatened species and their supporting habitats.

Enhance knowledge on fauna and the key links between water, native vegetation and animals.

Strategies

- Ensure water management arrangements take into account requirements of key habitats and support native fauna diversity (see 4.1 Hydrology).
- Ensure management practices for the Striped Legless Lizard and Southern Bell Frog take into account provisions of the National Action Plans and Regional Recovery Plans.
- Identify and monitor key indicator species of animals, ensuring integration with water and native vegetation as part of the implementation of an integrated management program.
- Work with the SENRMB, other relevant agencies and programs to minimise threats to native animals that may result in an adverse change to the ecological character of the site.
- Avoid negative impacts of cropping on dryland areas by ensuring licences have enforceable conditions.
- Encourage research to determine ongoing impacts of lead shot residues on waterbirds.

4.5 Introduced Plants

Dryland areas of the reserves are dominated by introduced plant species. This is attributed to fertile soils, surrounding land use, past land use and the role of the site as a ponding basin for inflow from the Mosquito Creek and local sources. There are 174 plant species recorded at Bool and Hacks Lagoons (Brownlow 1997 & DEH Oracle Database 2005) and of these, 76 species are introduced (Appendix A).

Introduced plant control programs have concentrated on species that pose a threat to the environment and adjoining agricultural areas, including:

- Phalaris (*Phalaris paradoxa*, *P. aquatica*)
- Variegated Thistle (*Silybum marianum*)
- Scotch Thistle (*Cirsium vulgare*)
- Sow Thistle (*Sonchus oleraceus*)
- Horehound (*Marrubium vulgare*)
- Cape Tulip (*Moraea flaccida*; *M. miniata*)
- African Boxthorn (*Lycium ferocissimum*)
- Buchan Weed (*Hirschfeldia incana*)
- Salvation Jane (*Echium plantagineum*)
- Bedstraw (*Galium sp.*)

African Boxthorn, Cape Tulip, Horehound, Red Dodder, Salvation Jane and Variegated Thistle are declared plants for the area under section 181 of the *Natural Resources Management Act 2004* and require special attention.

Wild Sage (*Salvia verbenacea*) is also a major concern in certain areas of the park. This species has the potential to adversely affect native species and control measures need to be undertaken.

Golden Wreath Wattle (*Acacia saligna*) and Swamp She-oak (*Casuarina glauca*) are both Australian natives species and competitive outside of their natural environment. They compete for nutrients and displace local native species. These plants were deliberately planted when Australian natives were commonly used in conservation projects. They should be removed and replaced with appropriate indigenous species.

Tall Wheat-grass (*Thinopyrum ponticum*), a perennial salt-tolerant pasture grass, is invading areas of the park, including habitat of the Striped legless Lizard. This species needs to be monitored and control measures implemented while the infestation is containable.

Red Dodder (*Cuscuta planiflora*), was found in the reserve at Little Bool in 2004. This species is a parasitic plant introduced from the Mediterranean and has potential to affect the world seed export market. It occurs in Fairview Conservation Park and appears to be confined to swamps. Infested areas may be quarantined.

The control of introduced plants on dryland areas of the reserves comprises a significant ongoing management commitment. Control methods include chemical treatment, hand pulling, biological agents, slashing and burning. Programs are usually planned with advice from Authorised Pest Plant Officers and where possible coordinated with neighbouring properties.

Cropping licenses have been issued within Bool Lagoon Game Reserve in order to control infestations and minimise fire risk posed by the dominance of Phalaris in dryland areas (see 4.11.1 Cropping Licences). Licence conditions stipulate that the licensee holds responsibility for introduced plant control. It is recognised that cropping is a temporary management tool and that cropping areas will be progressively revegetated with native species in the longer term (see 4.3 Native Vegetation).

It should be noted that in the absence of large areas of non-degraded native grassland, the Striped Legless Lizard may be dependent on areas of undisturbed Phalaris as habitat within the reserves (see 4.4 Native Animals).

Objectives

Reduce the threat posed by introduced plants and control methods to the ecological character of the reserves.

Maximise the effectiveness of introduced plant control programs, in cooperation with surrounding landholders.

Strategies

- Prepare and implement an introduced plant control action plan in consultation with the SENRMB and neighbouring landholders to achieve cooperative control programs.
- Administer licences to crop selected dryland areas in Bool Lagoon Game Reserve as a tool to control weed species and reduce fire risk. Ensure license conditions minimise risk to the ecological character of the reserves and that these are enforced.
- Progressively phase out cropping activities and increase areas of native vegetation through the implementation of a revegetation strategy (see 4.3 Native Vegetation).
- Liaise with the relevant pest plant organisations regarding the monitoring and eradication of Red Dodder in the reserves.

4.6 Introduced Animals

There are a number of introduced species present within the reserves. Redfin (*Perca fluviatilis*) are active predators on native fish and Gambusia (*Gambusia holbrooki*) attack native species, compete for food and prey on eggs, larvae and tadpoles (Hammer 2002 & pers. comm). Feral Cats (*Felis catus*) and the European Red Fox (*Vulpes vulpes*) directly prey on many species of native fauna, including nesting birds on the wetlands. The European Rabbit (*Oryctolagus cuniculus*) and Brown Hare (*Lepus capensis*) are direct competitors for resources with many native species, and in large numbers are capable of major habitat alteration. Hares and rabbits also prevent the natural regeneration of native vegetation, and can hamper revegetation efforts.

Annual fox baiting programs are undertaken within the reserves. Adjoining landholders are notified of planned baiting activities and are encouraged to coordinate their baiting programs with those undertaken by DEH to integrate pest species control to achieve maximum impact.

Rabbits and hares are controlled through baiting and fumigation programs. Introduced species are also controlled by spotlight shooting on the reserves by DEH staff. Licensees are responsible for vermin control on dryland areas under cropping licence.

The control of the threat to native animals posed by the European Red Fox, European Rabbit and Feral Cat is addressed and coordinated nationally through Australian Government Threat Abatement Plans (*Threat Abatement Plan for Predation by the European Red Fox*, (1999); *Threat Abatement Plan for Competition and Land Degradation by Feral Rabbits* (1999); *Threat Abatement Plan for Predation by Feral Cats* (1999)).

Objectives

Minimise the impact of introduced animals on the ecological character of the reserves.

Maximise the effectiveness of introduced animal control programs, in cooperation with surrounding landholders.

Strategies

- Address identified threats to ecological character through the implementation of targeted control programs in consultation with the SENRMB and neighbouring landholders to achieve coordinated control programs.
- Enforce licence conditions to ensure the control of introduced animals on dryland areas subject to cropping licences.

4.7 Cultural Heritage

4.7.1 Indigenous Heritage

Meintangk and Boandik Culture and Heritage

Bool and Hacks Lagoons are located on lands traditionally associated with the Meintangk and Boandik people (Tindale 1974).

The land and waters of the Bool and Hacks Lagoons are important to the Meintangk and Boandik people. Evidence suggests that the area may have been a meeting place or significant to other groups, coming from both the Lower and Upper South East (Murdoch 1991, p. 26).

Dreaming stories and ceremonies were important to the Meintangk and Boandik people. Corroborees and meetings were held to settle disagreements, to share stories and experiences.

Following European settlement, both the Meintangk and Boandik populations were substantially reduced as a result of introduced diseases, dispersal and dispossession of their land and water supplies.

Some of the language and traditional stories of the Meintangk and Boandik people have been recorded, however, to date the full extent of Aboriginal heritage at Hacks and Bool Lagoons has not been comprehensively researched.

Aboriginal Heritage Act 1988

The purpose of the *Aboriginal Heritage Act 1988* is the protection and preservation of Aboriginal sites, objects and remains. The Aboriginal Affairs and Reconciliation Division (AARD) of the Department of the Premier and Cabinet maintains a Central Archive, including the Register of Aboriginal Sites and Objects. Aboriginal site is defined under the Act as "An area of land that is of significance according to Aboriginal tradition; or that is of significance to Aboriginal archaeology, anthropology or history."

Currently there are no sites listed on the Central Archive or Register of Aboriginal Sites and Objects for Bool and Hacks Lagoon. The discovery of artefacts and campsites by early European settlers within and in close proximity to the reserves is documented in Murdoch (1991, p. 24). To promote better cultural heritage management at Bool and Hacks Lagoon, further research needs to be undertaken to identify and record sites of significance.

Land, developed or undeveloped, can contain sites. Sites relate to living patterns and use of environmental resources such as water, animal and vegetable foods and stone by Aboriginal people. They also relate to spiritual beliefs and ceremonial activities.

To ensure the protection of sites, DEH shall consult with AARD and the relevant Aboriginal Heritage organisations before planning and commencement of significant development works.

4.7.2 Non-Indigenous Heritage

European settlement of Bool and Hacks Lagoons occurred during the 1840s. Occupational Licenses were issued for the area in 1847. Struan, Moy Hall and Killanoola were the three original pastoral runs comprising the Bool Lagoon area.

During the nineteenth century, Bool and Hacks Lagoons were used for summer grazing and watering of stock.

In the 1900s, Bool and Hacks Lagoons were more intensively used for grazing and cropping in dryland areas. The Bool Lagoon settlement consisted of a Post Office, telephone exchange, area school and a community hall. With the exception of the hall, none of these facilities are in existence today and there are no sites listed on the State Heritage Register for the reserves.

A detailed history of the Bool Lagoon area is provided in *Bool Lagoon: A Changing Balance* (Murdoch 1991).

To this day, Bool Lagoon remains the focus of an active local community.

Objective

Conserve and protect significant cultural heritage sites and provide appropriate interpretive material.

Strategies

- Consult with local Aboriginal heritage committees and relevant Government Aboriginal heritage authorities in decisions regarding the management of Aboriginal cultural heritage at Bool and Hacks Lagoons.
- In cooperation with AARD, the Heritage Branch of DEH and other relevant authorities and organisations, identify, record, protect, restore and monitor known or relocated sites and items of archaeological, anthropological, cultural and historical significance located in the park. Aboriginal and historic cultural heritage sites require conservation plans to facilitate appropriate management.
- In consultation with local Aboriginal heritage committees, the Heritage Branch of DEH and other relevant authorities, research cultural and historic sites and stories that relate to the park. All sites should be recorded to the standards set by the Heritage Branch of DEH and/or AARD and submitted for inclusion on the AARD Central Archive.

4.8 Fire Management

Under the *National Parks and Wildlife Act 1972*, reserve management must give regard to the prevention and suppression of bush fires and other hazards. Fire management in reserves is based on objectives and policy contained in the *DEH Fire Management Policy* and reserve-specific fire management plans.

Fire management plans are a requirement of the *Country Fires Act 1989*. They are developed in conjunction with adjoining Country Fire Service Groups, regional and district Bushfire Prevention Committees, to integrate district fire management. Stakeholders and the wider community are also consulted to ensure an understanding of the fire risks and mitigating actions being proposed or undertaken in the reserve. Fire management planning will:

- identify natural and cultural heritage values and built assets;
- provide a framework for the management of bushfire suppression, including identification of strategic access and control lines;
- provide a framework for prescribed burning for ecological management and fuel reduction purposes; and
- identify performance indicators.

A fire management plan has been developed for Bool Lagoon Game Reserve and Hacks Lagoon Conservation Park and this will be reviewed periodically. DEH in the South East have a registered Country Fire Service Brigade and staff are members of the Country Fire Service. Fire suppression resources and responses are planned on a regional and state-wide basis.

Wood and solid fuel fires are prohibited in Bool Lagoon Game Reserve and Hacks Lagoon Conservation Park all year. Gas fires are permitted, except on total fire ban days. Both reserves may be closed for public safety during extreme fire conditions.

In recent history, there have been five significant fires in Bool Lagoon Game Reserve:

- 1961 & 1978 - Large fires burnt the south-western portion of the reserve.
- 1989 - Uncontained burn-off burnt approximately 100 hectares of the western side of Bool Lagoon.
- 1995 - Arsonists set alight a section of the Tea-tree Boardwalk, destroying surrounding Swamp Paperbark and Fairy Grass.
- 2002 - A stubble-burn broke containment and burnt 25 hectares on the western side of Bool Lagoon.
- 2003 - A controlled DEH fuel-reduction burn on the western margin of the Bool Lagoon basin, to protect adjoining property.

Bushfires caused by burn-offs, arson and lightning strikes have occurred in Bool Lagoon. As it is not usually possible to access the lagoon for fire suppression activities, these events threaten the integrity of wetland vegetation communities. Fires during times when wetlands are dry have potential to consume peat layers and destroy the rhizomes of wetland plant species (Higgins et al 1989).

Fuel reduction burns have been undertaken to reduce the risk to neighbouring assets and these are subject to monitoring to determine the ecological responses and assist future management. An assessment to determine the need to use fire for ecological purposes has not been undertaken but it is expected that the need for this will be limited (Bool Lagoon Technical Reference Group Workshop, 2004). The use of fire in reserves for management purposes is subject to DEH assessment and approval processes and the provisions outlined in fire management plans.

Objective

Manage fire to ensure the protection of life and property, the maintenance of biodiversity and the protection of natural, cultural and built values.

Strategies

- Develop, implement and review a fire management plan in association with CFS and other stakeholders.
- Continue to work with the relevant District Bushfire Prevention Committee and the CFS to minimise risk to life and property within the surrounding the reserve.
- Maintain water supply and vehicle access tracks for fire management purposes.
- Undertake prevention works and suppress wildfires to minimise long-term effects on wetland plant species.
- Manage dryland areas to minimise fire risks, including licence conditions for dryland areas subject to cropping licences.
- Ensure compliance with fire restrictions and the fire ban season by providing information and monitoring visitor use.

4.9 Infrastructure and Built Assets

The following infrastructure and built assets are located within Bool and Hacks Lagoons:

- Residence on Hacks Peninsula, currently used for rental accommodation;
- Disused office on Hacks Peninsula;
- Maintenance and storage sheds on Hacks Peninsula;
- Reserve boundary fencing;
- Sealed roads and carparks; and
- Infrastructure and built assets comprising visitor facilities (see section 4.10 Recreation and Tourism).

DEH assets are established and maintained through a departmental asset management program to ensure effective life and high standards of public safety, functionality and presentation.

Objective

Provide high quality infrastructure to meet management and visitor needs.

Strategies

- Ensure infrastructure and built assets are maintained to DEH standards.
- Develop infrastructure and built assets as identified for management and tourism and recreation needs, with regard to budget considerations, maintenance of ecological character and the requirements of the *Aboriginal Heritage Act 1988*.

4.10 Recreation and Tourism

The Limestone Coast region of South Australia attracted 1,333,000 day and overnight visitors in 2002 (SA Tourism Commission 2003). The three most common activities for holiday/leisure visitors to the Limestone Coast region are eating out, sightseeing and visiting friends. Nine percent of visitors named visiting national parks as their principal activity; related activities included walking/driving around/sightseeing (42 percent), and bushwalking (10 percent).

Visitor records from Bool and Hacks Lagoons are inconsistent and fail to provide accurate data on visitation patterns and statistics. Since the introduction of entry permit stations a better indication of visitor numbers is available, however, it remains problematic to factor in the uncertain level of compliance. Reserve management relies on the honesty of visitors to purchase entry and camping permits, with random checks undertaken by DEH staff to ensure visitor compliance with conditions. Previous records and observation indicate a positive relationship between visitor numbers and the presence of water and related wildlife.

The *Directory of Important Wetlands in Australia* documents visitation at 16,000 per year, but the source of this figure is unknown (ANCA 1996, p. 499). As an indicator of the quantity of tourism traffic in the local area, the nearby Naracoorte Caves National Park recorded 70,000 visitors for 2002/2003 (SA Tourism Commission 2003).

The following general recreation activities are undertaken at Bool and Hacks Lagoons:

- Bird watching and sightseeing;
- Walking, on boardwalks and walking trails;
- Picnics and barbeques; and
- Camping.

Recreational activities favoured at Bool and Hacks Lagoons are passive, undertaken generally by day visitors to the reserves.

Inappropriate recreational and tourism development may pose a threat to the ecological character of Bool and Hacks Lagoons. Adverse impacts of recreation and tourism activities may include litter and pollution, disturbance to sensitive species of flora or fauna, unregulated visitor access to the wetland, swimming, fishing, boating, unregulated camping, and bushfire caused by non-compliance with fire conditions.

Visitor Use and Facilities

The following visitor facilities are present within Bool Lagoon Game Reserve (Figure 2):

- Tea-Tree Boardwalk, incorporating a bird hide and interpretive information;
- Gahnia Walking Trail, incorporating a bird hide and interpretive information;
- Toilet facilities at the main entrance;
- Two bitumen carparks adjacent to the boardwalk and walking trail;
- Lookout on eastern side of the lagoon with disabled access;
- Information bay at main entrance with interpretive information, entry permit station, picnic table, and landscaped surrounds;
- Lookout from Big Hill, with an all weather access road; and
- All-weather vehicle access to Little Bool, car parking provision and entry permit station.

The following visitor facilities are located within Hacks Lagoon Conservation Park:

- Pat-Om Boardwalk, incorporating a viewing platform over the Mosquito Creek inlet, interpretive information and picnic table;
- Gunawar Trail, self guided tour with viewing platform, revegetated walking trail and printed information;
- Unpowered camping area, with picnic tables, gas barbeque, freshwater access, and sheltered picnic area;
- Bitumen access to both boardwalks with car parking; and
- Walking trail between Gunawar Trail and Pat-Om Boardwalk around the western margin of Hacks Lagoon.

All boardwalk facilities have been designed to enable access for disabled and aged visitors.

Visitor use of the reserves is primarily concentrated around the present distribution of visitor facilities in Hacks Lagoons Conservation Park, and the eastern side of Bool Lagoon Game Reserve. All wetland trails and boardwalks are self-guided. Group tours can be pre-arranged with DEH staff.

It is likely that any expansion of visitor facilities will be limited because of a lack of staff presence to service them. Camping facilities are available at Naracoorte and Naracoorte Caves.

Boating, fishing and swimming are not permitted within the reserves due to public safety precautions and threat posed to the ecological character of the wetland (for example, disturbance to breeding waterbirds).

The reserves, or part of, may be closed to the public on open days for duck hunting.

Vehicle Access

Vehicle access is mostly determined by road and weather conditions. Only sealed all-weather roads are suitable for access during the winter and spring months. Bitumen or all-weather vehicle access is available to all visitor facilities between the main entrance to Bool Lagoon (including Big Hill), and Hacks Lagoon. Unsealed roads within the reserves are signed accordingly.

Many areas of the reserve are unsuitable for public vehicle access due to the sensitivity of flora and fauna, and the risk posed through wet and/or slippery conditions.

Where possible, access around the perimeter of the reserves is maintained for management and fire control purposes.

Objectives

Provide appropriate, well maintained visitor facilities to meet visitor needs consistent with the principle of wise use, and to ensure the maintenance of the ecological character of the reserves.

Provide vehicle access throughout the reserves, for the purposes of public enjoyment, efficient reserve management, and fire management, with regard to public safety and the maintenance of the ecological character.

Strategies

- Develop and implement a tourism and recreation strategy and visitor facility plan to guide the future development of visitor facilities, in consultation with local and regional tourism organisations.
- Ensure visitor facilities and activities are consistent with the maintenance of the ecological character of the reserves.
- Prohibit public swimming, boating and fishing activities in the reserves.
- If considered necessary for public safety, close the reserves, or part of the reserves, during hunting events.
- Maintain vehicle access to visitor facilities.
- Provide self registration stations at public entrances for permit distribution and fee collection, ensuring public compliance with permit conditions through random monitoring by DEH staff.

4.10.1 Interpretive Information

Interpretive information at Bool and Hacks Lagoons fulfils the following functions:

- Enhances the experience of visitors by providing information on the features of the reserves;
- Promotes the Convention on Wetlands and natural and cultural values of the area;
- Visitor orientation;
- Provides information on the conservation significance of the reserves, encouraging appropriate visitor behaviour; and
- Regulatory functions.

The main entrance to Bool Lagoon Game Reserve has information on the hydrology, vegetation and birdlife of the lagoons, as well as detailing the visitor facilities and activities available.

Objective

Provide interpretive information for visitors.

Strategies

- Provide signage at visitor facilities to enhance visitor experiences, giving consideration to tourism and recreation strategy and visitor facility plan (see 4.10 Recreation and Tourism).
- Consult relevant Aboriginal Heritage organisations regarding the integration of Indigenous history and information into interpretive signage.
- Provide temporary/adaptive signage to highlight the seasonal features of the reserves to enhance visitor experience (for example, areas of water and bird concentrations).

4.11 Commercial Activities and Other Landuse

4.11.1 Cropping Licences

Cropping licences are issued as a management tool to control weed infestation and reduce fire risk on dryland areas of Bool Lagoon Game Reserve until such time that these areas are revegetated with native species (see 4.5 Introduced Plants).

There are currently three licences over an area of approximately 350 hectares in the vicinity of Little Bool, Twig Rush Lagoons and Big Hill. Licences are issued pursuant to section 35(3) of the *National Parks and Wildlife Act 1972*, and contain conditions relating to introduced animal and plant control, fencing, vegetation clearance and fire management. Frogs and tadpoles have been found to be very sensitive to some herbicide products, and in particular surfactants used to increase the effectiveness of chemicals (Bidwell and Gorrie 1995). Some chemicals are believed to cause feminisation of male frogs. Given the significance of species occurring in the reserve, including the nationally vulnerable Southern Bell Frog, the use of chemicals by DEH and licensees needs to be carefully considered.

Objectives

Utilise cropping on dryland areas as an interim management tool to control weeds and minimise the risk of fire, while progressively revegetating dryland areas with native species.

Minimise the impact of cropping practices on the ecological character of the reserves.

Strategies

- Administer licences to crop selected dryland areas in Bool Lagoon Game Reserve as a tool to control weeds and minimise fire risk. Progressively phase out cropping in favour of the revegetation of native species in accordance with the revegetation plan (see 4.3 Native Vegetation).
- Review cropping licence conditions, ensuring that licensee practices are consistent with the maintenance of the ecological character and threatened species management. Ensure licence conditions are complied with.

4.11.2 Hunting

In 1967, Bool Lagoon was the first Game Reserve in South Australia dedicated under the *Fauna Conservation Act 1964*. Concurrently, Hacks Lagoon was dedicated a Conservation Park. The *Fauna Conservation Act* was repealed by the passing of *the National Parks and Wildlife Act 1972* and all land transferred.

The first public shoot took place in 1969, but prior to this there was a history of duck hunting at Bool Lagoon. Under private pastoral leases small, invitation-only shoots occurred and with the introduction of the *Animals and Birds Protection Act 1919*, this practice continued with hunter numbers ranging from 30 to 100.

As early as 1940, the Flora and Fauna Committee and the South Australian Ornithological Association proposed, unsuccessfully, that all or part of Bool Lagoon be declared a Bird Sanctuary. Debate resumed in 1960 when the (former) South Eastern Drainage Board proposed to drain Bool Lagoon and use it as a ponding basin to relieve floodwaters from the Mosquito Creek. A Parliamentary Committee was formed in 1963 to adjudicate on the core issues of drainage and management.

Hunting groups supported the dedication of a Game Reserve and it is noted by Murdoch (1991) that little or no conflict of values existed, at that time, between preserving Bool Lagoon and permitting controlled shooting in the minds of conservationists. Private shoots had raised a significant amount of money for charity, and it was recognised by the then Department of Fisheries and Game that herein lay the economic base for a successful Game Reserve.

Game Reserves are preserved for the conservation of wildlife and management of game and may be declared open at prescribed times for strictly controlled hunting. Within South Australia, the timing of the open season, bag limits and permitted species can be varied from year to year according to seasonal conditions and population trends. Open days are declared based upon scientific advice regarding water availability, waterfowl abundance and the condition of other key wetlands in Australia. Hunting at Game Reserves is generally subject to additional restrictions and at Bool Lagoon open days may be cancelled on short notice by the Minister if observations or surveys indicate a risk to species of conservation significance or disturbance to breeding birds.

Since 1969 the numbers of hunters attending Bool Lagoon on an open day varied from 2,000 prior to 1980, to 120 in June 1991, which may in part be due to increased opportunities for hunting on private land. In addition, there has been a corresponding reduction in licensed duck hunters in South Australia (currently 2,300) and this is thought to be due to major changes in firearms laws, the introduction of Waterfowl Identification Testing and the ban on lead shot (Stokes 1990).

The Department for Environment and Heritage has an obligation to manage open days at Bool Lagoon and this requires considerable regional resources. The reserve has been closed to the general public on open days but since 1991, arrangements have been in place to allow animal welfare groups to enter the waters of the reserve for the purpose of rescuing injured birds. On average, 35 to 45 rescuers have attended open days.

The Ramsar Technical Reference Group raised concerns about the disturbance impact of hunting on birds at Bool Lagoon and recommended that the status of the reserve be changed to a Conservation Park (Ramsar Workshop April 2004). Hunting is not in conflict with the Ramsar principle of Wise Use of Wetlands but the government has an obligation to ensure that any activity, including hunting, does not pose a threat to the ecological character of Bool and Hacks Lagoons or conflict with other management objectives. Issues specific to hunting include: direct impact on off-target species; impact on species sensitive to disturbance; disturbance to nesting events; impact on the sites value as drought refuge when other parts of the country are dry; and, conflict with other reserve activities. Conditions and arrangements to address these issues will be formalised and regularly reviewed with stakeholders.

The South Australian Field and Game Association has contributed to conservation works at Bool and Hacks Lagoons (see 4.12 Involving the Community).

Objectives

Permit duck hunting at Bool Lagoon consistent with its status as a Game Reserve, in accordance with legislation, government policy and declarations.

Minimise conflict with other uses and users of the reserves.

Minimise threats to ecological character and impacts on species of conservation significance.

Strategies

- Allow open days for duck hunting in accordance with the *National Parks and Wildlife Act 1972* and the annual open season declaration by the Minister.
- Incorporate monitoring of potential impacts of hunting on ecological character and species of conservation significance as part of the Integrated Monitoring Program and Adaptive Management for the reserves (3.2 Monitoring of Ecological Character).
- Undertake bird surveys prior to the declaration of the open season and prior to open days.
- Assess the risk of hunting on ecological character, breeding, or species of conservation significance, based on survey, monitoring and biological criteria, and review arrangements prior to the declaration of the open season and open days.
- If considered necessary for public safety, close the reserves, or part of the reserves, during hunting events.

4.12 Involving the Community

Regional Communities and Park Neighbours

The Department for Environment and Heritage (DEH) supports and promotes partnerships and cooperative management arrangements to establish integrated natural resource management. This requires the development of effective working relationships with government agencies, local authorities and the local community. With regard to the management of Bool and Hacks Lagoons, DEH endeavours to maintain ongoing links with the following:

- South Eastern Water Conservation and Drainage Board
- South East Natural Resources Management Board*
- Regional Aboriginal Heritage Organisations
- Department of Water, Land and Biodiversity Conservation
- Grampians Wimmera Mallee Water and other Victorian NRM Agencies
- Naracoorte Lucindale Council
- Country Fire Service

Partnership arrangements should be developed to provide a positive direction for the shared development and management of the park to fulfil the objectives of this plan.

The process to develop this plan of management generated key working relationships with community stakeholders, and technical experts on wetland management. There are opportunities to build on these working relationships to achieve the greater integration of management actions both within and external to the reserves. Given the extent of external influences to the reserves, for example, ground and surface water influence, cooperative arrangements with outside agencies are desirable.

* The South East Natural Resources Management Board operates under the new *Natural Resources Management Act 2004* that brings together water, soil conservation and animal and plant control activities. The NRM Board replaces the current committees, boards and groups that previously had responsibility for these areas. In addition to this, the Board takes responsibilities previously managed by the South East Natural Resources Consultative Committee (SENCCC) and part of the Murray Darling Basin Integrated NRM group.

Aboriginal Partnerships

DEH is committed to reconciliation and to the development of partnerships with relevant Aboriginal Heritage organisations to effectively manage Bool and Hacks Lagoons in a way that respects both contemporary and traditional culture, knowledge and skills. Partnerships involve the delivery of programs that promote reconciliation, cultural awareness, Indigenous employment and training, cooperative management and Indigenous cultural heritage management in parks.

Community and Volunteer Involvement

It is recognised that the support of community and volunteer stakeholders is important for the ongoing management of Bool and Hacks Lagoons. The process to develop this plan of management benefited from the contribution of ideas and knowledge by many community representatives.

Whilst there is no formal Friends of Parks group for the reserves, there exists strong community interest in their management. Groups such as the South East Consultative Committee and local field naturalists have an ongoing interest and knowledge regarding the reserves. Neighbouring landholders have been actively involved in reserve management works, for example, revegetation, fencing, wildlife survey and introduced species control. The South Australian Field and Game Association has been an active contributor to conservation works within the reserves, including revegetation works and the introduction of nest boxes.

Objectives

Develop and maintain working relationships with organisations, statutory bodies and others to assist with the management of the park and enhance its natural values.

Engender wider community awareness of the natural and cultural importance of the reserves and encourage active community contribution to their ongoing management.

Strategies

- Maintain links with technical wetland experts in the ongoing management and monitoring of the wetland.
- Consult with the local council, relevant management boards, the local community and other relevant bodies to explore the benefits of partnership arrangements that will support future management decisions and resolve issues of common interest within and surrounding the park.
- Provide for ongoing consultation with key community stakeholder groups and individuals as identified through the planning process.
- To better understand and appreciate Aboriginal culture, lifestyle and knowledge of the reserve, involve Aboriginal people who have a traditional association with the land and the relevant Aboriginal Heritage Committees in the cooperative management of the reserves and the preservation of Indigenous cultural heritage.
- Encourage and support the involvement of volunteers in park management, with the aim to identify volunteer specialist groups and incorporate associated data into the integrated monitoring program.
- Ensure volunteer projects and activities are consistent with the objectives of this management plan.

5 SUMMARY OF MANAGEMENT STRATEGIES

STRATEGY	PRIORITY	DURATION
4.1 HYDROLOGY		
Subject to variations specified within the Memorandum of Understanding between DEH and SEWC&DB, manage water in accordance with agreed levels.	High	Ongoing
Develop and implement a Memorandum of Understanding between DEH and SEWC&DB relating to water management responsibilities.	High	Short
Maintain the health of <i>Melaleuca halmaturorum</i> through management of water levels to prevent where practicable greater than four years continuous inundation.	High	Ongoing
Maximise ecological value of the peripheral lagoons through the development of a water management strategy.	High	Ongoing
Coordinate surface and groundwater level and water flow monitoring in partnership with other relevant agencies, through the formation and implementation of an integrated monitoring program (see section 3.2 Monitoring of Ecological Character).	High	Ongoing
Maintain flowpaths between and within the lagoons through the development and implementation of a vegetation management strategy in cooperation with SEWC&DB.	High	Ongoing
Work with the SENRMB, other relevant agencies and programs to ensure surface water diversion schemes, groundwater use, and changes to landuse in the region do not adversely impact on ecological character.	High	Ongoing
Support the development of formal cross-border arrangements between the Victorian and South Australian Governments to develop agreed strategies for the management of the water and ecosystems of Mosquito Creek.	High	Med
4.2 WATER QUALITY		
Work with relevant agencies in South Australia and Victoria to minimise the threat of a change in surface water quality that may result in adverse change to the ecological character of the site.	High	Ongoing
Work with the SEWCMB and other relevant agencies to minimise the threat of a change in groundwater quality that may result in an adverse change to the ecological character.	High	Ongoing
Work with the SEWCMB and other relevant agencies to monitor the water quality, including biological indicators of Bool and Hacks Lagoons and off-site sources of ground and surface water, as part of an integrated monitoring program.	High	Ongoing

STRATEGY	PRIORITY	DURATION
4.3 NATIVE VEGETATION		
Ensure water management requirements of vegetation associations and habitats are addressed as part of the implementation of agreed water levels and the Memorandum of Understanding between DEH and the SEWC&DB (see 4.1 Hydrology).	High	Ongoing
Undertake surveying and monitoring to determine vegetation health and conservation significance as part of an integrated management program for the site, with the aim to minimise threats to native vegetation that may result in an adverse change to the ecological character of the site.	High	Ongoing
Prohibit stock grazing in the reserves to prevent negative impacts on native vegetation.	Med	Ongoing
Improve the conservation value of dryland areas through the review and implementation of the revegetation strategy for the reserves.	Med	Long
4.4 NATIVE FAUNA		
Ensure water management arrangements take into account requirements of key habitats and support native fauna diversity (see 4.1 Hydrology).	High	Ongoing
Ensure management practices for the Striped Legless Lizard and Southern Bell Frog take into account provisions of the National Action Plans and Regional Recovery Plans.	High	Ongoing
Identify and monitor key indicator species of animals, ensuring integration with water and native vegetation as part of the implementation of an integrated management program.	High	Ongoing
Work with the SENRMB, other relevant agencies and programs to minimise threats to native animals that may result in an adverse change to the ecological character of the site.	High	Ongoing
Avoid negative impacts of cropping on dryland areas by ensuring licences have enforceable conditions.	High	Ongoing
Encourage research to determine ongoing impacts of lead shot residues on waterbirds.	High	Ongoing
4.5 INTRODUCED PLANTS		
Prepare and implement an introduced plant control action plan in consultation with the SENRMB and neighbouring landholders to achieve cooperative control programs.	Med	Ongoing
Administer licences to crop selected dryland areas in Bool Lagoon Game Reserve as a tool to control weed species and reduce fire risk. Ensure license conditions minimise risk to the ecological character of the reserves and that these are enforced.	Med	Ongoing
Progressively phase out cropping activities and increase areas of native vegetation through the implementation of a revegetation strategy (see 4.3 Native Vegetation).	High	Long
Liaise with the relevant pest plant organisations regarding the monitoring and eradication of Red Dodder in the reserves.	High	Ongoing

STRATEGY	PRIORITY	DURATION
4.6 INTRODUCED ANIMALS		
Address identified threats to ecological character through the implementation of targeted control programs in consultation with the SENRMB and neighbouring landholders to achieve coordinated control programs.	Med-High	Ongoing
Enforce licence conditions to ensure the control of introduced animals on dryland areas subject to cropping licences.	Med-High	Ongoing
4.7 CULTURAL HERITAGE		
Consult with local Aboriginal heritage committees and relevant Government Aboriginal heritage authorities in decisions regarding the management of Aboriginal cultural heritage at Bool and Hacks Lagoons.	High	Ongoing
In cooperation with AARD, the Heritage Branch of DEH and other relevant authorities and organisations, identify, record, protect, restore and monitor known or relocated sites and items of archaeological, anthropological, cultural and historical significance located in the park. Aboriginal and historic cultural heritage sites require conservation plans to facilitate appropriate management.	High	Ongoing
In consultation with local Aboriginal heritage committees, the Heritage Branch of DEH and other relevant authorities, research cultural and historic sites and stories that relate to the park. All sites should be recorded to the standards set by the Heritage Branch of DEH and/or AARD and submitted for inclusion on the AARD Central Archive.	Med	Ongoing
4.8 FIRE MANAGEMENT		
Develop, implement and review a fire management plan in association with CFS and other stakeholders.	High	Ongoing
Continue to work with the relevant District Bushfire Prevention Committee and the CFS to minimise risk to life and property within the surrounding the reserve.	High	Ongoing
Maintain water supply and vehicle access tracks for fire management purposes.	Med	Ongoing
Undertake prevention works and suppress wildfires to minimise long-term effects on wetland plant species.	Med	Ongoing
Manage dryland areas to minimise fire risks, including licence conditions for dryland areas subject to cropping licences.	Med	Ongoing
Ensure compliance with fire restrictions and the fire ban season by providing information and monitoring visitor use.	High	Ongoing
4.9 INFRASTRUCTURE AND BUILT ASSETS		
Ensure infrastructure and built assets are maintained to DEH standards.	Med	Ongoing
Develop infrastructure and built assets as identified for management and tourism and recreation needs, with regard to budget considerations, maintenance of ecological character and the requirements of the <i>Aboriginal Heritage Act 1988</i> .	Med	Ongoing

STRATEGY	PRIORITY	DURATION
4.10 RECREATION AND TOURISM		
Develop and implement a tourism and recreation strategy and visitor facility plan to guide the future development of visitor facilities, in consultation with local and regional tourism organisations.	Med	Short
Ensure visitor facilities and activities are consistent with the maintenance of the ecological character of the reserves.	Med	Ongoing
Prohibit public swimming, boating and fishing activities in the reserves.	Med	Ongoing
If considered necessary for public safety, close the reserves, or part of the reserves, during hunting events.	High	Intermittent
Maintain vehicle access to visitor facilities.	Med	Ongoing
Provide self registration stations at public entrances for permit distribution and fee collection, ensuring public compliance with permit conditions through random monitoring by DEH staff.	Med	Ongoing
4.10.1 Interpretive Information		
Provide signage at visitor facilities to enhance visitor experiences, giving consideration to tourism and recreation strategy and visitor facility plan (see 4.10 Recreation and Tourism).	Med	Ongoing
Consult relevant Aboriginal Heritage organisations regarding the integration of Indigenous history and information into interpretive signage.	High	Short
Provide temporary/adaptive signage to highlight the seasonal features of the reserves to enhance visitor experience (for example, areas of water and bird concentrations).	Med	Short
4.11 COMMERCIAL ACTIVITIES AND OTHER LAND USE		
4.11.1 Cropping Licences		
Administer licences to crop selected dryland areas in Bool Lagoon Game Reserve as a tool to control weeds and minimise fire risk. Progressively phase out cropping in favour of the revegetation of native species in accordance with the revegetation plan (see 4.3 Native Vegetation).	High	Long
Review cropping licence conditions, ensuring that licensee practices are consistent with the maintenance of the ecological character and threatened species management. Ensure licence conditions are complied with.	High	Short
4.11.2 Hunting		
Allow open days for duck hunting in accordance with the <i>National Parks and Wildlife Act 1972</i> and the annual open season declaration by the Minister.	High	Ongoing
Incorporate monitoring of potential impacts of hunting on ecological character and species of conservation significance as part of the Integrated Monitoring Program and Adaptive Management for the reserves (3.2 Monitoring of Ecological Character).	High	Ongoing
Undertake bird surveys prior to the declaration of the open season and prior to open days.	High	Ongoing
Assess the risk of hunting on ecological character, breeding, or species of conservation significance, based on survey, monitoring and biological criteria, and review arrangements prior to the declaration of the open season and open days.	High	Ongoing
If considered necessary for public safety, close the reserves, or part of the reserves, during hunting events.	High	Intermittent

STRATEGY	PRIORITY	DURATION
4.12 INVOLVING THE COMMUNITY		
Maintain links with technical wetland experts in the ongoing management and monitoring of the wetland.	High	Ongoing
Consult with the local council, relevant management boards, the local community and other relevant bodies to explore the benefits of partnership arrangements that will support future management decisions and resolve issues of common interest within and surrounding the park.	High	Ongoing
Provide for ongoing consultation with key community stakeholder groups and individuals as identified through the planning process.	High	Ongoing
To better understand and appreciate Aboriginal culture, lifestyle and knowledge of the reserve, involve Aboriginal people who have a traditional association with the land and the relevant Aboriginal Heritage Committees in the cooperative management of the reserves and the preservation of Indigenous cultural heritage.	High	Ongoing
Encourage and support the involvement of volunteers in park management, with the aim to identify volunteer specialist groups and incorporate associated data into the integrated monitoring program.	High	Ongoing
Ensure volunteer projects and activities are consistent with the objectives of this management plan.	High	Ongoing

6 REFERENCES AND BIBLIOGRAPHY

- ANZECC. 2000. *The Guidelines for Fresh & Marine Waters and Guidelines for Monitoring and Reporting*. Accessed online 23rd August 2004:
<http://www.deh.gov.au/water/quality/nwqms/#quality>
- Australian Nature Conservation Agency. 1996. *A Directory of Important Wetland in Australia Second Edition*. ANCA, Canberra.
- Balla, S. 1994. *Wetlands of the Swan Coastal Plain Vol 1: Their nature and management*. Water Authority of Western Australia.
- Bidwell, J.R. and Gorrie, J.R. 1995. *Acute Toxicity of a Herbicide to Selected Frog Species*. Department of Environment Protection, Western Australia.
- Biggs, C. 2001. *Tracking Vegetation Changes in the Bool and Hacks Lagoon Wetlands Using Historical Environmental Records*. Unpublished Honours Thesis, University of Adelaide.
- Bourne, J. 2005. Personal communication.
- Brownlow, M. 1997. *Water Regime and the Aquatic Vegetation of Bool Lagoon, South Australia*. Unpublished PhD thesis, Department of Botany, University of Adelaide.
- Croft, T. Carruthers, S. Possingham, H. and Inns, B. 1999. *Biodiversity Plan for the South East of South Australia*. Department for Environment, Heritage and Aboriginal Affairs.
- Davis, J., Froend, R., Hamilton, D., Horwits, P., McComb, A., Oldham, C., & Thomas, D. 2001. *Environmental Water Requirements to Maintain Wetlands of National and International Importance – Bool Lagoon*. Australian Government Department of the Environment and Heritage. Accessed online, URL: www.erin.gov.au
- Denton, M. & Ganf, G.G. 1994. Response of juvenile *Melaleuca halmaturorum* to flooding: Management implications for a seasonal wetland, Bool Lagoon, South Australia. *Australian Journal of Marine and Freshwater Research* 45: 1395-1408.
- Department for Environment and Heritage. 2000. *A List of the Vertebrates of South Australia*. DEH Adelaide.
- Department for Environment and Heritage & Department of Water, Land and Biodiversity Conservation 2003. *Wetlands Strategy for South Australia*. Department for Environment and Heritage, South Australia.
- Department for Environment and Planning. 1984. *Draft Bool Lagoon Game Reserve and Hacks Lagoon Conservation Park Management Plan*. DEP, South Australia.
- Department for Environment and Planning. 1987. *Habitat Development and Management – peripheral Lagoons Bool Lagoon Game Reserve Draft Plan*. Unpublished.
- Environment Australia 2001. *A Directory of Important Wetlands in Australia*, Third Edition, Environment Australia, Canberra.
- Garnett, S.T. & Crowley, G.M. 2000. *The Action Plan for Australian Birds 2000*. Commonwealth of Australia, Canberra.
- Environment Australia 2000. *Revision of the Interim Biogeographic Regionalisation of Australia (IBRA) and Development of Version 5.1 – Summary Report*. Environment Australia, Canberra.
- Environment Australia. 1999. *Threat Abatement Plan for Competition and Land Degradation by Feral Rabbits*. Accessed online 20th August 2004:
<http://www.deh.gov.au/biodiversity/threatened/tap/rabbits/index.html>
- Environment Australia. 1999. *Threat Abatement Plan for Predation by the European Red Fox*. Accessed online 20th August 2004:
<http://www.deh.gov.au/biodiversity/threatened/tap/foxes/7.html>
- Environment Australia. 1999. *Threat Abatement Plan for Predation by Feral Cats*. Accessed online 20th August 2004: <http://www.deh.gov.au/biodiversity/threatened/tap/cats/index.html>

- Ganf, G. 2004. Personal communication.
- Hammer, M. 2002. *The South East Fish Inventory: Distribution and Conservation of Freshwater Fishes of South East South Australia*. Native Fish Australia (SA) Inc. Adelaide.
- Harper, M.J. 1990. 'Waterbird Dynamics at Bool Lagoon South Australia', 1983-1987, in *Australian Wildlife Journal* No. 17, pp. 113-122.
- Higgins, K.F., Kruse, A.D., Piehl, J.L. 1989. *Effects of fire in the Northern Great Plains*. South Dakota Cooperative fish and Wildlife Research Unit.
- Jaensch, R. 1982. *Birds of Bool Lagoon Game Reserve and Hacks Lagoon Conservation Park*. Dept of Environment and Planning. South Australia.
- Lang, P.J. & Kraehenbuehl, D.N. 2002. *Plants of Particular Conservation Significance in South Australia's Agricultural Regions*. Department for Environment and Heritage. South Australia.
- Laut, P., Heyligers, P.C., Keig, G., Loffler, E., Margules, C., Scott, R.M. & Sullivan, M.E. 1977. *Environments of South Australia: Province 1 South East*. CSIRO Canberra.
- Limestone Coast Regional Development Board. 2000. *A Regional Profile*. Accessed online 25th August 2004: <http://www.lcrdb.com/images/LC%20Profile1.pdf>
- Milne, S. 2002. *Population and habitat survey of the Striped Legless Lizard (Idelmar impar), in the South East of South Australia*. World Conservation Fund Report.
- Murdoch, J. 1991. *Bool Lagoon: A Changing Balance*. Bool Lagoon Hall Committee, Millicent.
- National Parks and Wildlife Service. 1985. *Bool Lagoon Game Reserve, South East South Australia - Draft Management Plan*. Department of Environment and Planning, Adelaide, Australia.
- Ramsar Convention on Wetlands: <http://www.deh.gov.au/water/wetlands/ramsar/>
- Ramsar Convention Bureau. 2000. *Ramsar handbooks for the wise use of wetlands*. Ramsar Convention Bureau, Gland, Switzerland.
- Smith, W.J.S. & P. Robertson. 1999. *National Recovery Plan for the Striped Legless Lizard (Delma impar): 1999-2003*. Unpublished report to Environment Australia, Canberra.
- South Australian Tourism Commission (SATC). 2003. *Limestone Coast Regional Tourism Profile*.
- South East Catchment Water Management Board. 2003. *South East Catchment Water Management Plan*. SECWMB, Mount Gambier.
- South East Catchment Water Management Board. 2001. *Water Allocation Plan for the Naracoorte Ranges Prescribed Wells Area*. SECWMB, Mount Gambier.
- South Eastern Water Conservation and Drainage Board. 2004. *South Eastern Water Conservation and Drainage Board Management Plan 2003-2006*. SEWC&DB, Millicent.
- Stokes, K.J. (Ed) 1990. *Report of the Task Force Enquiring into Duck Hunting in South Australia*, National Parks and Wildlife Service S.A.
- Thackway, R. and Creswell, I.D. (Eds) 1995. *An Interim Biogeographic Regionalisation for Australia: A Framework for setting priorities in the national reserves system cooperative program, Version 4.0*. Australian Nature Conservation Agency, Canberra.
- Tindale N. B. 1974. *Aboriginal Tribes of Australia*, ANU Press, Canberra
- Tyler, M.J. 1997. *The Action Plan for Australian Frogs*, Wildlife Australia,.
- Wetlands International. 2002. *Waterbird Population Estimates Third Edition. Wetlands International Global Series No. 12*, Wageningen, The Netherlands.

APPENDIX A: FLORA SPECIES AND VEGETATION ASSOCIATIONS

Flora

Species	Common Name	Status ⁴			Introduced
		Aus	SA	SE	
<i>Acacia melanoxylon</i>	Blackwood				
<i>Acacia pycnantha</i>	Golden Wattle				
<i>Acacia saligna</i>	Golden Wreath Wattle				*
<i>Agrostis aemula</i>	Blown-grass				
<i>Agrostis avenacea</i> var. <i>avenacea</i>	Common Blown-grass				
<i>Aira caryophyllea</i>	Silvery Hair-grass				*
<i>Allocasuarina verticillata</i>	Drooping Sheoak				
<i>Anagallis arvensis</i>	Pimpernel				*
<i>Angianthus preissianus</i>	Salt Angianthus				
<i>Apium prostratum</i> ssp. <i>prostratum</i>	Native Celery				
<i>Arctotheca calendula</i>	Cape Weed				*
<i>Asperula conferta</i>	Common Woodruff				
<i>Aster subulatus</i>	Aster-weed				*
<i>Atriplex prostrata</i>	Creeping Saltbush				*
<i>Avena barbata</i>	Bearded Oat				*
<i>Azolla filiculoides</i>	Pacific Azolla				
<i>Banksia marginata</i>	Silver Banksia				
<i>Batrachium trichophyllum</i>	Water Buttercup				*
<i>Baumea arthrophylla</i>	Swamp Twig-rush				
<i>Baumea articulata</i>	Jointed Twig-rush			U	
<i>Baumea juncea</i>	Bare Twig-rush				
<i>Bolboschoenus caldwellii</i>	Salt Club-rush				
<i>Briza minor</i>	Lesser Quaking-grass				*
<i>Bromus diandrus</i>	Great Brome				*
<i>Bromus hordeaceus</i> ssp. <i>hordeaceus</i>	Soft Brome				*
<i>Bursaria spinosa</i>	Sweet Bursaria				
<i>Calystegia sepium</i>	Large Bindweed				
<i>Carduus tenuiflorus</i>	Slender Thistle				*
<i>Carex appressa</i>	Tall Sedge				
<i>Carthamus lanatus</i>	Saffron Thistle				*
<i>Casuarina glauca</i>	Swamp She-oak				*
<i>Centaurea calcitrapa</i>	Star Thistle				*
<i>Centaureum erythraea</i>	Common Centaury				*
<i>Centaureum spicatum</i>	Spike Centaury				*
<i>Centaureum tenuiflorum</i>	Branched Centaury				*
<i>Chenopodium album</i>	Fat Hen				*

⁴ Status: Aus (EPBC Act), SA (NPW Act), SE (Lang & Kraehenbuehl 2002). See Appendix C for Conservation Status Codes.

Species	Common Name	Status ⁴			Introduced
		Aus	SA	SE	
<i>Cirsium vulgare</i>	Spear Thistle				*
<i>Convolvulus arvensis</i>	Field Bindweed				*
<i>Convolvulus erubescens</i>	Australian Bindweed				
<i>Cotula coronopifolia</i>	Water Buttons				*
<i>Cotula vulgaris var. australasica</i>	Slender Cotula				
<i>Craspedia sp.</i>	Button				
<i>Crassula helmsii</i>	Swamp Crassula				
<i>Crepis vesicaria ssp. haenseleri</i>	Bladder Hawksbeard				*
<i>Critesion marinum</i>	Sea Barley-grass				*
<i>Critesion murinum ssp. leporinum</i>	Wall Barley-grass				*
<i>Cynara cardunculus</i>	Artichoke Thistle				*
<i>Danthonia pilosa var. pilosa</i>	Velvet Wallaby-grass				
<i>Dichondra repens</i>	Kidney Weed				
<i>Distichlis distichophylla</i>	Emu-grass				
<i>Echium plantagineum</i>	Salvation Jane				*
<i>Eleocharis acuta</i>	Common Spike-rush				
<i>Eleocharis sphacelata</i>	Tall Spike-rush			R	
<i>Elymus scabrus var. scabrus</i>	Native Wheat-grass				
<i>Eragrostis benthamii</i>	Bentham's Love-grass				
<i>Eragrostis infecunda</i>	Barren Cane-grass		R	R	
<i>Erodium cicutarium</i>	Cut-leaf Heron's-bill				*
<i>Eucalyptus fasciculosa</i>	Pink Gum				
<i>Gahnia filum</i>	Thatching Grass				
<i>Gahnia trifida</i>	Cutting Grass				
<i>Galium divaricatum</i>	Slender Bedstraw				*
<i>Glyceria australis</i>	Australian Sweet-grass				
<i>Gyrostemon australasicus</i>	Buckbush Wheel-fruit				
<i>Hainardia cylindrica</i>	Common Barb-grass				*
<i>Hedypnois rhagadioloides</i>	Cretan Weed				*
<i>Helminthotheca echioides</i>	Ox-tongue				*
<i>Hirschfeldia incana</i>	Hoary Mustard				*
<i>Holcus lanatus</i>	Yorkshire Fog				*
<i>Hordeum vulgare ssp. vulgare</i>	Barley				*
<i>Hypochaeris glabra</i>	Smooth Cat's Ear				*
<i>Isolepis fluitans</i>	Floating Club-rush			U	
<i>Isolepis nodosa</i>	Knobby Club-rush				
<i>Isolepis platycarpa</i>	Flat-fruit Club-rush				
<i>Juncus bufonius</i>	Toad Rush				
<i>Juncus kraussii</i>	Sea Rush				
<i>Juncus pallidus</i>	Pale Rush				

Species	Common Name	Status ⁴			Introduced
		Aus	SA	SE	
<i>Labiatae sp.</i>	Mint Family				
<i>Lavatera plebeia</i>	Australian Hollyhock				
<i>Lemna trisulca</i>	Ivy-leaf Duckweed				
<i>Leontodon taraxacoides ssp. taraxacoides</i>	Lesser Hawkbit				*
<i>Lepilaena australis</i>	Austral Water-mat				
<i>Leptocarpus brownii</i>	Coarse Twine-rush				
<i>Leptorhynchos squamatus</i>	Scaly Buttons				
<i>Lilaeopsis polyantha</i>	Australian Lilaeopsis			R	
<i>Lobelia alata</i>	Angled Lobelia				
<i>Lolium rigidum</i>	Wimmera Ryegrass				*
<i>Lythrum hyssopifolia</i>	Lesser Loosestrife				
<i>Malva nicaeensis</i>	Mallow Of Nice				*
<i>Marrubium vulgare</i>	Horehound				*
<i>Medicago intertexta</i>	Calvary Medic				*
<i>Medicago minima var. minima</i>	Little Medic				*
<i>Melaleuca halmaturorum ssp. halmaturorum</i>	Swamp Paper-bark				
<i>Melaleuca lanceolata ssp. lanceolata</i>	Dryland Tea-tree				
<i>Mellilotus indica</i>	King Island Melilot				*
<i>Mimulus repens</i>	Creeping Monkey-flower				
<i>Montia australasica</i>	White Purslane		R	R	
<i>Muehlenbeckia florulenta</i>	Lignum			R	
<i>Myriophyllum muelleri</i>	Hooded Milfoil			Q	
<i>Myriophyllum salsugineum</i>	Lake Milfoil			Q	
<i>Myriophyllum simulans</i>	Amphibious Milfoil			Q	
<i>Myriophyllum variifolium</i>	Varied Milfoil		R	K	
<i>Myriophyllum verrucosum</i>	Red Milfoil			R	
<i>Papaver sp.</i>	Poppy				*
<i>Parapholis incurva</i>	Curly Ryegrass				*
<i>Parentucellia latifolia</i>	Red Bartsia				*
<i>Parentucellia viscosa</i>	Yellow Bartsia				*
<i>Persicaria decipiens</i>	Slender Knotweed			R	
<i>Phalaris aquatica</i>	Phalaris				*
<i>Phalaris paradoxa</i>	Paradox Canary-grass				*
<i>Phragmites australis</i>	Common Reed				
<i>Pimelea stricta</i>	Erect Riceflower				
<i>Plantago gaudichaudii</i>	Narrow-leaf Plantain				
<i>Plantago hispida</i>	Hairy Plantain				
<i>Plantago lanceolata var. lanceolata</i>	Ribwort				*
<i>Plantago varia</i>	Variable Plantain				
<i>Poa annua</i>	Winter Grass				*

Species	Common Name	Status ⁴			Introduced
		Aus	SA	SE	
<i>Poa bulbosa</i>	Bulbous Meadow-grass				*
<i>Poa labillardieri</i> var. <i>labillardieri</i>	Common Tussock-grass				
<i>Polygala monspeliaca</i>	Annual Milkwort				*
<i>Polypogon maritimus</i>	Coast Beard-grass				*
<i>Polypogon monspeliensis</i>	Annual Beard-grass				*
<i>Potamogeton pectinatus</i>	Fennel Pondweed				*
<i>Potamogeton tricarinatus</i>	Floating Pondweed				
<i>Pratia platycalyx</i>	Salt Pratia			U	
<i>Puccinellia fasciculata</i>	Borrer's Saltmarsh-grass				*
<i>Pultenaea stricta</i>	Erect Bush-pea			U	
<i>Ranunculus amphitrichus</i>	Small River Buttercup			U	
<i>Ranunculus inundatus</i>	River Buttercup		R	R	
<i>Ranunculus papulentus</i>	Large River Buttercup		V	K	
<i>Romulea rosea</i> var. <i>australis</i>	Common Onion-grass				*
<i>Rorippa nasturtium-aquaticum</i>	Watercress				*
<i>Rumex bidens</i>	Mud Dock			U	
<i>Rumex crispus</i>	Curled Dock				*
<i>Ruppia</i> sp.	Water-tassel				
<i>Salvia verbenaca</i> form	Wild Sage				*
<i>Samolus repens</i>	Creeping Brookweed				
<i>Sarcocornia quinqueflora</i>	Beaded Samphire				
<i>Schoenoplectus pungens</i>	Spiky Club-rush				
<i>Schoenoplectus validus</i>	River Club-rush				
<i>Schoenus nitens</i>	Shiny Bog-rush				
<i>Scorzonera laciniata</i>	Scorzonera				*
<i>Sebaea albidiflora</i>	White Sebaea			U	
<i>Selliera radicans</i>	Shiny Swamp-mat				
<i>Senecio lautus</i>	Variable Groundsel				
<i>Silybum marianum</i>	Variiegated Thistle				*
<i>Sonchus hydrophilus</i>	Native Sow-thistle				
<i>Sonchus oleraceus</i>	Common Sow-thistle				*
<i>Spirodela punctata</i>	Thin Duckweed				
<i>Sporobolus virginicus</i>	Salt Couch				
<i>Stackhousia spathulata</i>	Coast Candles				
<i>Stellaria caespitosa</i>	Starwort		V	V	
<i>Taraxacum officinale</i>	Dandelion				*
<i>Thinopyrum ponticum</i>	Tall Wheat-grass				*
<i>Trifolium angustifolium</i>	Narrow-leaf Clover				*
<i>Trifolium campestre</i>	Hop Clover				*
<i>Trifolium dubium</i>	Suckling Clover				*

Species	Common Name	Status ⁴			Introduced	
		Aus	SA	SE		
<i>Trifolium fragiferum</i> var. <i>fragiferum</i>	Strawberry Clover				*	
<i>Trifolium glomeratum</i>	Cluster Clover				*	
<i>Trifolium scabrum</i>	Rough Clover				*	
<i>Trifolium stellatum</i>	Star Clover				*	
<i>Trifolium subterraneum</i>	Subterranean Clover				*	
<i>Triglochin procerum</i>	Water-ribbons					
<i>Triglochin striatum</i>	Streaked Arrowgrass					
<i>Trithuria submersa</i>	Trithuria					
<i>Typha domingensis</i>	Narrow-leaf Bulrush					
<i>Typha orientalis</i>	Broad-leaf Bulrush					
<i>Urospermum picroides</i>	False Hawkbit				*	
<i>Urtica incisa</i>	Scrub Nettle			U		
<i>Utricularia</i> sp.	Bladderwort					
<i>Veronica anagallis-aquatica</i>	Blue Water-speedwell				*	
<i>Villarsia reniformis</i>	Running Marsh-flower					
<i>Wilsonia backhousei</i>	Narrow-leaf Wilsonia					
<i>Wilsonia rotundifolia</i>	Round-leaf Wilsonia					
<i>Wolffia angusta</i>	Narrow Duckweed					
Total		174	0	6	22	76

Vegetation Associations

Vegetation associations present at Bool and Hacks Lagoons (Brownlow 1997)

- *Potamogeton pectinatus* Aquatic herbland
- *Baumea arthropphylla* Sedgeland
- *Baumea articulata* Reed Swamp
- *Phragmites australis* Reed Swamp
- *Baumea arthropphylla* – *Myriophyllum salsugineum* – *Triglochin procerum* Sedgeland/Aquatic herbland
- *Baumea arthropphylla* – mixed Sedgeland
- *Triglochin procerum* free floating Aquatic herbland
- *Triglochin procerum* – Aquatic Herbland
- *Gahnia trifida* Tussock Sedgeland

APPENDIX B: FAUNA SPECIES

Birds

Common Name	Species	Status ⁵			Migratory	Introduced
		Aus	SA	SE		
Australasian Bittern (Brown Bittern)	<i>Botaurus poiciloptilus</i>		V	V		
Australasian Grebe, (Little Grebe)	<i>Tachybaptus novaehollandiae</i>					
Australasian Shoveler	<i>Anas rhynchotis</i>		R	R		
Australian Hobby (Little Falcon)	<i>Falco longipennis</i>			U		
Australian Kestrel (Nankeen Kestrel)	<i>Falco cenchroides</i>					
Australian Magpie	<i>Gymnorhina tibicen</i>					
Australian Magpie-lark	<i>Grallina cyanoleuca</i>					
Australian Pelican	<i>Pelecanus conspicillatus</i>					
Australian Pratincole	<i>Siltia isabella</i>					
Australian Shelduck (Mountain Duck)	<i>Tadorna tadornoides</i>					
Australian Spotted Crake	<i>Porzana fluminea</i>					
Australian White Ibis (Sacred Ibis)	<i>Threskiornis molucca</i>					
Australian Wood Duck, (Maned Duck)	<i>Chenonetta jubata</i>					
Baillon's Crake (Marsh Crake)	<i>Porzana pusilla</i>		R	R		
Banded Lapwing	<i>Vanellus tricolor</i>					
Banded Stilt	<i>Cladorhynchus leucocephalus</i>					
Barn Owl	<i>Tyto alba</i>					
Bar-tailed Godwit	<i>Limosa lapponica</i>				M	
Black Falcon	<i>Falco subniger</i>					
Black Kite	<i>Milvus migrans</i>			U		
Black Swan	<i>Cygnus atratus</i>					
Black-faced Cuckoo-shrike	<i>Coracina novaehollandiae</i>					
Black-fronted Dotterel (Black-fronted Plover)	<i>Euseyornis melanops</i>					
Black-shouldered Kite	<i>Elanus axillaris</i>					
Black-tailed Godwit	<i>Limosa limosa</i>				M	
Black-tailed Native-hen	<i>Gallinula ventralis</i>					
Black-winged Stilt (White-headed Stilt)	<i>Himantopus himantopus</i>				M (Aust)	
Blue-billed Duck	<i>Oxyyura australis</i>		R	U		

⁵ Status: Aus (EPBC Act), SA (NPW Act), SE (Carpenter & Reid 1998). See Appendix C for Conservation Status Codes.

Common Name	Species	Status ⁵			Migratory	Introduced
		Aus	SA	SE		
Blue-winged Parrot	<i>Neophema chrysostoma</i>		V	V		
Brolga	<i>Grus rubicunda</i>		V	E		
Brown Falcon	<i>Falco berigora</i>					
Brown Goshawk	<i>Accipiter fasciatus</i>					
Brown Quail	<i>Coturnix ypsilophora</i>		V			
Brown Songlark	<i>Cincloramphus cruralis</i>					
Brown Thornbill	<i>Acanthiza pusilla</i>					
Buff-banded Rail	<i>Gallirallus philippensis</i>			V		
Calamanthus (Striated Fieldwren)	<i>Calamanthus fuliginosus</i>					
Cape Barren Goose	<i>Cereopsis novaehollandiae</i>		R	O		
Caspian Tern	<i>Sterna caspia</i>					
Cattle Egret	<i>Ardea ibis</i>			U		
Chestnut Teal	<i>Anas castanea</i>			U		
Clamorous Reedwarbler	<i>Acrocephalus stentoreus</i>					
Collared Sparrowhawk	<i>Accipiter cirrhocephalus</i>			U		
Common Greenshank	<i>Tringa nebularia</i>				M	
Common Redshank	<i>Tringa totanus</i>			O	M	
Common Starling	<i>Sturnus vulgaris</i>					*
Crescent Honeyeater	<i>Phylidonyris pyrrhoptera</i>					
Crested Pigeon	<i>Ocyphaps lophotes</i>					
Crimson Rosella	<i>Platycercus elegans</i>					
Curlew Sandpiper	<i>Calidris ferruginea</i>				M	
Darter	<i>Anhinga melanogaster</i>			U		
Double-banded Plover	<i>Charadrius bicinctus</i>				M	
Dusky Moorhen	<i>Gallinula tenebrosa</i>					
Dusky Woodswallow	<i>Artamus cyanopterus</i>					
Eastern Rosella	<i>Platycercus eximius eximius</i>					
Eurasian Blackbird	<i>Turdus merula</i>					*
Eurasian Coot	<i>Fulica atra</i>					
Eurasian Skylark	<i>Alauda arvensis</i>					*
European Goldfinch	<i>Carduelis carduelis</i>					*
European Greenfinch	<i>Carduelis chloris</i>					*
Fairy Martin	<i>Petrochelidon ariel</i>					
Fan-tailed Cuckoo	<i>Cacomantis flabelliformis</i>					

Common Name	Species	Status ⁵			Migratory	Introduced
		Aus	SA	SE		
Flame Robin	<i>Petroica phoenicea</i>		R	R		
Forest Raven	<i>Corvus tasmanicus</i>			U		
Fork-tailed Swift	<i>Apus pacificus</i>				M	
Freckled Duck	<i>Stictonetta naevosa</i>		V	V		
Galah	<i>Cacatua roseicapilla</i>					
Glossy Ibis	<i>Plegadis falcinellus</i>		R	R		
Golden-headed Cisticola	<i>Cisticola exilis</i>		R	R		
Great Cormorant	<i>Phalacrocorax carbo</i>					
Great Crested Grebe	<i>Podiceps cristatus</i>		R	R		
Great Egret (White Egret)	<i>Ardea alba</i>					
Grey Fantail	<i>Rhipidura albiscapa</i>					
Grey Plover	<i>Pluvialis squatarola</i>				M	
Grey Shrike-thrush	<i>Colluricincla harmonica</i>					
Grey Teal	<i>Anas gracilis</i>					
Gull-billed Tern	<i>Sterna nilotica</i>					
Hardhead (White-eyed Duck)	<i>Aythya australis</i>			U		
Hoary-headed Grebe	<i>Poliocephalus poliocephalus</i>					
Horsfield's Bronze-cuckoo	<i>Chrysococcyx basalis</i>					
House Sparrow	<i>Passer domesticus</i>					*
Intermediate Egret (Plumed)	<i>Ardea intermedia</i>		R	R		
Latham's Snipe (Japanese Snipe)	<i>Gallinago hardwickii</i>		V	V	M	
Laughing Kookaburra	<i>Dacelo novaeguineae</i>					
Lewin's Rail (Water Rail)	<i>Rallus pectoralis</i>		V	V		
Little Bittern	<i>Ixobrychus minitus</i>		R	R		
Little Black Cormorant	<i>Phalacrocorax sulcirostris</i>					
Little Button-quail	<i>Turnix velox</i>					
Little Eagle	<i>Hieraaetus morphnoides</i>			U		
Little Egret	<i>Ardea garzetta</i>			U		
Little Grassbird	<i>Megalurus gramineus</i>					
Little Pied Cormorant	<i>Phalacrocorax melanoleucos</i>					
Little Raven	<i>Corvus mellori</i>					
Little Ringed Plover	<i>Charadrius dubius</i>				M	
Little Wattlebird	<i>Anthochaera chrysoptera</i>					
Long-billed Corella	<i>Cacatua tenuirostris</i>			U		

Common Name	Species	Status ⁵			Migratory	Introduced
		Aus	SA	SE		
Long-toed Stint	<i>Calidris subminuta</i>				M	
Magpie Goose	<i>Anseranas semipalmata</i>		E	X/I		
Marsh Sandpiper	<i>Tringa stagnatilis</i>				M	
Masked Lapwing	<i>Vanellus miles</i>					
Musk Duck	<i>Biziura lobata</i>		R	U		
Musk Lorikeet	<i>Glossopsitta concinna</i>					
Nankeen Kestrel	<i>Falco cenchroides</i>					
Nankeen Night Heron	<i>Nycticorax caledonicus</i>			U		
New Holland Honeyeater	<i>Phylidonyris novaehollandiae</i>					
Oriental Pratincole	<i>Glareola maldivarum</i>			O		
Pacific Black Duck	<i>Anas superciliosa</i>					
Pacific Golden Plover	<i>Pluvialis dominica</i>				M	
Painted Snipe	<i>Rostratula benghalensis or australis</i>	V	R	R	M (regional)	
Pallid Cuckoo	<i>Cuculus pallidus</i>					
Pectoral Sandpiper	<i>Calidris melanotos</i>				M	
Peregrine Falcon	<i>Falco peregrinus</i>		R	R		
Pink-eared Duck	<i>Malacorhynchus membranaceus</i>					
Plumed Whistling-Duck (Grass Whistle-duck)	<i>Dendrocygna eytoni</i>			O		
Purple Swamphen	<i>Porphyrio porphyrio</i>					
Purple-crowned Lorikeet	<i>Glossopsitta porphyrocephala</i>					
Rainbow Lorikeet	<i>Trichoglossus haematodus</i>					
Red Wattlebird	<i>Anthochaera carunculata</i>					
Red-browed Finch	<i>Neochmia temporalis</i>					
Red-capped Plover	<i>Charadrius ruficapillus</i>					
Red-chested Button-quail	<i>Turnix pyrrhothorax</i>		R			
Red-kneed Dotterel	<i>Erythronyctes cinctus</i>					
Red-necked Avocet	<i>Recurvirostra novaehollandiae</i>					
Red-necked Stint	<i>Calidris ruficollis</i>				M	
Red-rumped Parrot	<i>Psephotus haematotus</i>					
Restless Flycatcher	<i>Myiagra inquieta</i>			U		
Richard's Pipit	<i>Anthus novaeseelandiae</i>					
Royal Spoonbill	<i>Platalea regia</i>			U		
Ruff	<i>Philomachus pugnax</i>				M	

Common Name	Species	Status ⁵			Migratory	Introduced
		Aus	SA	SE		
Rufous Whistler	<i>Pachycephala rufiventris</i>			U		
Sacred Kingfisher	<i>Todiramphus sanctus</i>					
Sharp-tailed Sandpiper	<i>Calidris acuminata</i>				M	
Shining Bronze Cuckoo	<i>Chrysococcyx lucidus</i>		R	R		
Silver Gull	<i>Larus novaehollandiae</i>					
Silvereye	<i>Zosterops lateralis</i>					
Singing Bushlark	<i>Mirafra javanica</i>					
Southern Boobook (Boobook Owl)	<i>Ninox novaeseelandiae</i>					
Southern Emu Wren	<i>Stipituris malachurus</i>		R	R		
Spotless Crake	<i>Porzana tabuensis</i>					
Spotted Harrier	<i>Circus assimilis</i>					
Straw-necked Ibis	<i>Threskiornis spinicollis</i>					
Striated Pardalote	<i>Pardalotus striatus</i>					
Stubble Quail	<i>Coturnix pectoralis</i>					
Sulphur-crested Cockatoo	<i>Cacatua galerita</i>			U		
Superb Fairy-wren (Superb Blue Wren)	<i>Malurus cyaneus</i>					
Swamp Harrier	<i>Circus approximans</i>					
Tawny Frogmouth	<i>Podargus strigoides</i>					
Tree Martin	<i>Petrochelidon nigricans</i>					
Wandering Whistling Duck (Water Whistling Duck)	<i>Dendrocygna arcuata</i>					
Wedge-tailed Eagle	<i>Aquila audax</i>					
Welcome Swallow	<i>Hirundo neoxena</i>					
Whiskered Tern (Marsh Tern)	<i>Chlidonias hybridus</i>					
Whistling Kite	<i>Haliastur sphenurus</i>			U		
White-bellied Sea Eagle	<i>Haliaeetus leucogaster</i>		V	V	M (regional)	
White-browed Scrubwren	<i>Sericornis frontalis</i>					
White-faced Heron	<i>Egretta novaehollandiae</i>					
White-fronted Chat	<i>Epthianura albifrons</i>					
White-necked Heron	<i>Ardea pacifica</i>			U		
White-plumed Honeyeater	<i>Meliphaga penicillata</i>					
White-throated Needletail	<i>Hirundapus caudacutus</i>				M	
White-winged Black Tern	<i>Chlidonias leucopterus</i>					
White-winged Triller	<i>Lalage sueurii</i>					

Common Name	Species	Status ⁵			Migratory	Introduced
		Aus	SA	SE		
Willie Wagtail	<i>Rhipidura leucophrys</i>					
Wood Sandpiper	<i>Tringa glareola</i>				M	
Yellow-billed Spoonbill	<i>Platalea flavipes</i>					
Yellow-rumped Thornbill	<i>Acanthiza chrysorrhoa</i>					
Yellow-tailed Black-cockatoo	<i>Calyptorhynchus funereus</i>		V	V		
Total	167	1	26	46	22⁶	6

Source: J. Bourne, R. Jaensch, DEH Reserves Database

Mammals

Common Name	Species	Status ⁷			Introduced
		Aus	SA	SE	
Brown Hare	<i>Lepus capensis</i>				*
Chocolate Wattled Bat	<i>Chalinolobus morio</i>				
European Red Fox	<i>Vulpes vulpes</i>				*
Feral Cat	<i>Felis catus</i>				*
House Mouse	<i>Mus musculus</i>				*
Lesser Long-eared Bat	<i>Nyctophilus geoffroyi</i>				
European Rabbit	<i>Oryctolagus cuniculus</i>				*
Sheep	<i>Ovis aries</i>				*
Swamp Rat	<i>Rattus Lutriolus</i>				
Swamp Wallaby	<i>Wallabia bicolor</i>		V	V	
Water-rat	<i>Hydromys chrysogaster</i>				
Western Grey Kangaroo	<i>Macropus fuliginosus</i>				
Total	12		1	1	6

⁶ This figure includes International (19), State (1) and Regional (2) Migratory Species.

⁷ Status: Aus (EPBC Act), SA (NPW Act), SE (Croft a& Carpenter 2001). See Appendix C for Conservation Status Codes.

Reptiles

Common Name	Species	Status ⁸		
		Aus	SA	SE
Blotched Bluetongue	<i>Tiliqua nigrolutea</i>			
Common Long-necked Tortoise	<i>Chelodina longicollis</i>			
Eastern Bearded Dragon	<i>Pogona barbata</i>			
Eastern Bluetongue	<i>Tiliqua scincoides</i>			
Eastern Three-lined Skink	<i>Bassiana duperreyi</i>			
Eastern Tiger Snake	<i>Notechis scutatus</i>			
Glossy Grass Skink	<i>Pseudemoia rawlinsoni</i>		E	E
Lowland Copperhead	<i>Austrelaps superbis</i>			
Sleepy Lizard	<i>Tiliqua rugosa</i>			
Southern Grass Skink	<i>Pseudemoia entrecasteauxii</i>			
Striped Legless Lizard	<i>Delma impar</i>	V	E	E
Total	11	1	2	2

Amphibians

Common Name	Species	Status ⁸		
		Aus	SA	SE
Common Froglet	<i>Crinia signifera</i>			
Eastern Banjo Frog	<i>Limnodynastes dumerilli</i>			
Brown Striped Frog	<i>Limnodynastes peroni</i>			
Spotted Grass Frog	<i>Limnodynastes tasmaniensis</i>			
Brown Tree Frog	<i>Litoria ewingi</i>			
Southern Bell Frog	<i>Litoria raniformis</i>	V	V	V
Painted Frog	<i>Neobatrachus pictus</i>			
Sudell's Frog	<i>Neobatrachus sudelli</i>			
Marbled Toadlet	<i>Pseudophryne semimarmorata</i>			
Total	9	1	1	1

⁸ Status: Aus (EPBC Act), SA (NPW Act), SE (Croft a& Carpenter 2001). See Appendix C for Conservation Status Codes.

Fish

Common Name	Species	Status ⁹		Recorded Historically	Introduced
		Aus	SA		
Goldfish	<i>Carassius auratus</i>				*
Gambusia	<i>Gambusia holbrooki</i>				*
Redfin	<i>Perca fluviatilis</i>				*
Smallmouthed Hardyhead	<i>Atherinosoma microstoma</i>				
River Blackfish	<i>Gadopsis marmoratus</i>				
Common Galaxias	<i>Galaxias maculatus</i>			*	
Mountain Galaxias	<i>Galaxias olidus</i>				
Dwarf Galaxias	<i>Galaxiella pusilla</i>	V			
Murray Darling Carp Gudgeon	<i>Hypseleotris sp.</i>				
Southern Pygmy Perch	<i>Nannoperca australis</i>				
Yarra Pygmy Perch	<i>Nannoperca obscura</i>	V			
Mud Galaxias	<i>Neochanna cleaveri</i>			*	
Flathead Gudgeon	<i>Phlypnodon grandiceps</i>				
Western Blue Spot Goby	<i>Pseudogobius olorum</i>				
Total	14	2		2	3

⁹ Status: Aus (EPBC Act), SA (NPW Act). See Appendix C for Conservation Status Codes.

APPENDIX C: CONSERVATION STATUS CODES

Australian Conservation Status Codes

The following codes are based on the current listing of species under Section 179 of the *Environmental Protection and Biodiversity Conservation Act 1999*.

- EX Extinct:** there is no reasonable doubt that the last member of the species has died.
- EW Extinct in the Wild:** known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or it has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
- CE Critically Endangered:** facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
- E Endangered:** facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.
- V Vulnerable:** facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.
- CD Conservation Dependent:** the species is the focus of a specific conservation program, the cessation of which would result in the species becoming vulnerable, endangered or critically endangered within a period of 5 years.

Note: Prescribed criteria as defined under the IUCN Red List of Threatened Species.

South Australian Conservation Status Codes

The following codes are based on the current listing of species under Schedules of the *National Parks and Wildlife Act 1972*. Schedule listings are currently under review.

- E Endangered:** (Schedule 7) in danger of becoming extinct in the wild.
- V Vulnerable:** (Schedule 8) at risk from potential or long term threats which could cause the species to become endangered in the future.
- R Rare:** (Schedule 9) low overall frequency of occurrence (may be locally common with a very restricted distribution or may be scattered sparsely over a wider area). Not currently exposed to significant threats, but warrants monitoring and protective measures to prevent reduction of population sizes.

Regional Status Codes

The categories below apply to the species distribution at a regional level.

Mammals, Reptiles & Amphibians

Regional conservation status developed for mammals, reptiles and amphibians in the South East follow Croft and Carpenter (2001) Biological Resources of the South East.

Birds

Regional conservation status for birds follow Carpenter and Reid (1998) The Status of Native Birds in the Agricultural Areas of South Australia;

The regions are defined as follows;

ML	Mount Lofty	MN	Mid-North	SE	South-Eastern	KI	Kangaroo Island
MM	Murray Mallee	EP	Eyre Peninsula	YP	Yorke Peninsula		

Plants

Regional conservation ratings for plants follow:

Lang, P.J. & Kraehenbuehl, D.N. (2002). Plants of Particular Conservation Significance in South Australia's Agricultural Regions.

Update (2006) of unpublished database: Florlist. Department for Environment and Heritage.

The regions are as defined by the State Herbarium (Plant Biodiversity Centre), illustrated in the back cover of *Census of South Australian Vascular Plants (Edition V)* (Eds. B Barker, R Barker, J Jessop and H Vonow, 2005).

NW	North-Western	FR	Flinders Ranges	NL	Northern Lofty	SL	Southern Lofty
LE	Lake Eyre	EA	Eastern	MU	Murray	KI	Kangaroo Island
NU	Nullarbor	EP	Eyre Peninsula	YP	Yorke Peninsula	SE	South-Eastern
GT	Gairdner-Torrens						

In order of decreasing conservation significance:

- X Extinct/Presumed extinct:** not located despite thorough searching of all known and likely habitats; known to have been eliminated by the loss of localised population(s); or not recorded for more than 50 years from an area where substantial habitat modification has occurred.
- E Endangered:** rare and in danger of becoming extinct in the wild.
- T Threatened:** (*Plants only*) likely to be either endangered or vulnerable but insufficient data available for more precise assessment.
- V Vulnerable:** rare and at risk from potential threats or long term threats that could cause the species to become endangered in the future.
- K Uncertain:** likely to be either threatened or rare but insufficient data available for a more precise assessment.
- R Rare:** has a low overall frequency of occurrence (may be locally common with a very restricted distribution or may be scattered sparsely over a wider area). Not currently exposed to significant or widespread threats, but warrants monitoring and protective measures to prevent reduction of population sizes.
- U Uncommon:** less common species of interest but not rare enough to warrant special protective measures.
- Q Not yet assessed:** but flagged as being of possible significance.
- N Not of particular significance** (*Plants only*) Also indicated by a blank entry.
- C Common** (*Birds only*) Also indicated by a blank entry.
- O Occasional Visitor Only** (*Birds only*) Not considered of conservational status.
- I Re-introduced**

APPENDIX D: RAMSAR INFORMATION SHEET – DRAFT

Please Note: This RIS is current as submitted for Commonwealth endorsement.

1) NAME AND ADDRESS OF THE COMPILER OF THIS FORM:

South Australian Department for Environment and Heritage, South East Region, PO Box 1047
MOUNT GAMBIER 5290 SOUTH AUSTRALIA

2) DATE THIS SHEET WAS COMPLETED/UPDATED: Updated April 2005

3) COUNTRY: Australia

4) NAME OF THE RAMSAR SITE: Bool and Hacks Lagoons

5) MAP OF SITE INCLUDED:

- a) hard copy (required for inclusion of site in the Ramsar List)
- b) digital (electronic) format (optional)

6) GEOGRAPHICAL COORDINATES (LATITUDE/LONGITUDE):

Latitude: 37° 06'S to 37° 10'S; Longitude: 140° 39'E to 140° 44'E.

7) GENERAL LOCATION:

Bool and Hacks Lagoons are located in the South East Region of the State of South Australia. The lagoons are 24 kilometres by road south of the township of Naracoorte, population 5,200.

8) ELEVATION:

Approximately 50 metres Australian Height Datum (AHD); the floors of the basins vary between 47.67 metres AHD in the central basin to 48.00 metres AHD in the western basin.

9) AREA:

Total 3,221 hectares: Bool Lagoon Game Reserve comprises 3,023ha; Hacks Lagoon Conservation Park comprises 198ha. The wetland area of both reserves covers 2,530ha at maximum storage capacity; the dryland area is 691 ha.

10) OVERVIEW:

The site comprises several shallow, circular basins surrounded by lunettes. Hacks Lagoon is a largely semi-permanent freshwater wetland, whilst adjoining Bool Lagoon is seasonal, receiving the majority of water in the winter/spring months (June – September/October). Bool Lagoon is connected to Hacks Lagoon by several channels, and managed as a contiguous unit. Water levels within the lagoons are artificially maintained by a regulating structure, and are managed for ecological (habitat diversity and drought refuge) and regional flood mitigation purposes.

The diversity in flora and fauna, and presence of semi-permanent water make Bool and Hacks Lagoons one of the most important wetland areas remaining in the South East Region of South Australia, and an important protected area in the Naracoorte Coastal Plains bioregion. The site is significant for biodiversity conservation, supporting a high diversity and abundance of species, including an appreciable number of globally, nationally and state threatened species of fauna, and regionally threatened wetland vegetation communities. The site is widely recognised for its importance for waterbirds, serving as a drought refuge and breeding site for waterbirds in southern Australia, and habitat for 19 migratory species recognised in International conventions and agreements (JAMBA, CAMBA, Bonn Convention).

The lagoons serve as a floodwater storage basin in the regional drainage system, a recreation, tourism and research resource, and are valued for their cultural heritage.

11) RAMSAR CRITERIA:

1	2	3	4	5	6	7	8
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12) JUSTIFICATION FOR THE APPLICATION OF EACH CRITERION LISTED IN 11. ABOVE:

a) **Criterion 1: Contains a representative, rare, or unique example of a natural or near natural wetland type found within the appropriate biogeographic region.**

- The site is an important example of a freshwater inland wetlands over fertile, high pH soil.
- Bool and Hacks Lagoons is one of the most important remnant wetland in a region that has been extensively drained and developed for agricultural use. It is estimated that only 6 per cent of wetlands remain in the South East Region (DEH & DWLBC 2003). The reserves constitute important wetland habitat in the poorly protected Naracoorte Coastal Plains Bioregion, of which an estimated 5-10 per cent is adequately conserved (Thackway & Cresswell 1995).
- Example of semi-permanent wetland type, a significant proportion of which have been lost through regional drainage.

b) **Criterion 2: It supports vulnerable, endangered, or critically endangered species or threatened ecological communities.**

Bool and Hacks Lagoons supports a high number of threatened species at an international, national, state and regional level. Threatened species at the national level have legislative protection under the *Environment Protection and Biodiversity Conservation Act 1999*. The Act works to protect matters of National Environment Significance, including threatened and migratory species. Within the State of South Australia, threatened species are listed under the *National Parks and Wildlife Act 1972*. The table below lists threatened species present at the site.

COMMON NAME	SCIENTIFIC NAME	STATUS ¹
GLOBAL²		
FAUNA		
Australasian Bittern	<i>Botaurus poiciloptilus</i> (IUCN Red List)	V
NATIONALLY THREATENED SPECIES³		
FAUNA		
Painted Snipe	<i>Rostratula benghalensis</i>	V
Southern Bell Frog	<i>Litoria raniformis</i>	V
Striped Legless Lizard	<i>Delma impar</i>	V
Yarra Pygmy Perch	<i>Nannoperca obscura</i>	V
Dwarf Galaxias	<i>Galaxiella pusilla</i>	V

¹ V: vulnerable; E: endangered; R: rare

² IUCN Threat Status

³ Nationally threatened species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)

STATE THREATENED SPECIES⁴

FAUNA		
<u>Birds</u>		
Australasian Bittern (Brown Bittern)	<i>Botaurus poiciloptilus</i>	V
Australasian Shoveler	<i>Anas rhynchotis</i>	R
Baillon's Crake (Marsh Crake)	<i>Porzana pusilla</i>	R
Blue-billed Duck	<i>Oxyyura australis</i>	R
Blue-winged Parrot	<i>Neophema chrysostoma</i>	V▼
Brolga	<i>Grus rubicunda</i>	V
Brown Quail	<i>Coturnix ypsilophora</i>	V
Cape Barren Goose	<i>Cereopsis novaehollandiae</i>	R
Flame Robin	<i>Petroica phoenicea</i>	R
Freckled Duck	<i>Stictonetta naevosa</i>	V
Glossy Ibis	<i>Plegadis falcinellus</i>	R
Golden-headed Cisticola	<i>Cisticola exilis</i>	R
Great Crested Grebe	<i>Podiceps cristatus</i>	R
Intermediate Egret (Plumed)	<i>Ardea intermedia</i>	R
Latham's Snipe (Japanese Snipe)	<i>Gallinago hardwickii</i>	V
Lewin's Rail (Water Rail)	<i>Rallus pectoralis</i>	V
Little Bittern	<i>Ixobrychus minitus</i>	R
Magpie Goose	<i>Anseranas semipalmata</i>	E
Musk Duck	<i>Biziura lobata</i>	R
Painted Snipe	<i>Rostratula benghalensis</i>	R
Peregrine Falcon	<i>Falco peregrinus</i>	R
Red-chested Button-quail	<i>Turnix pyrrhоторax</i>	R
Shining Bronze Cuckoo	<i>Chrysococcyx lucidus</i>	R
Southern Emu Wren	<i>Stipituris malachurus</i>	R
White-bellied Sea Eagle	<i>Haliaeetus leucogaster</i>	V
Yellow-tailed Black-cockatoo	<i>Calyptorhynchus funereus</i>	V▼
<u>Mammals, Reptiles and Amphibians</u>		
Swamp Wallaby	<i>Wallabia bicolor</i>	V
Striped Legless Lizard	<i>Delma impar</i>	E
Glossy Grass Skink	<i>Pseudemoia rawlinsoni</i>	E
Southern Bell Frog	<i>Litoria raniformis</i>	V

Note: ▼ indicates bird species not dependant on wetland.

⁴ Listed under the *National Parks and Wildlife Act 1972* (South Australia).

STATE THREATENED SPECIES ⁵		
FLORA		
Barren Cane-grass	<i>Eragrostis infecunda</i>	R
Large River Buttercup	<i>Ranunculus papulentus</i>	V
River Buttercup	<i>Ranunculus inundatus</i>	R
Starwort	<i>Stellaria caespitosa</i>	V
Varied Milfoil	<i>Myriophyllum variifolium</i>	R
White Purslane	<i>Montia australasica</i>	R

REGIONALLY THREATENED SPECIES ⁶		
FAUNA⁷		
<u>Birds</u>		
Australian Hobby (Little Falcon)	<i>Falco longipennis</i>	U
Black Kite	<i>Milvus migrans</i>	U
Buff-banded Rail	<i>Gallirallus philippensis</i>	V
Cattle Egret	<i>Ardea ibis</i>	U
Chestnut Teal	<i>Anas castanea</i>	U
Collared Sparrowhawk	<i>Accipiter cirrhocephalus</i>	U
Common Redshank	<i>Tringa totanus</i>	O
Darter	<i>Anhinga melanogaster</i>	U
Forest Raven	<i>Corvus tasmanicus</i>	U
Hardhead (White-eyed Duck)	<i>Aythya australis</i>	U
Little Eagle	<i>Hieraaetus morphnoides</i>	U
Little Egret	<i>Ardea garzetta</i>	U
Long-billed Corella	<i>Cacatua tenuirostris</i>	U
Nankeen Night Heron	<i>Nycticorax caledonicus</i>	U
Oriental Pratincole	<i>Glareola maldivarum</i>	O
Plumed Whistling-Duck (Grass Whistle-duck)	<i>Dendrocygna eytoni</i>	O
Restless Flycatcher	<i>Myiagra inquieta</i>	U
Royal Spoonbill	<i>Platalea regia</i>	U
Rufous Whistler	<i>Pachycephala rufiventris</i>	U
Sulphur-crested Cockatoo	<i>Cacatua galerita</i>	U
Whistling Kite	<i>Haliastur sphenurus</i>	U
White-necked Heron	<i>Ardea pacifica</i>	U

⁵ Listed under the *National Parks and Wildlife Act 1972* (South Australia).

⁶ Carpenter, G. & Reid, J. (2000). The status of native birds in South Australia's agricultural regions. Department for Environment & Heritage, Unpublished. database.

⁷ Species not previously listed as global, national or state threatened species.

REGIONALLY THREATENED SPECIES ⁸		
FLORA⁹		
<i>Baumea articulata</i>	Jointed Twig-rush	U
<i>Eleocharis sphacelata</i>	Tall Spike-rush	R
<i>Isolepis fluitans</i>	Floating Club-rush	U
<i>Lilaeopsis polyantha</i>	Australian Lilaeopsis	R
<i>Muehlenbeckia florulenta</i>	Lignum	R
<i>Myriophyllum muelleri</i>	Hooded Milfoil	Q
<i>Myriophyllum salsugineum</i>	Lake Milfoil	Q
<i>Myriophyllum simulans</i>	Amphibious Milfoil	Q
<i>Myriophyllum verrucosum</i>	Red Milfoil	R
<i>Persicaria decipiens</i>	Slender Knotweed	R
<i>Pratia platycalyx</i>	Salt Pratia	U
<i>Pultenaea stricta</i>	Erect Bush-pea	U
<i>Ranunculus amphitrichus</i>	Small River Buttercup	U
<i>Rumex bidens</i>	Mud Dock	U
<i>Sebaea albidiflora</i>	White Sebaea	U
<i>Urtica incisa</i>	Scrub Nettle	U

As a result of extensive regional drainage, many plant communities associated with wetlands are considered threatened. Bool and Hacks Lagoons support the following regionally threatened wetland plant communities.

REGIONALLY THREATENED VEGETATION COMMUNITIES ¹⁰	
<i>Gahnia filum</i> Sedgeland	V
<i>Gahnia trifida</i> Sedgeland	V
<i>Baumea juncea</i> Sedgeland	E
<i>Phragmites australis</i> – <i>Typha domingensis</i> Sedgeland	R

⁸ Species not previously listed as global, national or state threatened species.

⁹ Lang, P.J. & Kraehenbuehl, D.N. (2001). Plants of Particular Conservation Significance in South Australia's Agricultural Regions.

¹⁰ Croft, T., Carruthers, S., Possingham, H. and Inns, B. (1999) *Biodiversity Plan for the South East of South Australia*. Department for Environment, Heritage and Aboriginal Affairs, pp. 116.

- c) **Criterion 3: It supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.**
- 226 bird species have been recorded in the region, with 166 recorded within Bool and Hacks Lagoons. The site provides general habitat for 79 species of waterbird, 67 of which are resident, or regular visitors to the complex.
 - The number of breeding species is exceptionally high, with 48 species of waterbird recorded breeding at the site, 29 of them regularly.
 - Bool and Hacks Lagoons are the only site in the Region where Little Bittern (*Ixobrychus minitus*) and Magpie Goose (*Anseranas semipalmata*) have been recorded breeding.
 - Fourteen species of raptors are present at the site, utilising a variety of habitats.
 - The wetland supports a high diversity of aquatic vegetation communities. As a consequence of extensive wetland drainage and agricultural development in the region, most plant communities associated with wetlands are now considered to be regionally rare and threatened (Croft *et al* 1999, p. 115).
- d) **Criterion 4: It supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.**
- The lagoons are of high value as a drought refuge and summer habitat for many species of waterbirds in southern Australia, including Freckled Duck (*Stictonetta naevosa*).
 - Bool Lagoon is an important flocking site for the southern Australian population of Brolga (*Grus rubicunda*), at times supporting around one third of the population for up to half of the year. The total numbers of individuals in the southern Australian population is estimated between 750 and 1,000; up to 200 Brolga have been recorded at Bool and Hacks Lagoons, utilising a range of habitats.
 - The complex constitutes breeding habitat for 48 species of waterbirds, including important colonial breeding species and a migration stopover for 19 species of shorebirds. All migratory waterbirds listed under International migratory bird agreements¹¹, and their habitats, are protected as matters of National Environmental Significance under the *Environment Protection and Biodiversity Conservation Act 1999*.
- e) **Criterion 5: It regularly supports 20,000 or more waterbirds.**
- Duck numbers can vary between 15,000 and 50,000; regularly supports in excess of 20,000 ducks.
 - Straw-necked Ibis (*Threskiornis spinicollis*) and Australian White Ibis (*Threskiornis molucca*) are common in the nesting season and numbers often exceed 50,000, with occasional counts between 150,000 to 500,000 nests on record.

¹¹ Nineteen species occurring at Bool and Hacks Lagoons are listed under the China-Australia Migratory Bird Agreement, or the Japan-Australia Migratory Bird Agreement and the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention).

f) **Criterion 6: It regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.**

Bool and Hacks Lagoons supports 1 percent of the individuals in a population of 10 species or subspecies of waterbird (see below).

Species		Subspecies / population	1% threshold*	Regular Bool Lagoon Count
Common Name	Scientific Name			
Australasian Bittern	<i>Botaurus poiciloptilus</i>	SE Australian	20	20
Painted Snipe	<i>Rostratula benghalensis</i>	Australian	15 ¹²	30 (1980); 28 (1985)
Australian Shoveler	<i>Anas rhynchos</i>	SE Australian	1,500 ¹³	Up to 2,000
Australian White Ibis	<i>Threskiornis molucca</i>	<i>strictipennis</i>	700	1,500
Black Swan	<i>Cygnus atratus</i>	Australian	4,000	5,000
Blue-billed Duck	<i>Oxyura australis</i>	SE Australian	180	600
Brolga	<i>Grus rubicunda</i>	Sth Australian	10	100-200
Freckled Duck	<i>Stictonetta naevosa</i>	SE Australia	190	200
Great (White) Egret	<i>Egretta alba</i>	<i>modesta</i>		120 pairs (1983); 500 individuals
Straw-necked Ibis	<i>Threskiornis spinicollis</i>	Australian	5,000	Up to 150,000 breeding pairs.

Wetlands International. 2002. *Waterbird Population Estimates Third Edition. Wetlands International Global Series No. 12*, Wageningen, The Netherlands.

g) **Criterion 7: It supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.**

- The Mosquito/Bool Lagoon system is a significant area for native fishes both in a regional (South East), state (SA) and national perspective as it supports at least nine native fishes (a relatively high species richness e.g. nearly half the regional total), several of which are conservation listed.
- The area is a stronghold for the nationally vulnerable Yarra Pygmy Perch (*Nannoperca obscura*) and the Dwarf Galaxias (*Galaxiella pusilla*), the later of which is strongly seasonal. This is also the only recorded location for the Mud Galaxias (*Neochanna cleaveri*) in South Australia.

h) **Criterion 8: It is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.**

- The Bool/Hacks Lagoon wetland system is a highly productive seasonal wetland offering significant habitat and food resources for rapid recruitment and population expansion of wetland fish species.
- Bool/Hacks Lagoon is a refuge for indigenous fish species from drought and drainage and the quality and quantity of habitat is important for providing a source of fish to seed surrounding areas during large wet events.
- This system is the largest example of this habitat type remaining in the South East and potentially southern Australia.

¹² Source: Australian Government Department of the Environment and Heritage 2004. (Fact Sheet)

¹³ Source: del Hoyo, J., Elliot, A., & Sargatal, J. (1992) *Handbook of the Birds of the World Volume 1*, Lynx Edicions, Barcelona.

13) BIOGEOGRAPHY

a) Biogeographic Region:

Naracoorte Coastal Plain IBRA (Interim Biogeographic Regionalisation for Australia)

b) Biogeographic Regionalisation Scheme (include reference citation):

Thackway, R. and Creswell, I.D. (Eds) 1995. *An Interim Biogeographic Regionalisation for Australia: A Framework For Setting Priorities In The National Reserves System Cooperative Program*, Version 4.0. Australian Nature Conservation Agency, Canberra.

14) PHYSICAL FEATURES OF THE SITE:

Bool and Hacks Lagoons lie in an interdunal flat, which slopes gently toward the coast in a north-westerly direction. The interdunal flats consist of Gambier Limestone overlain by estuarine and swamp deposits, including clays, silts and some dolomites and peat. The wetland complex is characterised by black, poorly drained organic soils with a high pH. Lunettes are a distinctive feature of the Bool Lagoon landscape. The Bool Lagoon main basin lunette is one of the largest in South Australia. Within the larger swamp basin lies a complex of smaller lakes, each with its associated lunette. These developed after the formation of the main lunette.

Surface Water: The lagoons receive surface water from the Mosquito Creek catchment, which extends into the State of Victoria. Prior to regional drainage, Mosquito Creek was poorly defined and discharged to flood the interdunal corridor. Bool and Hacks Lagoons received only limited surface water through a relatively small inlet in Hacks Lagoon during times of large flows. Water trapped in the lagoons would evaporate during summer; it is estimated that the lagoons retained water only periodically during summer and autumn under a natural regime. Subsequent drainage developments of the 1960s channelled Mosquito Creek directly into the eastern side of Hacks Lagoon. A regulating structure was located on the western side of the Bool Lagoon basin to enable the retention of water in Bool Lagoon over summer and autumn for ecological purposes, as well as providing a storage basin in the regional drainage system. Water can be released from Bool Lagoon via the regulating structure to discharge into the Southern Ocean via Drain M. However, during times of high rainfall in the catchment, the inflow volume of Mosquito Creek can exceed the capacity of Drain M downstream of the wetland, necessitating the storage of water within Bool and Hacks Lagoons. A series of 21 stopbanks have been constructed on the northern and western sides of Bool Lagoon to improve the integrity of the basin structure for flood mitigation purposes. Channels have been dug within the lagoons to accelerate the movement of floodwater from the Hacks Lagoon inlet to the Bool Lagoon outlet. The average water depth is one metre; the maximum depth is 1.5metres. In the short term, water levels can fluctuate as much as one metre between Hacks Lagoon and Bool Lagoon, as large inflows move from east to west across the lagoons.

To the north and west of the Bool Lagoon basins are a series of circular peripheral lagoons, including Little Bool and Round and House Lagoons, the Gahnia, Twig Rush and Tea-Tree Lagoons. After the construction of stopbanks around Bool Lagoon, the peripheral lagoons were deprived from their natural water supply via over flow from the main basin. Since the late 1970s, the peripheral lagoons have been progressively reconnected to the hydrological regime through a series of regulators. There is the ability to retain water in the peripheral lagoons during summer and autumn, increasing their values as a refuge area for waterbirds.

Under the current regime, it is expected that parts of the wetland will dry out on average once every two years. With the exception of a series of very dry years, Hacks Lagoon retains water semi-permanently, due to the influence of groundwater. The release of water via the regulator can be expected to occur on average once every three years (SEDB 1984).

Groundwater: The complex acts as a groundwater recharge and discharge site. Groundwater in the region is shallow (on average two metres depth). Within parts of the Bool and Hacks Lagoon basin, groundwater generally rises above the lagoon floor in winter and early spring, and falls below it by late summer.

Water Quality: Bool and Hacks Lagoons is predominantly a freshwater wetland, with salinity increases accompanying seasonal drying and evaporation in summer and autumn. The table below indicates the amplitude of available water quality data. However, there is limited comprehensive physico-chemical data available from the site.

Location	pH	Conductivity us/cm	TDS mg/L
Hacks Lagoon – Mosquito Creek inlet	7.8	1,330	730
Bool Lagoon – outlet	8.7	24,500	15,000

Source: South Australian Water Corporation, Australian Water Quality Centre Chemical Analysis Report. June 1995.

The contrast in recordings between Hacks Lagoon inlet and Bool Lagoon outlet can likely be explained by the relative location of each reading, and the interactions between freshwater inflows and evaporation in different parts of the wetland. Given the time of data collection in June (at the beginning of winter), Hacks Lagoon may have been subject to freshwater inflows via Mosquito Creek. However, winter inflows would not have reached the western outlet of Bool Lagoon, resulting in the much higher salinity readings from evaporation of water from the lagoons over summer/autumn.

Climate: A Mediterranean climate; average annual rainfall is approximately 550-600mm; annual evaporation is approximately 1,400mm. The highest rainfall occurs during the winter months, between June to September, and highest evaporation occurs during January and February.

Climate Feature	Amount	Month
Highest mean monthly rainfall	84mm	September
Lowest mean monthly rainfall	11mm	February
Highest mean monthly temperature	28°C	February
Lowest mean monthly temperature	14°C	July

15) PHYSICAL FEATURES OF THE CATCHMENT AREA:

The principal catchment for Bool and Hacks Lagoons extends into the State of Victoria, comprising a surface area of 1,215 km². The Mosquito Creek drains the southern part of the catchment while its main tributary, the Yelloch Creek drains the northern part of the catchment.

The catchment largely consists of agricultural landuse, with areas of plantation timber, viticulture and irrigation. The Mosquito Creek catchment area is gently undulating with little pondage area. Some drainage has been undertaken in this section of the catchment. There is approximately 130 km² covered by heavy native vegetation. Much of this area has to be inundated to a shallow depth before run-off occurs. The Yelloch Creek catchment is gently undulating to the west, and very flat to the east. There is a considerable amount of pondage in this part of the catchment. Several significant swamps, including Newlands Lake, Leah/Dixon's Swamp, and Kidman Swamp, have to be filled before substantial runoff occurs.

The Mosquito Creek/Yelloch Creek catchment receives between 575mm (northern) to 750mm (southern) rainfall annually. The maximum run-off occurs during the months of June to October. Significant flows in the catchment usually occur after heavy rainfall over a two to three day period, when the catchment is already very wet from rainfall over the previous weeks.

16) HYDROLOGICAL VALUES:

Bool and Hacks Lagoons are an important storage basin in the regional flood mitigation system. The capacity of the Mosquito Creek inlet is up to three times that of the outlet and Drain M, necessitating the ponding of floodwaters. The maximum capacity of the lagoons is 16,500ML. The lagoons act as sumps for the 1,215km² catchment. Bool and Hacks Lagoon is a groundwater recharge and discharge zone.

17) WETLAND TYPES

a) Presence:

Marine/coastal :

A	B	C	D	E	F	G	H	I	J	K	Zk(a)
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Inland:

L	M	N	O	P	Q	R	Sp	Ss	Tp	Ts	U	Va	Vt	W	Xf	Xp	Y	Zg	Zk(b)
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Human-made:

1	2	3	4	5	6	7	8	9	Zk(c)
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b) Dominance:

P: Seasonal/intermittent freshwater lakes (>8ha);

Tp: Permanent freshwater marshes/pools; ponds (<8ha) marshes and swamps on inorganic soils; with emergent vegetation water logged for at least most of the growing season; and

W: Shrub-dominated wetlands; shrub swamps, shrub-dominated freshwater marshes, shrub carr, alder thicket on inorganic soils.

18) GENERAL ECOLOGICAL FEATURES:

Nine of the 11 defined vegetation associations found in South East wetlands sampled by Brownlow (1997) are present at the site. Of the sampled wetlands, Bool and Hacks Lagoons have the highest level of floristic diversity in the region (Brownlow 1997, p. 221-224).

- *Potamegeton pectinatus* Aquatic herbland
- *Baumea arthrophylla* Sedgeland
- *Baumea articulata* Reed Swamp
- *Phragmites australis* Reed Swamp
- *Baumea arthrophylla* – *Myriophyllum salsugineum* – *Triglochin procerum* Sedgeland/aquatic herbland
- *Baumea arthrophylla* – Mixed Sedgeland
- *Triglochin procerum* (free floating) Aquatic Herbland
- *Triglochin procerum* – Aquatic Herbland
- *Gahnia trifida* Tussock Sedgeland

There has been a documented shift in the relative abundance of *Baumea spp* and *Triglochin procerum*. Alterations in the hydrological regime associated with drainage development of the late 1960s have been implicated in the large-scale shift in species dominance where sedgeland communities have retreated and semi-emergent species have increased in their range (Brownlow 1997, p. 4; Rea 1993; Rea & Ganf 1994).

Bool and Hacks Lagoons offer a diverse range of habitats, resulting from interactions between the fluctuating water regime and responses of wetland vegetation.

Habitat Types Present At Bool And Hacks Lagoons (After Biggs 2001; Jaensch 1982; And Seaman 2004):

Habitat	Dominant species/genera	Characteristics
1. Aquatic / floating-leaved vegetation	<i>Triglochin procerum</i> , <i>Myriophyllum</i> , <i>Potamogeton</i>	<i>Triglochin</i> most common, emergent with green, spongy, floating or semi-erect leaves. Dominant in main basin and extensive in central basin. Found in deeper water in flowpath linking Hacks Lagoon and Bool Lagoon, and through Bool Lagoon. Subject to frequent and/or prolonged inundation.
2. Tea Tree Tall Shrubland	<i>Melaleuca halmaturorum</i>	Stand in the main basin approximately 8.5ha (Biggs 2001). Also found fringing eastern side of main basin, and Hacks Lagoon.
3. Tussock	<i>Gahnia trifida</i> , <i>G. filum</i>	Tall individuals growing as dense clumps up to 2m. Both generally occur in dense stands. Dominant in western basin and many peripheral western lagoons.
4. Sedge	<i>Baumea arthrophylla</i> , <i>B. juncea</i> , <i>B. articulata</i> , <i>Leptocarpus brownii</i> , <i>Eleocharis gracilis</i> .	1m in height, dense stands. Dominant in the Western Basin and peripheral western lagoons. Subject to inundation.
5. Bare Ground/Mud-mat	<i>Selliera radicans</i> , <i>Sarcocornia spp.</i>	Ground-hugging annual species, often intermingled with areas of unvegetated soil. Located around Little Bool, eastern and northern margin on main basin and western peripheral lagoons. Bare margins (often with receding water) valuable waterbird habitat.
6. Reed	<i>Phragmites australis</i> , <i>Typha domingensis</i>	Range of growth habits: scattered individuals <1m; dense stands 1.2-2m; impenetrable stands >2.2m. Located on fringes of lagoons, for example, southern lobe of Bool Lagoon main basin, Hacks Lagoon and Hacks Island.
7. Open Water		Little Bool, House and Round Swamps, Hacks Lagoons, Bool Lagoon main basin. Areas of open water critical waterbird habitat.
8. Native and Exotic Grassland	<i>Distichlis distichophylla</i> , <i>Sporobolus virginicus</i> ; <i>Phalaris aquatica</i> , <i>P. paradoxa</i>	Both dry and subject to inundation. Found on dry and marginal areas of the reserves, north and east boundary of Hacks Lagoon.

The lagoons are significant for their high diversity of waterbirds: Pacific Black Duck (*Anas superciliosa*) and Grey Teal (*A. gibberifrons*) are the most common species in the lagoons; historic numbers of Pacific Black Duck have been estimated between 1000 to 100,000, and numbers of Grey Teal between 30,000 to 50,000. Species regularly present include Pink-eared Duck (*Malacorhynchus membranaceus*), Hardhead (*Aythya australis*), Chestnut Teal (*Anas castanea*), Musk Duck (*Biziura lobata*), Cape Barren Goose (*Cereopsis novaehollandiae*), Yellow-billed Spoonbill (*Platalea flavipes*), Royal Spoonbill (*P. regia*), Eurasian Coot (*Fulica atra*), and Purple Swamphen (*Porphyrio porphyrio*).

The *Melaleuca halmaturorum* tall shrubland is important breeding habitat for waterbirds. Royal Spoonbill (*Platalea regia*), Australian White Ibis (*Threskiornis moluccas*), and Straw-necked Ibis (*Threskiornis spinicollis*) regularly breed in large numbers in tall shrubland habitat; Glossy Ibis (*Plegadis falcinellus*), Great Egret (*Egretta alba*), Little Pied Cormorant (*Phalacrocorax melanoleucos*), Intermediate Egret, Little Black Cormorant (*Phalacrocorax sulcirostris*), Great Cormorant (*Phalacrocorax carbo*) and Nankeen Night Heron (*Nycticorax caledonicus*) less frequently breed at the site, utilising the same habitat.

The site is habitat for 19 migratory birds listed under treaties between the Australian Government and the Governments of China and Japan and the Bonn Convention. Many shorebird species are highly specialised regarding habitat requirements, utilising only the bare ground/mud-mat habitat on the edges of the lagoons and islands.

There is a high concentration of raptor species, including Wedge-Tail Eagle (*Aquila audax*), and Swamp Harrier (*Circus approximans*), and White-bellied Sea Eagle (*Haliaeetus leucogaster*), all of which utilise a range of available habitats.

Eleven native fish species are present in the Mosquito Creek-Bool Lagoon system, including the nationally vulnerable Yarra Pygmy Perch (*Nannoperca obscura*) and Dwarf Galaxias (*Galaxiella pusilla*). These species favour slow moving, more permanent water. There is a high level of diversity in aquatic invertebrates.

Fauna species: the Swamp Wallaby (*Wallabia bicolor*), vulnerable within South Australia, and the Western Grey Kangaroo (*Macropus fuliginosus*) are resident within the site as well as using it as a corridor and temporary refuge. Bool and Hacks Lagoons provide habitat for the Swamp Rat (*Rattus lutriolus*) and Water Rat (*Hydromys chrysogaster*) due to the presence of semi-permanent water.

There are records of Lesser Long-eared Bat (*Nyctophilus geoffroyi*) and Chocolate Wattled Bat (*Chalinolobus morio*) within the reserves.

Reptile species include the nationally vulnerable Striped Legless Lizard (*Delma impar*), state endangered Glossy Grass Skink (*Pseudemoia rawlinsoni*), and the more common Eastern Tiger Snake (*Notechis scutatus*), Lowland Copperhead (*Austrelaps superbus*), Blotched Bluetongue (*Tiliqua nigrolutea*), Eastern Bluetongue (*T. scincoides*), Sleepy Lizard (*T.rugosa*), Eastern Bearded Dragon (*Pogona barbata*), Eastern Three-lined Skink (*Bassiana duperreyi*), Southern Grass Skink (*Pseudemoia entrecasteauxii*) and the Long-necked Tortoise (*Chelodina longicollis*). Frog species present include nationally vulnerable Southern Bell Frog (*Litoria raniformis*); Brown Tree Frog (*L. ewingi*); Common Froglet (*Crinia signifera*); Eastern Banjo Frog (*Limnodynastes dumerilli*), Brown Striped Frog (*L. peroni*), Spotted Grass Frog (*L. tasmaniensis*), Painted Frog (*Neobatrachus pictus*), Sudell's Frog (*N. sudelli*) and Marbled Toadlet (*Pseudophryne semimarmorata*).

Introduced species present within the reserves include the European Red Fox (*Vulpes vulpes*), Feral Cat (*Felis catus*), European Rabbit (*Oryctolagus cuniculus*) and the Brown Hare (*Lepus capensis*).

19) NOTEWORTHY FLORA:

As a consequence of the high level of hydrological alteration sustained by wetlands in the region, most wetland vegetation communities are considered rare or threatened (Croft *et al* 1999). The wetland flora of Bool and Hacks Lagoons is noteworthy because it comprises significant remaining areas of *Baumea* spp sedgeland, *Gahnia* spp tussock lands, *Phragmites australis* – *Typha domingensis* sedgeland, and *Triglochin procerum* swamps in the bioregion.

The mature Swamp Paperbark (*Melaleuca halmaturorum*) stand is an important breeding habitat for several species of waterbirds, many for which the site is Internationally recognised.

The small area of native grassland (*Distichlis distichophylla*-*Sporobolus virginicus* association) in the south-east corner of Hacks Lagoons is of high conservation value and is an example of a poorly conserved habitat type in the Naracoorte Coastal Plains bioregion.

There are numerous species of introduced plants present within the lagoons. Many dryland and marginal locations within the site are dominated by Phalaris (*Phalaris paradoxa*; *P. aquatica*). Phalaris is a highly invasive pasture grass, which successfully out-competes many species of native vegetation, including native grasses.

20) NOTEWORTHY FAUNA:

Bool and Hacks Lagoons is the most important wetland in Australia for the Australasian Bittern (*Botaurus poiciloptilus*), which is on the IUCN Red List as globally vulnerable. Bool Lagoon is a confirmed breeding location of this species, of which an estimated 85% of the global population occur in Australia. Australasian Bitterns have narrow habitat preferences, preferring shallow, freshwater to brackish swamps. *Baumea* sedgeland at Bool Lagoon provides important habitat.

It is now recognised that the Painted Snipe (*Rostratula benghalensis*) is a distinct species from the Painted Snipe of Africa and Asia. This species is declining, poorly understood, and population estimates are as low as 1,500. Regular and significant records of the Painted Snipe at Bool and Hacks Lagoons make it an important wetland for this species.

Prior to 1900, Bool and Hacks Lagoons was one of the few recorded locations in south eastern Australia where Magpie Goose (*Anseranas semipalmata*) were breeding. By 1911, the species was extinct from South Australia. In 1968, a program commenced to re-establish a population on the reserves. By 1989, approximately 320 individuals were present; in 2003, 3,000 individuals were present on the lagoons, comprising a significant breeding population in southern Australia.

One of only two known sites in South Australia for the Striped Legless Lizard (*Delma impar*), which is listed as vulnerable in Australia.

Water Rat (*Hydromys chrysogaster*) is the only endemic small mammal present in the lagoons. The presence of this species within the lagoons represents an extension of their known range by 50 kilometres.

Whilst Brolga (*Grus rubicundus*) are widespread throughout northern, central and north eastern Australia, the southern Australian population is isolated, confined to south-eastern South Australia and south western Victoria. Bool and Hacks Lagoons is an important summer/autumn (late December to April) flocking site, due to the presence of semi-permanent water, a diverse range of habitats, shallow water, and low disturbance. It is estimated that up to one quarter of the southern population of Brolga utilise Bool and Hacks Lagoons for up to half of the year.

The presence of introduced species, including European Red Fox (*Vulpes vulpes*), Feral Cats (*Felis catus*), European Rabbit (*Oryctolagus cuniculus*) and Brown Hare (*Lepus capensis*) is noteworthy due to the threat they pose to native flora and fauna, both by direct predation, and habitat modification.

21) SOCIAL AND CULTURAL VALUES:

Socio-economic Value: The site is an important recreation and tourism resource, complementing other eco-tourism destinations in the region. The site provides sharecropping access to surrounding landholders.

Bool Lagoon Game Reserve is a well-known duck hunting site, and the location for scientific research expeditions by Universities.

Cultural Value: Bool and Hacks Lagoons is an important site for Aboriginal communities. The Meintangk people are the traditional owners of the land comprising Bool and Hacks Lagoons, and evidence suggests that the reserves may have been located at the boundary of more than one group's territory. The site may have been a meeting place for other groups coming from the Lower and Upper South East.

The lagoons are the site of early European settlement in the district; Occupation Licences were issued for the area as early as 1847. Today, Bool Lagoon is the focus of an active local community.

22) LAND TENURE/OWNERSHIP:

a) Within the Ramsar site:

The Ramsar site is Crown Land, proclaimed under the *National Parks and Wildlife Act 1972* as Bool Lagoon Game Reserve and Hacks Lagoon Conservation Park.

b) In the Surrounding area:

Land surrounding the wetland is under private ownership.

23) CURRENT LAND (INCLUDING WATER) USE:

a) Within the Ramsar site:

Conservation Park and Game Reserve, under the *National Parks and Wildlife Act 1972*. Land use includes: Conservation-based recreation and tourism; wetland pondage basin for the regional flood mitigation scheme; sharecropping of dryland areas; academic research; controlled duck hunting of prescribed species.

b) In the Surroundings/Catchment:

Directly surrounding the site, the dominant land use is agriculture, including dryland cropping and grazing. The land use of the catchment is similar, with small areas of plantation timber, viticulture and irrigation.

24) FACTORS (PAST, PRESENT OR POTENTIAL) ADVERSELY AFFECTING THE SITE'S ECOLOGICAL CHARACTER, INCLUDING CHANGES IN LAND (INCLUDING WATER) USE AND DEVELOPMENT PROJECTS:

a) Within the Ramsar site:

PAST

- Past duck hunting practices resulted in high concentrations of lead shot in the lagoons. Lead poisoning was detected in waterfowl species (in particular, Black Swan and Magpie Goose) due to the ingestion of spent lead shot. Lead shot is now banned from use in all South Australian Game Reserves.
- The grazing of stock around and within the lagoons impacted on the integrity of wetland vegetation (especially around the wetland margins) and increased disturbance sustained by wetland habitat. Grazing of stock can lead to disturbance and loss of native dryland species, disturbance of habitat, and the introduction of exotic plant species. Grazing within the reserves had a detrimental impact on the recruitment and survival of juvenile Swamp Paperbark. Licences to graze stock within the site were cancelled in 1998/9.
- In the past, there have been isolated incidences in the shooting of protected species of waterbird, most notably Freckled Duck.
- There has been a documented deterioration of the senescent Swamp Paperbark stand in the centre of the main basin due to extended impoundment of water within the lagoons, and the subsequent increase in seedling recruitment along lagoon margins.
- There has been a documented loss of Swamp Paperbark due to arson; and bushfire within the reserves.
- The spread of exotic species of flora and fauna, including foxes, cats, rabbits and hares, and plants species including invasive pasture plant varieties (*Phalaris*) and agricultural weeds. The spread of exotic plant species originates from surrounding agricultural land, and grazing of the reserves.

PRESENT

- Introduced fauna species, such as foxes and cats, which directly prey on native species; and rabbits and hares, which compete with native species for resources and are capable of significant habitat alteration.
- There have been instances of non-compliance with cropping license conditions, leading to the persistence of introduced plant species and vertebrate pests, and unauthorised stock grazing.
- The dominance of introduced plant species in dryland areas, threatening existing native flora communities and disadvantaging the recruitment of native dryland species.
- Lack of knowledge regarding the quantifiable influence of groundwater to the hydrology.
- Diversion of Mosquito Creek flows for irrigation, domestic and stock water supply.

POTENTIAL

- The use of chemicals within the lagoons to clear the flowpath of vegetation.
- Change in water quality, including salinity increase, nutrient enrichment. Wetland vegetation is vulnerable to nutrient enrichment from adjoining cropping activities.
- Introduction of aquatic weeds.
- Bushfires.
- Potential climate change.

b) In the Surrounding Area:

- Human-induced change in the Mosquito Creek catchment leading to any alteration in the volume, timing, frequency, and quality of surface water in the Mosquito Creek, outside of natural limits. Such changes may include, but are not limited to: Extraction or diversion of surface water; ponding or dam construction; drainage development; water quality alterations, including direct pollution; loss of riparian habitat and stability leading to increased sedimentation; and cumulative landuse changes, such as forestry and viticulture development.
- The limited capacity of Drain M downstream forcing the extended impoundment of floodwater within the lagoons.
- Change in regional groundwater (for example, extraction, changed recharge characteristics) leading to an alteration of groundwater influence to the hydrology.

25) CONSERVATION MEASURES TAKEN:

The reserves are legally protected under the *National Parks and Wildlife Act 1972* (South Australia), as Bool Lagoon Game Reserve (1967) and Hacks Lagoon Conservation Park (1967). The ecological character of the wetlands and all nationally threatened and migratory species present – and their habitats - are protected under the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth). Bool Lagoon Game Reserve is listed on the Register of the National Estate (Australian Heritage Commission) as a place of natural heritage importance. Bool Lagoon Game Reserve is listed under Category IV (Habitat/Species Management Area) under the IUCN Protected Area Management Categories.

The wetland is managed by the South Australian Department for Environment and Heritage in accordance with the *Bool Lagoon Game Reserve and Hacks Lagoon Conservation Park Ramsar Management Plan* (2005). The strategic objectives of the management plan provide for the maintenance of the ecological character, management for species and habitat diversity, improved cooperative arrangements for the management of water both on and off-site, and the wise use of the site as a tourism and recreation resource. The management of the site is underpinned by the principles of active adaptive management.

26) CONSERVATION MEASURES PROPOSED BUT NOT YET IMPLEMENTED:

- An integrated monitoring program is planned, to inform effective ongoing management. The principal purpose of the monitoring program is to ensure that the ecological character of the site is maintained, and ensure that present and planned management actions are consistent with the site's Ramsar status.
- Bool and Hacks Lagoons is the most south-eastern wetland of the Wetlands Waterlink proposal of the Upper South East Scheme linking Bool and Hacks Lagoon to the Coorong through the historic flow path.

27) CURRENT SCIENTIFIC RESEARCH AND FACILITIES:

- Permanent water level indicators to enable data collection by the South Eastern Water Conservation and Drainage Board.
- Botanical research by the University of Adelaide.
- Annual waterbird monitoring prior to the proclamation of Duck Hunting Open Season.
- Vegetation monitoring associated with prescribed burning.

28) CURRENT CONSERVATION EDUCATION:

Interpretive information is located at all major visitor facilities, including information on the Ramsar Convention, the ecological importance of the wetlands, physical features, birdlife identification etc. Pamphlets for self-guided walks are available on the site. Four boardwalks enable visitors to access and observe different areas of the wetland basins, including Swamp Paperbark habitat, and open water habitat. Bird hides, viewing platforms and walking trails offer a number of opportunities to observe birdlife. Guided tours are available by prior request for groups.

29) CURRENT RECREATION AND TOURISM:

The wetland is used for multiple passive recreation pursuits, including bird and wildlife observation, walking on nature trails and boardwalks, limited camping, and barbeques and picnics. Visitor facilities for these activities are provided, with interpretive signage at all facilities. The lagoons are an important tourism resource in the local area, with potential at a state and interstate level for greater visitation.

Increased visitor use directly correlates with high water levels (and associated wildlife) in the lagoons.

Bool Lagoon Game Reserve is open to duck hunters on a limited number of days during the duck hunting open season in South Australia, which is declared by the Minister for Environment and Conservation. Bool Lagoon is declared open only under favourable ecological conditions; the presence of rare or breeding waterfowl may cancel open days. Only species (and numbers) proclaimed by the Minister may be shot.

30) JURISDICTION:

South Australian Department for Environment and Heritage, South East Region.

31) MANAGEMENT AUTHORITY:

South Australian Department for Environment and Heritage, South East Region, PO Box 1047 MOUNT GAMBIER 5290 SOUTH AUSTRALIA

32) BIBLIOGRAPHICAL REFERENCES:

Australian Government Department of the Environment and Heritage (2003). *Nationally threatened species and ecological communities – Painted Snipe*. (Fact Sheet)

Biggs, C. 2001. *Tracking Vegetation Changes in the Bool and Hacks Lagoon Wetland Using Historic Environmental Records*, Honours Thesis, Department of Soil and Water, University of Adelaide.

Brownlow, M.D. 1997. *Water Regime and the Aquatic Vegetation of Bool Lagoon, South Australia*. unpublished PhD thesis. Department of Botany, University of Adelaide.

Commonwealth Bureau of Meteorology. 2004. *Climate Averages for Australian Sites – Struan & Naracoorte*. Accessed online May 2004, URL: http://www.bom.gov.au/climate/averages/tables/ca_sa_names.shtml

Croft, T., Carruthers, S., Possingham, H. and Inns, B. 1999. *Biodiversity Plan for the South East of South Australia*. Department for Environment, Heritage and Aboriginal Affairs. Adelaide.

del Hayo, J., Elliot, A., & Sargatal, J. 1992. *Handbook of the Birds of the World Volume 1*, Lynx Edicions, Barcelona

Department for Environment and Heritage. 2000. *A List of the Vertebrates of South Australia*. DEH Adelaide.

Department for Environment and Heritage & Department of Water, Land and Biodiversity Conservation. 2003. *Wetlands Strategy for South Australia*. Department for Environment and Heritage, South Australia.

Department for Environment and Planning. 1985. *Bool Lagoon Game Reserve Draft Management Plan*. DEP. Adelaide.

Department for Environment and Planning. 1992. *Bool Lagoon Game Reserve and Hacks Lagoon Conservation Park Amended Management Plan*. DEP. Adelaide.

Hammer, M. 2002. *The South East Fish Inventory: Distribution and Conservation of Freshwater Fishes of South East South Australia*. Native Fish Australia (SA) Inc. Adelaide.

Hammer, M. 2004. Personal communications.

Rea, N. 1993. *Influence of water regime on the population ecology of two emergent macrophytes*. Ph. D. thesis, The University of Adelaide.

Rea, N. and Ganf, G. 1994. Influence of water regime on the performance of aquatic plants. *Water Science and Technology* 29, pp. 127-132.

South Eastern Drainage Board. 1984. *Guidelines for the Operation of Bool Lagoon and Drain M Regulators for Flood Mitigation Purposes*. SEDB. Millicent.

Thackway, R. and Creswell, I.D. (Eds) 1995. *An Interim Biogeographic Regionalisation for Australia: A Framework For Setting Priorities In The National Reserves System Cooperative Program, Version 4.0*. Australian Nature Conservation Agency. Canberra

Wetlands International. 2002. *Waterbird Population Estimates Third Edition. Wetlands International Global Series No. 12*, Wageningen, The Netherlands.